Periodontal and dental health and oral self-care
among adults with diabetes mellitus

Soheila Bakhshandeh

Academic dissertation

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ABSTRACT


The aim of the present study was to assess oral health and treatment needs among Iranian adults with diabetes according to socio-demographic status, oral hygiene, diabetes related factors, and to investigate the relation between these determinants and oral health. Moreover, the effect of an educational oral health promotion intervention on their oral health and periodontal treatment needs was studied.

The target population comprised adults with diabetes in Tehran, Iran. 299 dentate patients with diabetes, who were regular attendants to a diabetic clinic, were selected as the study subjects. Data collection was performed through a clinical dental examination and self-administered structured questionnaire. The questionnaire covered information of the subject’s social background, medical history, oral health behaviour and smoking. The clinical dental examinations covered the registration of caries experience (DMFT), community periodontal index (CPI) and plaque index (PI). The intervention provided the adults with diabetes dental health education through a booklet. Reduction in periodontal treatment needs one year after the baseline examination was used as the main outcome.

A high prevalence of periodontal pockets among the study population was found; 52% of the participants had periodontal pockets with a pocket depth of 4 to 5 mm and 35% had periodontal pockets with pocket depth of 6 mm or more. The mean of the DMFT index was 12.9 (SD=6.1), being dominated by filled teeth (mean 6.5) and missing teeth (mean 5.0). Oral self-care among adults with diabetes was inadequate and poor oral hygiene was observed in more than 80% of the subjects. The educational oral health promotion decreased periodontal treatment needs more in the study groups than in the control group.

The poor periodontal health, poor oral hygiene and insufficient oral self-care observed in this study call for oral health promotion among adult with diabetes. An educational intervention showed that it is possible to promote oral health behaviour and to reduce periodontal treatment needs among adults with diabetes. The simplicity of the model used in this study allows it to be integrated to diabetes programmes in particular in countries with a developing health care system.

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<tr>
<td>ADA</td>
<td>American Diabetes Association</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<td>CPI</td>
<td>Community Periodontal Index</td>
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<td>DMFT</td>
<td>Decayed, Missing, and Filled permanent Teeth</td>
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<td>DT</td>
<td>Decayed permanent Teeth</td>
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<td>FT</td>
<td>Filled permanent Teeth</td>
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<tr>
<td>HbA1c</td>
<td>Glycosylated haemoglobin A1c</td>
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<td>IDF</td>
<td>International Diabetes Federation</td>
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<td>MHME</td>
<td>Ministry of Health and Medical Education</td>
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<tr>
<td>MT</td>
<td>Missing permanent Teeth</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<td>PI</td>
<td>Plaque Index</td>
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<td>SD</td>
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10. ORIGINAL PUBLICATIONS
1. INTRODUCTION

The World Health Organization Global Oral Health Programme has worked hard to increase the awareness of oral health worldwide as an important component of general health and quality of life. Meanwhile, the burden of oral disease is growing in many low- and middle-income countries (Petersen 2008).

Iran, with a population of over 68 million in 2002, is located in the Eastern Mediterranean region, with approximately 67% of the population living in urban area. The general level of adults’ oral health in Iran is unsatisfactory (Pakshir 2004, Hessari et al. 2007).

The most common oral diseases, chronic periodontitis and dental caries, are not life-threatening, but they are considered as the most important public health problems all over the world owing to their high prevalence and incidence (Petersen 2003a, Petersen et al. 2005). Their impacts on both society and individual are significant; pain, disability and handicap from disease are common. The causes of caries and chronic periodontitis are known, and the conditions are largely preventable (Sheiham & Watt 2003). Oral health is integrated with general health for well-being and it significantly impacts quality of life (WHO 2003). Oral diseases share common risk factors with the four leading chronic diseases: cardiovascular diseases, cancer, chronic respiratory diseases, and diabetes. These include unhealthy diet, tobacco use, and harmful alcohol use (WHO 2007). According to the common risk factor approach, poor oral hygiene, poor diet (excessive sugar consumption), and smoking are major risk factors, not only for oral health, but also for general health (Sheiham & Watt 2000). They concluded that further improvements in oral health would only be secured through the adoption of oral health promotion policies based upon the common risk factor approach.

In terms of general health, diabetes has become one of the main public health concerns in the world. Diabetes is classified as type 1, type 2, and other types, according to its aetiology and pathogenesis (WHO 2006). Today, at least 285 million people worldwide suffer from diabetes (IDF 2010). Its incidence is increasing rapidly, and it is estimated that by the year 2030 the number of subjects with diabetes will double.

Diabetes mellitus and chronic periodontitis are among the most prevalent human disorders. Frequently these two medical problems are present concurrently. For years, attempts have been made to relate these two processes, and periodontitis has even been regarded as one of the multiple complications of diabetes mellitus (Löe 1993, Tervonen & Karjalainen 1997, Promsudthi et al. 2005). While chronic periodontitis is one of the major oral health problems encountered in patients with diabetes (Bacic et al. 1988, Page & Beck 1997, Guneri et al. 2004), reports of an increased risk for dental caries among subjects with diabetes are controversial (Albrecht et al. 1988, Pohjamo et al. 1991, Miralles et al. 2006).

Subjects with diabetes need special care regarding their oral health, especially their periodontal health (Ship 2003). The purpose of this study was to assess oral health status and its determinants among Iranian adults with diabetes, with the focus of the intervention part of the study on the effect of an educational intervention on periodontal treatment needs.
2. LITERATURE REVIEW

2.1. Chronic periodontitis
Chronic periodontitis is a chronic bacterial infection of the periodontium with a high prevalence in the general population (Brown & Löe 1993, Petersen 2003a). During the 1960s and 1970s chronic periodontitis was considered to be a slowly and continually progressive condition. This continuously progressive model was based on the belief that gingivitis, once developed, would progress into the periodontium, leading to loss of attachment, bone destruction and eventually loss of teeth (Locker et al. 1998).

Findings from clinical and epidemiological research have challenged the traditional progressive disease model and questioned the extent of chronic periodontitis within the population (Locker et al. 1998, Sheiham 1991). Evidence indicates that chronic periodontitis has an episodic nature, in which short bursts of tissue destruction take place in certain teeth, at certain sites: the so-called burst theory (Goodson et al. 1982, Socransky et al. 1984, Hernández et al. 2011). These short periods of disease activity are followed by longer periods of remission and healing. Although there is still much debate about models of progression, there is widespread consensus that loss of attachment is neither evenly distributed within the mouth nor within the population (Pilot 1997). In spite of the still existing gaps in knowledge about the precise nature of the condition and its correlates, it is critically important that preventive and public health approaches to chronic periodontitis are based upon current scientific understanding of the condition (Sheiham 1991, Page 1995).

2.2. Dental caries
Worldwide, the prevalence of dental caries among adults is high (Petersen et al. 2005). Dental caries afflicts humans of all ages and in all regions of the world. In particular, it is a great concern in dental public health because of its high prevalence in some countries with emerging economies (Petersen 2003a, Anderson 2002). Dental caries is the result of mineral loss of dental hard tissues attributable to the activity of biofilm on the tooth surface. Three principal factors for this infectious process of teeth are (1) the host, (2) the microflora, and (3) the diet (Clarkson 1999).

2.3. Factors predisposing to chronic periodontitis and dental caries
Chronic periodontitis is apparently multifactorial. Kinane (2001) described periodontitis as an irreversible, cumulative condition, initiated by bacteria but propagated by host factors. Systemic factors modify periodontitis principally through their effects on the normal immune and inflammatory defences (Kinane 2001).

A variety of factors have been shown to influence the course of chronic periodontitis and the host response after treatment. Among these factors are race, ethnicity, genotype, systemic conditions (acquired immunodeficiency syndrome, stress, and obesity), medications (immunosuppressants, anticoagulants), malnutrition, occlusal trauma, gender, socioeconomic status, and age (Shaddox & Walker 2009). Some factors considered to influence the risk of developing chronic periodontitis are: oral hygiene level (Löe 2000, Albandar & Tinoco 2002), microorganisms (Christersson et al. 1991, Cortelli et al. 2005), site-specific factors of tooth (Nunn 2003), smoking (Albandar et al. 2000, Susin et al. 2005, Torrungruang et al. 2005) and systemic diseases (Garcia et al. 2001, Kinane & Marshall 2001, Jansson 2006).

