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On temporomandibular disorders

Time trends, associated factors, treatment need and treatment outcome

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"Knowledge is justified true belief"

Plato

Abstract

During the last few decades, and especially during the 1990s, an increase in musculoskeletal pain conditions and stress-related ill-health has been observed in Sweden. At the same time, an improvement in the oral health of the population has been noted. The overall aim of this thesis was to acquire knowledge relating to possible time trends for the presence of temporomandibular disorders (TMD) in the population. A further objective was to study factors that possibly influence the presence of these disorders and the outcome of their treatment.

Studies I–III are based on a series of repeated cross-sectional population-based investigations. Three independent samples of 130 individuals in the age groups of 3, 5, 10, 15, 20, 30, 40, 50, 60 and 70 years were randomly selected from the inhabitants of the city of Jönköping, Sweden in 1983, 1993 and 2003. The total participation rate was 21%, 22% and 29% respectively. The participants were examined using a questionnaire, interview and a clinical examination of the stomatognathic system regarding the presence of symptoms and signs indicative of TMD. Study IV is a retrospective survey of a clinical sample of patients referred to and treated at the Department of Stomatognathic Physiology, The Institute for Postgraduate Dental Education, Jönköping, in 1995–2002.
The overall frequencies of symptoms and the rates for some clinical signs and consequently of an estimated treatment need in adults increased during the study period. In 2003, the prevalence of frequent headache in 20-year-olds, mainly females, had markedly increased. The reports of bruxism among adults increased from 1983 to 2003. Awareness of bruxism and self-perceived health impairment were associated with TMD symptoms and signs. A favourable treatment outcome was observed for the majority of patients with common TMD sub-diagnoses and no strong predictors of treatment outcome were found.

In conclusion, the results suggest some time trends towards an increased prevalence in the overall symptoms and some signs indicative of TMD in the Swedish adult population during the time period 1983–2003. A profound understanding of the social determinants of health is recommended when planning public health resources.

Original papers

The thesis is based on the following papers, which are referred to by their Roman numerals in the text:

Paper I

Anastassaki Köhler, A., Nydell Helkimo, A., Magnusson, T., Hugoson, A. Prevalence of symptoms and signs indicative of temporomandibular disorders in children and adolescents. A cross-sectional epidemiological investigation covering two decades. Eur Arch Paediatr Dent 2009;10Suppl 1:16-25.

Paper II

Anastassaki Köhler, A., Hugoson, A., Magnusson, T. Prevalence of symptoms indicative of temporomandibular disorders in adults: cross-sectional epidemiological investigations covering two decades. Acta Odontol Scand 2012;70:213-23.

Paper III

Anastassaki Köhler, A., Hugoson, A., Magnusson, T. Clinical signs indicative of temporomandibular disorders in adults: time trends and associated factors (accepted).

Paper IV

Anastassaki, A., Magnusson, T. Patients referred to a specialist clinic because of suspected temporomandibular disorders: a survey of 3194 patients in respect of diagnoses, treatments and treatment outcome. Acta Odontol Scand 2004;62:183-92.

Abbreviations

Ai	Anamnestic Index
CI	95% confidence interval
Di	Clinical Dysfunction Index
Di*	Modified Clinical Dysfunction Index used in the 1983 investigation
GBD	The Global Burden of Disease project conducted by WHO
ICD-9	International Classification of Diseases, 9th Revision
IMMPACT	Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials
MR	Multiple regression analysis
NSAID	Non-steroidal anti-inflammatory drugs
OA	Osteoarthrosis
OR	Odds ratio
RCT	Randomised clinical trial
RDC/TMD	Research Diagnostic Criteria for TMD
SPSS	Statistical Package for Social Sciences
TMD	Temporomandibular disorders
TMJ	Temporomandibular joint
TNest	Estimated treatment need
TNest*	Estimated treatment need in the 1983 investigation
UR	Univariate regression analysis
VAS	Visual analogue scale
WHO	World Health Organization