It is well established that gingivitis precedes periodontitis (Löe 1965, 1983) and that gingivitis is induced by bacterial plaque composed of nonspecific
opportunistic pathogens (Listgarten 1988, Theilade 1996). Bacterial accumulations on the teeth are essential to the initiation and progression of periodontal infection (Christersson et al. 1991, Cortelli et al. 2005). As soon as oral hygiene is not maintained, dental plaque immediately develops by a dynamic intraplaque interaction, resulting in the establishment of a community of microflora (Nishihara & Koseki 2004). Combinations of putative periodontal pathogens, rather than the presence of a certain single pathogen, have been identified as potential aetiologic agents in the periodontal destruction associated with chronic periodontitis (Könönen et al. 2007, Tanner et al. 2007, Paju et al. 2009).

Diabetes mellitus is an important risk factor for chronic periodontitis (Page & Beck 1997, Albandar 2002). Individuals with uncontrolled or poorly controlled diabetes are at risk for more severe periodontitis than are those with controlled diabetes and subjects without diabetes. The risk for severe periodontitis for subjects with well-controlled diabetes, particularly for those without calculus and with good dental care and oral hygiene, is no greater than for subjects without diabetes (Page & Beck 1997).

Various factors predisposing to dental caries are encountered, such as altered salivary flow and composition, high number of cariogenic bacteria, insufficient fluoride exposure, immunological components, and genetic factors (Fejerskov & Kidd 2003, Selwitz et al. 2007). Poor oral hygiene and poor dietary habits also include in dental caries risk factors, as do lifestyle and behavioural factors (Fejerskov & Kidd 2003).

2.4. Diabetes mellitus

Diabetes is a chronic disease which occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. This leads to an increased concentration of glucose in the blood (hyperglycemia) (WHO 2010). The current ADA and WHO classifications of diabetes are based on the etiology and pathogenesis of diabetes mellitus. Type 2 diabetes is the most prevalent form of diabetes mellitus with 90–95% of total cases, and it is characterized by insulin resistance and relative insulin deficiency (ADA 2007). In type 1 diabetes, which accounts for 5–10% of those with diabetes, hyperglycemia results from an absolute deficiency of insulin caused by the destruction of insulin-secreting pancreatic cells (ADA 2007, WHO 2006). Also other types of diabetes are recognized, such as gestational diabetes, diabetes induced by genetic syndromes or special diseases, and drugs.

Diabetes requires lifelong management to reduce the high morbidity and premature mortality caused by its associated complications. These complications can be reduced, if not completely prevented, with optimal glycemic control (Tan et al. 2006). At present, at least 285 million people have some type of diabetes worldwide (IDF 2010). As a result of increased urbanization, high rates of obesity and stress, combined with too little of physical exercise, each year another 7 million people develop diabetes. By the year 2025 the largest increases in diabetes prevalence is estimated to take place in countries with emerging economies, and particularly on adults of working age (Bennett 2007).

2.4.1. Prevalence of diabetes in Iran

The prevalence of all types of diabetes and of impaired glucose tolerance (IGT) in Tehran among adults above 30 years of age is 7.2% and 7.3%, respectively (Delavari et al. 2004). Owing to population shifts from rural areas to big cities, and – at the
same time – changes in life style in general, it can be estimated that the number of subjects with diabetes is rapidly increasing. The prevalence of diabetes in urban areas in Iran is twice as high as in rural areas (Delavari et al. 2004). In a WHO forecast (King et al. 1998), the prevalence of diabetes mellitus in Iran was estimated to be 5.5% in 1995, 5.7% in 2000, and 6.8% in 2025. This means 1.6, 1.9, and 5.1 million affected Iranians, respectively (King et al. 1998). Screening programmes conducted in different parts of Iran have revealed a large proportion (50%) of undiagnosed diabetes (Larijani et al. 2003, Esteghamati et al. 2008); this high percentage of undiagnosed diabetes could be a particular challenge to the Iranian health care system in coming decades.

2.4.2. Diabetes and chronic periodontitis
An association between diabetes and chronic periodontitis has been well documented (Grossi 2001, Taylor 2001, Jansson et al. 2006, Lalla 2007). Several studies have provided evidence that the prevalence, extent, severity and progression of chronic periodontitis are increased in patients with diabetes mellitus (Bacic et al. 1988, Page & Beck 1997, Guneri et al. 2004, Mealey & Oates 2006, Silvestre et al. 2009). On the other hand, prospective studies have shown that periodontal infection in patients with diabetes may be associated with poorer diabetic metabolic control and an increased number of chronic diabetic complications (Thorstensson et al. 1996, Taylor & Borgnakke 2008). Both type 1 and type 2 diabetes increase the probability of developing chronic periodontitis (Page & Beck 1997, Salvi et al. 1997). Wang et al. (2009) reported that the risk for periodontitis increases approximately 2- to 4-fold when diabetes is present.

In diabetes the inflammatory processes are suggested to be affected by advanced glycated end products resulting in an increase in the production of pro-inflammatory mediators. The level of pro-inflammatory mediators seems to have a direct effect on the magnitude of periodontal tissue destruction (Nassar et al. 2007.) Also Nishimura et al. (2007) conclude in their review article that exaggerated host responses are the main cause of subjects with diabetes developing severe periodontitis.

Acute infections and inflammatory conditions lead to an increase in glucose and insulin utilization, and therefore complicate the metabolic control of subjects with diabetes (Bell et al. 1999, Yalda et al. 1994). Grossi (2001) suggested that the chronic periodontal infection increases the severity of diabetes and complicates diabetes control. Accordingly, control of periodontal inflammation has the potential to affect glucose metabolism in individuals with poor metabolic control, especially when concomitant antibiotics are used (Miller et al. 1992, Grossi et al. 1997). On the other hand, there is evidence that where systemic adjunctive antibiotics have not been used, little positive effect of periodontal treatment on metabolic control has been observed (Seppälä & Ainamo 1994, Aldridge et al. 1995, Westfelt et al. 1996, Christgau et al. 1998).

2.4.3. Diabetes and caries
While chronic periodontitis is one of the major oral health problems encountered in patients with diabetes (Bacic et al. 1988, Page & Beck 1997, Guneri et al. 2004), reports of an increased risk for dental caries among subjects with diabetes are controversial. Several studies have reported a higher prevalence of caries for subjects with diabetes, particularly for those with poorly-controlled disease (Jones et al. 1992, Karjalainen et al. 1997, Twetman et al. 2002, Miralles et al. 2006). Some studies
report that patients with diabetes tend to have more fillings and caries (Albrecht et al. 1988, Kirk & Kinirons 1991), whereas other studies have verified that no differences in caries levels (Tenovuo et al. 1986, Bacic et al. 1989, Falk et al. 1989, Pohjamo et al. 1991) or in the occurrence of root caries (Tavares et al. 1991) exist between patients with diabetes and subjects without diabetes. Positive correlations between caries and poor metabolic control were found by Karjalainen et al. (1997) but not by Lin et al. (1999).

Similar counts and distribution of Streptococcus mutans in subjects with diabetes and healthy controls have been found. The authors hypothesized that the dietary treatment of subjects with diabetes may reduce the number of lactobacilli in saliva without affecting S. mutans (Tenovuo et al. 1986, Twetman et al. 1989, Swanljung et al. 1992, Collin et al. 1998).

The health of the oral tissues is known to be related to saliva, and both the composition and flow of saliva may be altered in patients with diabetes (Sharon et al. 1985). In subjects with diabetes the main causes of the higher or lower susceptibility to caries are generally sought in salivary changes. Tenovuo et al. (1986) reported that the saliva of subjects with diabetes contains larger quantities of glucose owing to leakage of glucose from the blood to the oral cavity. Moreover, Närhi et al. (1996) have shown how saliva flow rates and pH are decreased in subjects with diabetes.

2.5. Common risk factors strategy for prevention of chronic periodontitis and caries

The selection of oral health promotion and disease prevention strategies can be based on the common risk approach (Sheiham & Watt 2000). According to the common risk approach, controlling a small number of risk factors (especially those that may have a major impact on a large number of diseases) promotes general health at a lower cost and with greater efficacy and effectiveness than a disease-specific approach (Sheiham & Watt 2003). Oral health is not only related to good oral hygiene, but also to socio-environmental determinants and lifestyle factors, which are risks for most chronic diseases (Sheiham & Watt 2000).

Periodontal disease contributes significantly to the burden of oral disease, which qualifies it as a dental public health problem (Sheiham 1991, Petersen & Ogawa 2005). In addition to poor oral hygiene, the important risk factors for severe periodontal disease relate to tobacco use, malnutrition, excessive alcohol consumption, stress, diabetes mellitus and certain other systemic-disease conditions (Genco 1996, Tezal et al. 2001, Sandberg et al. 2001, Pitiphat et al. 2003). Since periodontal disease has risk factors in common with a number of other non-communicable diseases, effective prevention of periodontal disease requires setting the focus more intensively on the common behavioural and environmental risk factors (Petersen & Ogawa 2005). The link between periodontal disease and diabetes mellitus is most consistent among the associations observed between oral health status and chronic systemic diseases (Grossi & Genco 1998, Soskolne & Klinger 2001).

Based on the common risk factors approach, periodontal health may be improved along with a better control of a chronic disease, such as diabetes mellitus, and intervention in relation to unhealthy habits and lifestyle (Petersen & Ogawa 2005). The WHO gives priority to the rising impact of diabetes mellitus in the world, especially in countries with emerging economies, through support to national diabetes control programmes. Oral health promotion has initiated several activities that may help national health authorities integrate oral health into general health programmes and diabetes prevention (Petersen & Ogawa 2005).
In spite of the fact that inflammatory periodontal diseases are largely preventable (Sheiham & Watt 2003), the high prevalence of these diseases indicates that both dental practitioners and patients need a better understanding of how to achieve and maintain the state of health. The three key elements of primary prevention of periodontal disease are (i) educational interventions on periodontal disease and related risk factors, (ii) regular self-performed plaque removal, and (iii) professional mechanical removal of plaque and calculus (Weijden & Slot 2011).

Since the two most prevalent oral diseases – dental caries and periodontal disease – share the major factors influencing their development and course, oral health promotion should concentrate on oral hygiene, sugar consumption, use of fluoride and dental services, and promotion of oral health at all levels (individual, community, national and global) (Schou 1993). Sheiham (1995) also included smoking cessation and prevention of tooth trauma to oral health promotion policies.

Tobacco has harmful effects on general and oral health (Reibel 2003), and tobacco use is currently considered to be a major public health problem that contributes significantly to the global oral disease burden (Petersen 2003b). According to WHO's common risk factors approach, smoking and alcohol consumption should be catered for when designing community oral health promotion programmes (Morita et al. 2006, Petersen 2003b, Jané-Salas et al. 2003).

2.5.1. Recommended oral self-care
Long-term clinical studies have clearly demonstrated that regular and effective removal of bacterial plaque from teeth can prevent periodontitis (Axelsson & Lindhe 1981). Effective removal requires excellent oral hygiene, including interproximal cleaning and periodic professionally administered plaque removal (Axelsson et al. 2004, Watt & Marinho 2005). The agreement statement on oral hygiene of the Federation Dental International (FDI) second world conference on oral health promotion in 1999 recommended tooth cleaning twice-daily, professional mechanical tooth cleaning at time intervals tailored to the patients’ need, effective interdental cleaning, and use of antimicrobial agents to augment oral hygiene (Löe 2000). The overall benefit of twice-daily cleaning is derived from the summary benefit of mechanical plaque removal as well as the adjunctive chemical benefit derived from using toothpaste containing fluoride (Addy et al. 1990), combined with the removal of interdental plaque once every 24 hours (Axelsson 1993, Claydon 2008).

As concluded by Claydon (2008) there are no scientific studies to indicate that one specific manual toothbrush design is superior to another in the maintenance of gingival health. It is certain that for a motivated, well-instructed person with the time and skill, mechanical plaque-control measures are sufficient to attain complete dental health, and gingivitis can be prevented by twice-daily tooth brushing (Claydon 2008). The majority of studies have presented a positive significant difference in the plaque index when using the interdental brush compared with floss. Berchier et al. (2008) concluded that a routine instruction to use floss is not supported by scientific evidence. As an adjunct to brushing, the interdental brush removes more dental plaque than brushing alone, and using interdental brush showed a positive significant difference with respect to the plaque scores, bleeding scores and probing pocket depth (Slot et al. 2008).

2.5.2. Promotion of oral health among adults with diabetes
Dental professionals generally agree that tooth brushing as a mechanical measure for removing dental plaque is the most appropriate and effective oral hygiene habit (Löe
The majority of oral health promotion studies, as reviewed by Watt & Marinho (2005), have reported a reduction in plaque and gingival bleeding. In promoting oral health behaviour, essential factors are to motivate the patient to strive for optimal oral care (Inglehart & Tedesco 1995) and to prevent periodontal relapse and disease progression (Löe 2000).

To motivate people successfully, not only is it necessary to provide them with information but also one must pay attention to issues which might restrict oral health behaviour (Syrjälä et al. 1992). Furthermore, the level of knowledge of oral health among subjects with diabetes has been shown to be relatively low when compared to subjects without diabetes (Sandberg et al. 2001). Regarding health behaviour in general and in particular periodontal disease, patient’s knowledge plays a significant role in disease management. Individuals with diabetes may be unaware of their increased risk for periodontal disease (Moore et al. 2000, Sandberg et al. 2001), and providing them with information is a fundamental factor in improving periodontal health. Particularly in periodontics it is important for the patients to know the nature of the disease as well as the methods for its prevention and treatment. This information is based on the principal and basic cause of most of periodontal diseases, plaque, and the patient’s role in removing it. Consequently, to an individual with diabetes, the significance of good oral health should be emphasized like any other aspect of diabetic complications (Kneckt et al. 2000, Karikoski et al. 2003).

2.6. Theoretical framework of the study

The theoretical framework for the present study was based on the ICS II model (Chen et al. 1997). This framework shows that an individual’s health behaviours, as an outcome, are affected by predisposing and enabling characteristics. This model also states that predisposing, enabling factors and health behaviours have effects on periodontal health.

![Theoretical framework of the study](image-url)
The framework explains the association between diabetes and periodontal health (Figure 2.1). Based on this framework, oral health education may affect health behaviours of adults with diabetes, which will reduce periodontal treatment needs.

2.7. Population demography of Iran
The population of Iran has grown rapidly and tripled during the past 50 years, being more than 68 million in 2002. Tehran province has a population that exceeds 15% of the total population of Iran. The tendency to emigrate from rural areas to big cities is high; the percentage of urban residents has increased from 61% in 1996 to 67% in 2005 (Statistical Centre of Iran 2008).

2.8. Organization and use of oral health care services in Iran
In Iran, the Ministry of Health and Medical Education is responsible for the provision of primary oral care services for all inhabitants of the country. After the establishment of a comprehensive primary health care system throughout Iran in 1983 (Nasseri et al. 1991), oral health has been considered an important aspect of general health by the Ministry of Health and Medical Education. In 1997, oral health services were integrated into the primary health care system (Pakshir 2004). These services are delivered at Public Dental Clinics. The oral health care system comprises both the governmental sector and the private sector. The majority (80%) of dentists work in the private sector (Pakshir 2004) and, thus, the main provider of oral health care services is the private sector. The Ministry of Health and Medical Education, responsible for the governmental sector, is in charge of primary oral health care services in villages and cities. The number of public dental clinics in 2004 was 1548 in rural areas, 1362 in urban areas and 98 in Tehran (MHME 2004). In the private sector, more than 20,000 dentists provide general and specialized dental services in cities. A dentist: population ratio of 1:5500 has been reported for the whole country (Bayat et al. 2006).

2.9. Diabetes prevention and care in Iran
The national programme for the prevention and control of diabetes was adapted to fit the current health care system since 1999 (Azizi 2005). The aim of this programme is primary, secondary and tertiary prevention, through community and high-risk screening and the integration of diabetes care into the primary health care network. Government services, health insurance and private sector are involved in the provision of health. The private health sector has an important role in the delivery of health care services, particularly in the urban areas.

The public health care system includes the district, provincial and national level. In the district health care network some 22000 health workers in 15000 health houses located in villages provide care for about 20 million people (Azizi 2005). The rural health centres (n=2243) supervise the health houses in their village and in a number of other health houses in the neighbouring villages (Azizi et al. 2003).
3. AIMS OF THE STUDY

3.1. General aim
The general aim of the present study was:
- To explore risk factors for periodontal diseases and dental caries among adults with diabetes.
- To assess the effects of an educational intervention on periodontal treatment needs.

3.2. Specific objectives
To achieve the general aim, the following specific objectives were set:
- To investigate the association of diabetes-related factors with periodontal treatment needs (I).
- To explore the association of diabetes-related factors with dental status (II).
- To investigate oral health behaviour and smoking habits among adults with diabetes (III).
- To investigate changes in periodontal treatment needs among adults with diabetes after an intervention on oral health promotion (I, IV).

3.3. Hypotheses
Working hypotheses of the study were:
- Periodontal treatment needs and dental status are related to diabetes-related factors and oral self-care.
- Oral health behaviour has an effect on diabetic control.
- An educational intervention leads to a reduction of periodontal treatment needs.
4. SUBJECTS AND METHODS

The present study is part of a joint programme between the University of Helsinki, Finland, and the Shaheed Beheshti Medical University, Iran, initiated by WHO (EMRO) in 2002.

4.1. General description of the study
The present study used cross-sectional and interventional designs. The target population comprised adults with diabetes in Tehran, Iran. The study subjects of this cross-sectional and prospective investigation comprised 299 dentate patients with diabetes who were regular attendants to a diabetic clinic in Tehran, Iran. Data collection in the cross-sectional part was performed by clinical examination and a self-administered questionnaire. Periodontal treatment needs were measured by means of the Community Periodontal Index (CPI, WHO 1984) and the oral hygiene level by Plaque Index (PI, Silness & Löe 1964). Dental health status was described by Decayed, Missing, and Filled Teeth (DMFT, WHO1997). The questionnaire covered information on each subject’s social background, medical history, oral health behaviour and smoking. The intervention was directed towards adults with diabetes by offering them dental health education through a booklet and education by a dental hygienist designed for the present study. In the intervention study reduction in CPI and PI one year after the baseline examination demonstrated the outcome.

4.2. Pilot study
The feasibility of the study design was tested by conducting a pilot study before data collection. The pilot study was carried out in a private office by means of questionnaire (n=40) and a clinical examination (n=10) for subjects with diabetes in February 2005. Results from this pilot study highlighted the need for minor revisions in phrasing of the questionnaire. For some questions, the response alternatives were expanded to comprise more possible options.

4.3. Cross-sectional study
4.3.1. Study subjects
The survey was conducted during a two-month period (May–July) in 2005 in a diabetic clinic in Tehran. This clinic is associated with the Iranian Diabetic Association and has the responsibility for 6000 patients serving on the average 30 patients daily. The study group was selected from a daily roster of patients, in a consecutive manner, to include about 300 subjects who were currently attending the clinic and who had volunteered to participate in the survey. Criteria for inclusion were being at least 25 years of age and having at least one tooth. The subjects were called by telephone and invited to a dental clinic near the diabetic clinic. Twenty-two patients did not agree to participate in this study, and another 50 who had agreed to participate did not attend the dental appointment. Recruitment of study subjects was continued until a study group of 299 subjects was attained. The most frequently mentioned reasons for missing the appointment were forgetting the date and lack of time. The mean age of the study population was 49 years (SD 7.6, range 25–69), and the mean duration of diabetes (including all types of diabetes) was 9.6 years (SD 6.6, range 1–44 years).
4.3.2. Study questionnaire
A self-administered questionnaire was distributed to the patients during their dental appointment. Illiterate subjects (n=15) were interviewed by a secretary who assisted them in filling in the questionnaire. Questions were mostly multiple choices with alternative statements. Grouped into four categories, the questions covered 1) subject’s background, 2) medical history, 3) oral self-care and smoking, and 4) utilisation of dental services.

Background information: Background information consisted of gender, birthday and education attained. The age was categorized for analysis into three: age being under 45, 45 to 54, and 55 or over. Information regarding level of education was requested on a 6-point scale ranging from illiterate to doctoral degree. For data analysis, the subjects were allocated into three groups according to their level of education. A university degree represented a high level and high school diploma a medium level of education. All the others were determined to have a low level of education.

Medical history: Information concerning the medical history of the study subjects was acquired with the help of a questionnaire which covered the year of onset of diabetes and occurrence of complications related to diabetes, such as nephropathy, neuropathy, retinopathy, cardiovascular disease, and numbness in the feet. For data analysis, the variables were categorized as presence or absence of complications related to diabetes, and the duration of disease as less than 7 years, 7 to 12 years, and 13 years or over.

Information about type of diabetes and latest glycosylated haemoglobin level (HbA1c) were obtained from patients’ records from the diabetic clinic. Diabetes was categorized as type 1 or type 2 according to the patients’ records, and those who had some other type (n=11) were excluded when the type of diabetes was examined as an independent variable. Diabetic control level was determined to be good if the HbA1c value was less than 7.6%, moderate between 7.6%, and 8.5%, and above 8.5% as poor.

Oral self-care and smoking: Oral self-care was assessed by three questions on frequency of tooth brushing and interdental cleaning, and type of interdental cleaning device. Tooth brushing was determined with the question ‘How often do you brush your teeth?’ with four alternative answers: ‘occasionally’, ‘once daily’, ‘more often than once daily’, or ‘never’. For analysis the answers were categorized in to three categories: at least twice a day, once a day, and less than once a day.

For interdental cleaning, four alternatives were available: dental floss, toothpick, interdental brush, and nothing. The four alternatives given for the question ‘How often do you clean the spaces between your teeth?’ were ‘almost every day’, ‘once daily’, ‘weekly’, or ‘never’. For analysis the answers were dichotomised in two groups according to daily or less than daily interdental cleaning.

Smoking status was dichotomised as smoking (originally the alternatives were regular and occasional smoking) and not smoking (originally the alternatives were quitted smoking and never smoking).

Utilisation of dental services: Utilization of dental services was covered by four questions. As to the time of the latest dental visit, the question was ‘When was your most recent dental visit?’, and it offered five alternatives: ‘less than 1 year ago’, ‘1–2 years ago’, ‘3–5 years ago’, ‘more than 5 years ago’, and ‘I do not remember’. For further analysis the responses were dichotomized to ‘Within 12 months’ and ‘More than 12 months ago’. The reason for the latest dental visit was determined with the following question: ‘What was the main reason for your most recent dental visit?’
The answer alternatives were: ‘Pain or emergency treatment’, ‘Dental check-up’, ‘Preparing or fixing a denture’, ‘Extraction of a tooth’, ‘Other reason’, and ‘I do not remember’. For analysis the subjects were dichotomised into two groups according to reporting a dental check-up or as the reason or not. Reasons for not having visited a dentist within the previous two years were determined with following multiple choice questions: ‘In case you have had no dental visit during the last two years, what is the reason?’ The answer alternatives were: ‘Dental care is unpleasant’, ‘Dental care is too expensive’, ‘I have had no problems’, ‘Due to my work it is difficult to fix an appointment’, ‘I did not know I need a dental check-up’, and ‘Other reason’. Whether the subject had a physician’s referral for dental care or not was determined with the following question: ‘Have you ever received a physician’s referral for dental care?’ with three alternatives: ‘Yes’, ‘No’, and ‘I do not know’. For further analysis the answers were dichotomised to ‘Yes’ and ‘No’, the latter representing other answers than ‘Yes’.

4.3.3. Clinical dental examination
The dental examination was carried out by one examiner in a dental clinic. The presence of teeth, extracted teeth, sound teeth, teeth with caries, and teeth with fillings were recorded tooth by tooth according to WHO criteria for the definition of DMFT, DT, MT, and FT indices (WHO 1997). The presence of dental plaque on four surfaces of the six index teeth (upper right first molar, upper right central incisor, upper left first molar, lower left first molar, lower left central incisor and lower right first molar) was recorded by tooth according to its highest PI score (Silness & Löe 1964). A subject’s oral cleanliness was described as the sum of the six tooth-based PI scores. The number of teeth was recorded for each subject according to the WHO criteria. Periodontal treatment needs were assessed by use of the Community Periodontal Index (CPI, WHO 1984). An individual CPI was made for each sextant containing at least two functional teeth, excluding third molars, according to the highest CPI score.

4.4. Intervention study
After the baseline examination the cohort of adults with diabetes constituting the study subjects of this study was randomly divided into three groups: two intervention groups and one control group (Figure 4.1). At baseline, there were no differences between the study groups by subjects’ background (gender, age and level of education), diabetes-related factors (type, duration and metabolic control of diabetes) and oral self-care (frequencies of tooth brushing and interdental cleaning, and dental attendance during the previous year).

In order to reduce the possibility of bias, the study was designed as an examiner-blinded trial. The examiner was kept strictly unaware of the allocation of the subjects to the different groups. In another room of the clinic, a trained dental hygienist randomly allocated the subjects to three groups: an active, passive, and control group. The randomization was accomplished by random selection of the starting group and with a subsequent three-day rotation in the assignment to the groups. The whole process of the intervention was administered by the same trained dental hygienist. At follow-up, before the dental examination, a self-administered questionnaire on oral health behaviour was handed to the subjects in the waiting room.
At the time of follow-up, which was one year after the collection of base-line data and implementation of the interventions, one participant had died, 18 had moved, one had received full dentures, one was pregnant, 6 were in-patient, 5 refused to participate, and 85 did not attend their appointments even after three invitations by telephone. Thus, out of the 299 subjects invited, 182 (61%) participated in this part of the study. No statistically significant differences were observable between the participants in the study programme and the drop-outs according to their characteristics and CPI scores, as well as PI sum (mean=7.6, SD=2.2 vs. mean=7.4, SD=2.3; p=0.512). At baseline there was no difference in the mean number of teeth between those who completed the oral health intervention programme and the dropout subjects (23.13 vs. 22.91, p=0.675).

During the baseline and follow-up examinations, the examiner informed the patients of their periodontal status. Those who required periodontal treatment (having a CPI≥ 2) were referred to the Shaheed Beheshti Dental School clinic. At baseline, all study subjects were informed of another examination to be performed one year later. No statistically significant differences were found between the study groups in CPI scores (p=0.31) and PI scores (p=0.19) at the baseline examination, and no differences were observed in the mean number of teeth at either the baseline examination (p=0.99) or at the follow-up examination (p=0.93) in all study groups of those subjects who completed the oral health intervention programme.

**Figure 4.1.** The outline of the one year intervention study on oral health of adults with diabetes.
4.4.1. Intervention design

Intervention groups were divided into active intervention group and passive intervention group. In the active intervention group, the intervention was both informational and educational. The information was given by means of an eight-page booklet on periodontal disease and its relation to diabetes, are created for the present purpose. The booklet covered the following topics of periodontal health in relation to diabetes: the definition of periodontal disease, dental plaque and periodontal pockets; the symptoms and aetiology of periodontal disease; the relation between diabetes and periodontal disease; the effect of smoking on periodontal health, the prevention of periodontal disease, and the importance of regular dental visits and oral self-care. Simple language and colored illustrations were used to catch the readers’ attention. In addition to the booklet, a trained dental hygienist explained the content of the booklet with the help of larger pictures, focusing on periodontal disease, tooth structure, food debris, plaque formation, and periodontal pockets. For this group, the dental hygienist also gave a custom-selected interdental brush, and with the help of a model, instructions for its proper use. No particular method of manual tooth brushing was advised. However, the necessity of thorough twice-daily brushing of all surfaces of the teeth was emphasised to obtain a sufficient degree of cleanliness.

In the passive intervention group, the intervention was informational only. The above-mentioned booklet was distributed to all in this group.

The control group received neither information on oral health promotion, nor instructions at the baseline examination. After the follow-up examination, these subjects also received the same booklet. Toothbrushes and toothpastes were distributed among the three study groups in appreciation of their participation both at the baseline and at the follow-up dental examination.

4.4.2. Analysis of the intervention

No differences were observed between the participants and drop-out according to their characteristics, CPI scores, sum of PI and mean number of teeth. Thus, only subjects who participated in the follow-up examination were included in the analysis of the intervention. Similarly, each unavailable sextant at the follow-up was excluded from the analysis. The outcomes of the intervention study were the mean change in the subjects’ maximum CPI scores and the mean change in the sum of plaque scores. Further, a positive outcome per subject was defined as improvement in CPI scores in at least 50% of sextants. The outcomes regarding oral health behaviour were defined as change in proportion of subjects reporting twice daily tooth brushing, daily interdental cleaning and dental visit within one year.

4.5. Ethical considerations

The present study was approved by Ethics Committee of the School of Dentistry, Shaheed Beheshti University of Medical Sciences. Participation was voluntary, and an informed consent was acquired from all subjects before the study. The subjects were entered into the database with a numerical code only.

4.6. Statistical methods

Data were analysed using the statistical software SPSS, Windows version 13.5. Statistical analyses were performed using t-test, variance analysis (ANOVA) and with Chi-square test for frequencies. Logistic regression models were fitted to the data, and corresponding odds ratios (OR) and their 95% confidence intervals (95% CI) were calculated. Goodness of fit was assessed by means of the Hosmer and Lemeshow test.
5. RESULTS

5.1. Periodontal health indicators (I)
The general periodontal health of the study subjects was poor; none of the subjects had a healthy periodontium, 52% had shallow periodontal pockets (CPI=3), and 35% had deep periodontal pockets (CPI=4). No statistically significant gender-difference was observed. Figure 5.1 shows the distribution of sextant-based CPI scores according to the study subjects’ backgrounds and diabetes-related factors.

![Figure 5.1. Distribution (%) of CPI scores by sextant according to subjects’ gender, age, level of education and diabetes-related factors (n=299), CPI = X stands for missing sextant.](image)

All subjects had dental plaque and 66% had plaque on all six index teeth. Highest score of PI (PI=2) was more prevalent among women than men (91% vs. 82%, p=0.03). The sum of PI scores ranged from 1 to 12; the mean was 7.6 (SD 2.3) with no statistically significant gender-difference. Deepened periodontal pockets (CPI≥ 3) occurred more frequently among those having score 2 as their highest PI score when compared to those having score 1 as their highest PI score (89% vs. 71%, p=0.003).

In order to study the relation between the presence of deepened periodontal pockets and the subject’s socio-demographic background, dental findings, and diabetes-related factors, similar logistic regression models were fitted to the data to explain separately the conditions of CPI=4 and CPI≥ 3. In both models (I), the summed plaque scores increased the likelihood for the presence of deepened periodontal pockets (OR=1.2; 95% CI=1.1–1.5 and OR=1.3; 95% CI=1.1–1.6) when controlling for all other factors in the model. Diabetes-related factors were not statistically significantly associated with the presence of deepened pockets, except for HbA1c which showed a negative association with CPI≥ 3 (OR=0.7; 95% CI=0.6–0.9).
5.2. Dental status (II)
Of all subjects (n=299), 82 % had 20 teeth or more with no statistically significant gender-difference. The subjects averaged 23.1 teeth (SD=4.4, range 6–28), of which 15.1 (SD=6.1) were sound. Figure 5.2 shows the mean values for dental health indicators by gender, age, level of education, and diabetes-related factors. The mean of the DMFT index was 12.9 (SD=6.1), being dominated by filled teeth (FT=6.5; SD=4.4) and missing teeth (MT=5.0, SD=4.3). Mean MT was greater for those with poor diabetic control (HbA1c>8.5) than for those with a low (HbA1c<7.6) or moderate (HbA1c=7.6–8.5) level of diabetic control (6.00 vs. 4.88 and 4.06, p=0.042). Patients with diabetes-related complications had more DT (1.8 vs. 1.3, p=0.059) and MT (5.5 vs. 4.5, p=0.059), and fewer FT (5.7 vs. 7.1, p=0.005) than those without diabetes-related complications.

![Figure 5.2. Mean numbers of teeth according to dental findings of adults with diabetes by gender, age, level of education and diabetes-related factors (n=299).](image)

Untreated caries (DT>0) occurred in 58% of study subjects, with no gender-difference. Figure 5.3 shows the corresponding figures by subjects’ background and diabetes-related factors, separately for men and women. Longer duration of diabetes and poor diabetic control (HbA1c > 8.5) were associated with greater prevalence of untreated caries among men, but not women.
Figure 5.3. Subjects (%) having caries (DT>0) according to their background and diabetes-related factors, separately for men (n=82) and women (n=217).

In order to study the association between the presence of untreated caries (DT>0) and subject’s background and diabetes-related factors separately among women and men, logistic regression models were fitted. Men with poor diabetic control were more likely to have untreated caries than men with good diabetic control (OR=1.4; 95% CI=1.0–2.2). In addition, their older age indicated a slightly elevated caries risk (OR=1.1; 95% CI=1.0–1.2). For women, none of the factors included in the model explained their having untreated caries (DT>0).

5.2. Oral health behaviour among adults with diabetes (III)

5.2.1. Tooth brushing
Of all the subjects 29% reported brushing their teeth on a twice-daily basis, 54% once daily, and 17% less frequently; twice-daily tooth brushing was more common among women than men (32% vs. 21%, p=0.05).

Reported smoking was rare (9%). The smokers reported tooth brushing on a twice-daily basis more frequently than did the non-smokers (50% vs. 27%, p=0.01).

In the oldest age group, those with no diabetes-related complications reported twice-daily tooth brushing more frequently than did their counterparts with complications (46% vs. 13%, p=0.001).

To show the impact of various factors on reporting twice-daily tooth brushing, a logistic regression model was fitted to the data. Smokers (OR=2.9; 95% CI=1.2–7.0) and women (OR=2.1; 95% CI=1.1–4.1) were more likely to report twice-daily tooth
5.2.2. Interdental cleaning
Of all subjects, 35% reported interdental cleaning at least once daily. When analyzed according to diabetes-related factors, those with no diabetes-related complications showed a higher rate of daily interdental cleaning than those with diabetes-related complications (41% vs. 28%, p=0.02). The most common device for interdental cleaning was a toothpick (36%), followed by dental floss (22%), and interdental brush (6%); 25% of the subjects reported no interdental cleaning, and 11% used a combination of several interdental cleaning devices.

5.2.3. Utilization of dental services
Of all the study subjects, 47% reported a dental visit within the past 12 months, and 27% one to two years previously, with no statistically significant gender-difference. The prevailing reason for the most recent dental visit was pain and emergency (24%), followed by need for tooth extraction (20%) and a regular dental check-up (14%). Reporting a check-up as the reason for a recent dental visit was more prevalent among those who had visited a dentist within the past 12 months than among those who hadn’t visited a dentist (21% vs. 8%, p=0.002).

Twelve per cent of subjects had received a physician’s referral for dental care. They reported having visited a dentist during the past 12 months more frequently than did those without a physician’s referral (74% vs. 43%, p=0.001).

In the analysis based on diabetic control the lowest rates in having had a dental visit within 12 months were among subjects with poor diabetic control and suffering complications related to diabetes (18%), or with a low level of education (27%). When analysed according to diabetes-related complications, a dental visit during the past 12 months was more frequent among those without complications than those with complications (52% vs. 41%, p=0.05), in particular for women (53% vs. 39%, p=0.03). Highly educated subjects without complications tended most frequently to report a dental visit within the past 12 months (60% vs. 35%, p=0.06), whereas subjects with complications and poor diabetic control less often reported such a visit (18% vs. 49%, p=0.01). A logistic regression model revealed that subjects with a physician’s referral had more likely had a dental visit within the past 12 months (OR=4.4; 95% CI=1.9–10.2).

5.4. The effect of oral health promotion on periodontal treatment needs (IV)
In all study groups, a decrease in periodontal treatment needs from the baseline to the follow-up examination was found, with no statistically significant gender-difference (Figure 5.4), and when analysed according to the highest CPI scores (Figure 5.5). The mean reduction in the subjects’ maximum CPI score was 0.52 (SD 0.99) in the active intervention group and 0.44 (SD 0.83) in the passive intervention group, both of which showed a statistically significant improvement when compared to the control group (0.16, SD 0.78, p=0.01 and p=0.04, respectively). Figure 5.6 shows the changes in sum of CPI scores among the study groups.
Figure 5.4. Changes in periodontal findings (sum of CPI) among study groups separately for men (n=52) and women (n=130).

Figure 5.5. Distribution of the highest individual Community Periodontal Index (CPI) among the study groups at baseline and follow-up examination (n=182).
Figure 5.6. Percentages of subjects (n=182) with a decrease, no change, or increase in their periodontal treatment needs (as the sum of CPI scores), separately in each study group.

In comparison to the active group, where the mean change in sum of the CPI scores was 3.4 (SD 3.3), the control group showed less improvement (2.3, SD 3.2; p=0.07), and the passive intervention group showed significantly more improvement than did the control group (4.0, SD 3.4; p=0.004). Figure 5.7 shows plotting of individual sum of CPI scores at baseline and at follow-up separately for each study group. Dots falling on the diagonal represent no change from baseline to follow-up, dots above the diagonal indicate worsening from baseline to follow-up, and dots under the diagonal indicate improvement from baseline to follow-up.

The mean reduction in the sum of plaque scores (PI) was 1.3 (SD 2.6) for the active intervention group and 2.0 (SD 2.4) for the passive intervention group, changes which were statistically significant greater than for the control group (0.34, SD 2.2, p=0.03 and p=0.000, respectively). The changes in sum of plaque scores in the study groups are presented in Figure 5.8.

At baseline, self-reported twice-daily tooth brushing was as follows: 27% in the active intervention group, 24% in the passive intervention group, and 32% in the control group with no statistically significant differences (p=0.90). Minor changes occurred in twice-daily tooth brushing at the follow-up examination, the corresponding percentages being 38%, 30% and 30%, with no statistically significant differences between the groups (p=0.60).
Figure 5.7. Individual change in sum of CPITN scores of functional sextants between baseline (x-axis) and follow-up (y-axis) in separate groups of the study.

Figure 5.8. Percentages of subjects (n=182) with a decrease, no change, or increase in their level of oral hygiene (as the sum of PI scores), separately in each study group.
Of all the subjects, 65% reported having had a dental visit during the previous year. No statistically significant differences were found among the study groups according to the number of those who reported having had a dental visit during the study period (active intervention group 61%, passive intervention group 70%, control group 65%; p=0.55). As a reason for their dental visit, subjects in the active intervention group reported periodontal treatment more often (62%, p=0.02) than did those in the passive (48%) or control group (29%).

The mean HbA1c value was 7.4% (SD 1.8%) at baseline and 7.5% (SD 1.2%) at follow-up with no statistically significant differences between the study groups.

To show the impact of the factors related to the reduction of periodontal treatment needs in at least 50% of the sextants, separate logistic regression models were fitted to the data. The results of the logistic regression analysis showed that the passive intervention group was the strongest determinant for the reduction of CPI scores in at least half of the sextants (OR=3.4; 95% CI=1.4–8.5). The corresponding figures for the active intervention group were: OR=2.2 and 95% CI=0.9–5.7.
6. DISCUSSION

6.1. Methodological aspects of the study

6.1.1. Sampling method

Since periodontal disease is one of the major oral health problems encountered in patients with diabetes (Bacic et al. 1988, Page & Beck 1997, Guneri et al. 2004) the intervention part of this study was focused on periodontal treatment needs. Therefore, due to the natural history of chronic periodontitis, only individuals aged 25 years and older were included.

The target population of the present study comprised adults with diabetes in Tehran. In Iran, the private sector has an important role in delivering diabetic care, similar as it does in delivering other health services, particularly in the urban areas (Azizi 2005).

Because selection of representative groups of patients in a big city in Iran faces difficulties, the choice was a disease-based approach. An established clinic associated with the Iranian Diabetic Association and having a total number of 6000 patients allowed a geographical distribution of the subjects which facilitated the conduction of the study as well as the acquisition of the telephone contact information of the potent study subjects.

As reported by Esteghamati et al. (2008), in Iran female gender is associated with a higher prevalence of diabetes. Also, apparently women tend to attend their appointments at the diabetic clinic more regularly than do men, which resulted in a higher proportion of women in the study group.

Participation in this study was on a voluntary basis, which may have resulted in the participation of those who were more willing to change their health behaviour. They were willing to participate in a trial lasting as long as for one whole year and demanding their individual activity; it is questionable whether a similar reduction in periodontal treatment needs could be brought about in other patients with diabetes.

A cross-sectional study design has certain advantages (Levin 2006). It is relatively inexpensive and takes up little time to conduct. Also, it offers an estimate of the prevalence of outcome of interest because the sample is usually taken from the whole population. Several outcomes and risk factors can be assessed simultaneously, which makes the approach useful for public health planning, understanding disease aetiology, and for the generation of hypotheses. In addition, there is no loss to follow-up. Levin (2006) also points out some disadvantages of cross sectional studies: the difficulty to make a causal inference, the possibility of a different result if another time-frame had been chosen, and prevalence-incidence bias.

6.1.2. Clinical examination

The clinical examination and measurements in this study were performed by one examiner (SB), who was carefully trained and calibrated by two experienced specialists in periodontology and cariology. The study met an acceptable level of intra-examiner reliability; kappa values for determination of DMFT, CPI and PI were 0.9, 0.82 and 0.86, respectively. Examination of all study subjects by one examiner can be a limitation and lead to bias. In order to reduce the possibility of examiner-based bias, this study was designed as an examiner-blinded.

For increased validity and reliability, WHO standard criteria were used to record the data (WHO 1997). The examinations took place in a dental office with the use of a dental mirror and a WHO probe. For recording dental caries, the DMFT index was used, because it is a well-accepted measure of caries prevalence to describe
the actual caries experience within population studies (WHO 1997). Obvious limitations of the DMFT index are that it gives equal weights to missing teeth, teeth with untreated decay, and well-restored teeth. Caries experience can be overestimated if teeth have preventive restorations or have been lost for reasons other than caries (Benigeri et al. 1998).

Periodontal treatment needs were assessed by the Community Periodontal Index of Treatment Needs (CPITN; WHO 1984). CPI recording has been applied in several studies worldwide (Pilot & Barmes 1987, Schürch et al. 1988, Österberg et al. 1995, Bourgeois et al. 1997), since it has been widely recommended (WHO 1997, Petersen & Ogawa 2005) to increase international uniformity. The CPI is designed for rapid and practical assessment of various periodontal treatment needs in population surveys (Ainamo et al. 1982). The advantages of CPI include simplicity, speed and reproducibility (Pilot & Miyazaki 1994, Petersen & Ogawa 2005). Furthermore, the time needed to provide periodontal care can be estimated when using this index, which is the reference index for the WHO Global Oral Data Bank. Standard recordings do not include direct measures of tissue destruction, and this has been considered a limitation of CPI (Pilot & Barmes 1987, Baelum & Papapanou 1996). Recognized limitations of the CPI index include recording of values for index teeth only, and the hierarchy of scoring may not yield a resolution refined enough for all purposes (Pilot & Miyazaki 1994).

The presence of dental plaque was measured by means of the plaque index (PI) of Silness & Löe (1964). PI has been a reliable measure in earlier studies for assessing the outcome of mechanical anti-plaque procedures and for the level of oral hygiene in educational oral health interventions (Kay & Locker 1996).

6.1.3. Questionnaire
The questionnaire used in the present study included questions on the subjects’ oral health behaviour such as their self-reported frequency of tooth brushing and the time of and reason for their most recent dental visit, used earlier in similar context (Murtomaa et al. 1984 & 1997, Murtomaa & Metsäniitty 1994, Karikoski 2003). However, as in any questionnaire study, a tendency to give favourable responses, also referred to as social desirability (Sjöström & Holst 2002) may affect the respondents’ answers. Thus, respondents’ self-reported oral health behaviour may have been overestimated in the present study. Their answers to these questions provided no direct information about how effectively the respondents take care of their teeth, but nevertheless offer some indication of their motivation towards oral health.

For gathering the medical history of the study subjects in this study, patients’ records were used. Knowledge about the accuracy of this kind of information, is limited (Ehrenberg & Ehnfors 2001), especially in Iran where there are no electronic medical records. In order to cope with this problem, questions concerning the year of onset of diabetes and the occurrence of diabetes related complications were added to the questionnaire used in this study.

6.2. Results of the study
6.2.1. Periodontal health indicators and associated factors
Individual CPI≥3 score was more prevalent in the present study (82%) for 35- to 44-year-olds with diabetes when compared to the value of 52.7% published for the whole population in the Iranian Adults Oral Health survey (Pakshir 2004). This difference supports previous findings that subjects with diabetes are more susceptible to periodontal disease than are those without diabetes (Page & Beck 1997, Almas et al.
Asians are not only particularly susceptible to periodontitis (Corbet & Leung 2011), but approximately half of existing diabetes is in an Asian country (IDF 2010). On the other hand, the severity of periodontitis in this study population may indicate insufficient professional periodontal care. Lack of awareness of periodontal disease among patients with diabetes and insufficient accessibility of periodontal treatment may be other reasons for our patients’ poor periodontal health. This calls for greater emphasis on undergraduate periodontal training and up-to-date continuing education for dentists. For adults with diabetes, provision of information is a fundamental factor in improving their periodontal health.

In accordance with the findings of Bacic et al. (1988), this study showed no differences with regard to CPI scores between type I and type II patients with diabetes; furthermore found no relation between the duration of diabetes and severity of periodontal disease, which is similar to the findings of Awartani (2009). However, the occurrence of the value of CPI=3 was statistically significantly more prevalent and the number of missing teeth statistically significantly higher among those with a longer duration of diabetes. This may indicate that severely periodontally diseased teeth had been removed.

Diabetic complications are usually separated into micro- and macro vascular diseases (Fowler 2008). Hyperglycemia is essential for the development of diabetic micro vascular diseases. These complications could be totally prevented by good diabetic control which does not imply for macro vascular diseases, especially among those with type 2 diabetes (Fowler 2008). Periodontal disease associated with diabetes may be related to macro vascular complications of diabetes (King 2008), although poor diabetic control did not seem to have any detectable effect on periodontal disease severity in the present study setting.

Presence of dental plaque was a significant factor explaining the presence of deepened periodontal pockets. This is in contrast to findings by Karikoski et al. (2002a). The strength of the dental plaque sum index score in explaining the presence of periodontal disease in this study emphasizes the necessity of oral hygiene counselling in adults with diabetes. Poor oral hygiene among Iranian adults with diabetes indicates their insufficient oral self-care, and improvement in oral health behaviour among adults with diabetes is essential to compensate for their increased risk for oral diseases.

6.2.2. Dental status
In this study men with poor metabolic control of diabetes showed higher cumulative caries experience, which is in line with the findings by Siudikiene et al. (2006). Also, a longer duration of diabetes was associated with a higher cumulative caries experience, which is in accordance with the findings by Moore et al. (2001). Of those reporting twice-daily tooth brushing, men had a lower, but women a higher DMFT when compared to those reporting less frequent brushing.

Among the participants of this study, those with diabetes-related complications exhibited higher numbers of DT, which is in line with recent findings by Miralles et al. (2006). On the other hand, Harrison and Bowen (1987) and Bacic et al. (1989), found no association between diabetic complications and dental caries. Higher numbers of decayed teeth (DT) were found in subjects with a higher level of HbA1c, which is in line with the studies by Twetman et al. (1992, 2002, 2005), Karjalainen et al. (1997), and Miralles et al. (2006). Improvements in metabolic control may reduce salivary glucose, and thus, caries risk. On the other hand, Collin et
al. (1998) and Syrjälä et al. (2003) found no association between metabolic control of diabetes and dental caries.

Metabolic control of diabetes has been associated with the factors that contribute to the development of dental caries, such as reduced salivary flow, growth of oral yeasts, high count of mutans streptococci, and high count of lactobacilli (Karjalainen et al. 1996 & 1997, Twetman et al. 2002, Syrjälä et al. 2003). For patients with diabetes, possible increased caries susceptibility means that to prevent dental caries, they must adhere well to oral health recommendations in addition to those related to diabetes control.

6.2.3. Oral self-care, smoking and utilisation of dental services
Adopting healthy habits, including sufficient oral self-care (Löe 2000, Axelsson et al. 2002) and regular dental visits (Richards & Ameen 2002), is essential to control oral diseases. The prevention and treatment of oral diseases, as well as diabetes, requires persistent daily self-care (Kneckt et al. 1999). Common determinants both for dental health behaviour and for diabetes self-care have been identified; good self-care management positively influences compliance with diabetes treatment among subjects with type 1 diabetes (Kneckt et al. 2000). The interrelation between diabetes and periodontal inflammation suggests that routine preventive dental care (dental prophylaxis or cleaning) may be important in preventing complications of both diseases.

In this study, the rate of reported twice-daily tooth brushing was far below rates reported for the general population, for example in the UK (Kelly et al. 2000). Low rate of twice-daily tooth brushing among adults with diabetes is in accordance with Karikoski et al. (2002b), who found that the rate of twice-daily tooth brushing among adults with diabetes was considerably lower than that reported for the general population in Finland. This association between poor metabolic control of diabetes and low frequency of tooth brushing suggests that dental health education is important, especially in those with poor metabolic control (Syrjälä et al. 1999). There is a demanding challenge in Iran to reach the goal of twice-daily tooth brushing, since no more than 57% to 67% of dental educators, dental students and dentists themselves perform twice-daily tooth brushing (Khami et al. 2006, 2007; Ghasemi et al. 2007). Since prevention plays a primary role in hindering the development of periodontal disease among patients with diabetes, they may require more frequent plaque control and scaling than do subjects without diabetes (Galili et al. 1994).

Smokers in general, but smoking women in particular, reported more twice-daily tooth brushing than did non-smokers. Despite that they brush their teeth more often, smokers, and especially smokers with diabetes, are at an increased risk for severe periodontal disease (Jansson et al. 2006). Thus, adults with diabetes should be made aware of the health hazards of smoking, and encouraged to act accordingly.

Almost half of all subjects in this study reported having made a dental visit within the past 12 months; subjects with complications and poor diabetic control showed the lowest rates. Bayat et al. (2006) has reported that 52% of Tehranians made a dental visit within the past 12 months, the figure being high among women and those with a medium or high level of education. Reporting a dental visit in the past 12 months was more frequent among twice-daily brushers in the present study.

For subjects with diabetes, who are at high risk for periodontal diseases, the importance of regular dental visits is indisputable (Oliver & Tervonen 1993, Moore et al. 1999). Dental check-ups are commonly recommended as part of preventive health behaviour (Beirne et al. 2005, Mettes et al. 2006). In the present study, reporting a
dental check-up as a reason for the most recent dental visit was very rare. It has also been reported that fewer patients with diabetes than non-diabetic control subjects paid a regular visit to the dentist (Sandberg et al. 2001). Patients with diabetes missed more dental appointments (Pohjamo et al. 1995), and dentate adults with diabetes were less likely to have seen a dentist within the preceding 12 months than were those without diabetes (Tomar & Lester 2000). The reported low rate (16%) of the inhabitants of Tehran having visited a dentist for a check-up (Bayat et al. 2008) emphasizes the need to support preventive oral health behaviour by encouraging for regular check-ups, particularly among adults with diabetes.

A physician’s referral was a strong factor for having made a dental visit within past 12 months; this speaks for the importance of physicians’ awareness of good oral health. Among the subjects of this study, oral self-care and awareness of the importance of preventive care, including regular dental check-ups, seems to be insufficient to compensate the increased risk for periodontal diseases. Regarding the interrelation between diabetes and oral health, up-to-date continuing education for physicians, dentists and health care professionals, in particular regarding the importance of regular dental care for patients with diabetes, is required to better emphasize the interrelation of periodontal disease and diabetes. Thus, reliable and up-to-date information regarding perceptions of oral health behaviours among adults with diabetes is required to develop effective and useful prevention strategies. Improvement in the level of oral health behaviour among Iranian with diabetes is essential to compensate for their increased risk for oral diseases.

6.2.4. Intervention to reduce periodontal treatment needs
No statistically significant differences were found in the monitored background variables and clinical findings between the two intervention groups and the control group at baseline. The passive intervention group exhibited the greatest reduction in plaque index as well as the greatest reduction in periodontal treatment needs by means of CPI. The lowest number of drop-outs in the passive intervention group suggests that the subjects in this group may be even more concerned with their health than are the subjects in the other study groups.

The somewhat surprising result that the passive intervention was the most effective one could be explained with the theory of psychological reactance (Brehm’s theory) which explains why attempts to encourage patients to care for their health have a lesser effect (Woller et al. 2007). According to Brehm’s theory, messages perceived to reduce or to threaten personal freedoms arouse a motivational state known as reactance, which compels individuals to re-establish the lost or threatened freedom. This often produces anticonformity “boomerang effect”.

In the follow-up examination, reduction in periodontal treatment needs occurred also among the control group, which may, at least in part, be attributed to the trial effects. Exposing subjects with diabetes to a dentist’s examination and a questionnaire can have positive effects on their self-care (Baranowski et al. 2006) and oral health (Karikoski et al. 2003). Here, however, the significant reduction in plaque and periodontal treatment needs in the intervention groups speak for the true effect of the intervention.

This finding of low rates of recommended oral health behaviour at the baseline examination places even more emphasis on the necessity of an oral health promotion programme among adults with diabetes in Iran. Only minor changes in brushing frequency were observed after the intervention in this study. However, the change in the sum of PI could presumably be related to a change in brushing quality. These
findings emphasise the importance of better patient guidance in regard to qualitative aspects of oral hygiene at home. Oral health education activities focusing on oral self-care and key oral health educational messages, in particular periodontal health, should be established for adults with diabetes, giving special attention to those with poor diabetic control.

Frequent dental visits correlate with better periodontal health (Lang & Corbet 1995). In the present study the subjects (among the 35- to 44-year-olds) showed at baseline better dental status but worse periodontal health than found in the national data in Iran (Pakshir 2004, Hessari et al. 2007). This may indicate insufficient professional dental care received and might call for greater emphasis on undergraduate periodontal training and up-to-date continuing education.

One of the major criticisms of preventive measures and oral health education has been the narrow, isolated and compartmentalised approach adopted, thus conceptually separating the mouth from the rest of the body. An uncoordinated approach at best leads to duplication of effort, but in fact often results in conflicting and contradictory messages being delivered to the public (Watt 2005). Traditional oral health education using health professionals is relatively costly (Watt et al. 2001). It has been suggested that an integrated approach is likely to be more cost-effective than programmes targeting a single disease (Petersen 2003a). Karikoski et al. (2003) have established the positive effects of integrating oral health education with general health care services by promoting the periodontal health of adults with diabetes through a simple intervention by diabetic nurses.

The common risk approach recognises that chronic non-communicable diseases such as obesity, heart disease, stroke, cancer, diabetes, mental illness and oral disease share a set of common risk conditions and factors (Sheiham & Watt 2000). In diabetes care, the common risk factor approach can be implemented to promote oral health as well as control of the diabetic conditions. As recommended by the WHO, national health authorities should therefore ensure that the prevention of periodontal disease becomes an integral part of the prevention of diabetes and other chronic diseases, as well as of general health promotion (Petersen 2003a). The common risk approach provides a rationale for partnership work and is particularly applicable in countries with limited numbers of oral health personnel (Watt 2005), which has been taken into account in the national programme for the prevention and control of diabetes in Iran (Azizi 2005).
7. CONCLUSIONS

Extensive periodontal treatment needs and insufficient oral hygiene were observed in the studied group of Iranian adults with diabetes. Poor oral hygiene showed high impact on the presence of poor periodontal health.

Improvement in oral hygiene plays an efficient role in preventing and treating periodontal infections among patients with diabetes. In diabetes care, the common risk factors approach can be implemented to promote oral health as well as control of the diabetic condition.

This study demonstrated that an easy-to-organize and inexpensive educational intervention by means of a simple informational booklet can be effective in improving the periodontal health of adults with diabetes. In order to optimize general and dental health benefits, evidence-based oral health programme based on the common risk approach should be integrated into, rather than just added to, the diabetic care. As the model used in this study can also be executed by health care personnel other than oral health care professionals, it can be recommended especially for countries with a developing health care system.
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