Contents

THEORETICAL AND HISTORICAL BACKGROUND

Temporomandibular disorders

The term "temporomandibular disorders (TMD)" represents a cluster of assorted pain and dysfunction conditions in the masticatory system. These conditions have been recognised since the 1930s and have been given various names; in the last few decades, they have been labelled as Costen's syndrome, temporomandibular joint pain-dysfunction syndrome, myofascial pain dysfunction syndrome, mandibular dysfunction, functional disorders of the masticatory system, craniomandibular disorders and oromandibular dysfunction. TMD are pathophysiologically related to the masticatory muscles, temporomandibular joints (TMJs) or their associated structures and share main symptom expressions and clinical features. Symptoms commonly related to TMD are pain from the face and jaw area at rest or on function, jaw tiredness, TMJ sounds such as clicking or crepitation, jaw movement limitations and locking/catching or luxation of the mandible. Signs regarded as clinical indicators of TMD are tenderness upon palpation of the TMJs and the masticatory muscles, TMJ sounds and irregular paths of jaw movement, impaired jaw movement capacity and pain on jaw movement.

There is evidence supporting a relationship between headaches, mainly those of the tension-type, and TMD symptomatology (38,95,163,244,268). However, other types of headache have also been related to the presence of TMD (12,148,231). Frequent headaches have been found to be associated and co-vary with TMD signs, primarily palpatory tenderness of masticatory muscles (10,14), which has been discussed as the connecting link between the two conditions based on common neurobiological mechanisms, such as peripheral and central sensitisation and dysfunction of the endogenous pain modulatory system (10,250).

Viewing the masticatory system as part of the human musculoskeletal system signifies the classification of TMD as a sub-group of musculoskeletal disorders. Despite decades of research, a comprehensive aetiological picture of TMD is still lacking. The variety of included conditions and the complexity of the masticatory system are reflected in the currently accepted multifactorial aetiology.

Similar to laws relating to any other physiological system, TMD as a pathological condition of the masticatory system is elicited when a critical point is reached at which the adaptive capacity of the components of the system is overwhelmed (allostatic overload) by intrinsic and/or extrinsic disturbing forces or stressors (9,36,184). The balance between function and dysfunction or adaptation and maladaptation can be affected by a number of factors, such as the magnitude and duration of the stressor, the genetic predisposition of the individual, the social environment and the specific time point at which the stressor acts (36). Biological components, such as anatomical factors relating to skeletal anatomy (113) and dental occlusion (30,60,131,179,215,257,270); systemic factors, i.e. rheumatic diseases (133,252,274) and joint laxity (275), local pathophysiological factors (137) and genetic susceptibility (57); trauma, such as external macro-trauma to the face (51,95,132,214), indirect trauma as in whiplash (71,128,233), or repeated micro-trauma, mostly related to oral parafunctions (30,37) and psychosocial elements (18,194,220,236,239; for a review see 248) have all been discussed as issues potentially connected to the aetiology of TMD. All the above-mentioned factors interact dynamically and can, in certain individual circumstances, act as predisposing, initiating or perpetuating elements, leading to the disturbed equilibrium and dysfunction (mal-adaptation) of the masticatory system.

TMD symptoms and signs have often been found to co-exist with general health problems, mostly other pain conditions (34,93,95,104,117,206,213, 237,244,265,283), but also with chronic fatigue syndrome (1,138), gastrointestinal disorders (130) and depression (235,239). Enhanced pain perception, changes in brain activation, the dysregulation of immunological and neuroendocrine function and genetic factors have been proposed as potentially and partly common pathophysiological mechanisms explaining the observed co-existence of TMD pain and various pain syndromes labelled as "functional" (130). This co-morbidity has been found to worsen the psychological functioning of patients with TMD and the importance of addressing the medical status when treating patients with TMD has therefore been underlined (21).

Trends in global public health

The last few decades have been characterised by dramatic changes in public health worldwide. Preventable deaths have decreased and life expectancy has increased in all countries and especially in the developed countries, where all previous expectations have been exceeded (278). However, large inequalities among and within countries still remain (181). The world population is both growing and ageing and this is resulting in a change in the health status panorama, with a shift from states with high mortality to states with high morbidity. Accelerated population ageing, which the World Health Organisation (WHO) has termed a "demographic revolution" (278), forecasts an increase in the economic and social demands on all countries, as morbidity rates, especially in middle and later adulthood, rise (181).

In 2003, the WHO (278) described the adult health status at the beginning of the 21st century using two trends, widening gaps and the increasing complexity of the burden of disease, with non-fatal conditions playing a progressively more important role. As a result, measurements of mortality, such as the causes of death, which have been the most used health status measurement to date, no longer give a comprehensive description of current population health (181). For several other important domains of health and disabling conditions, such as musculoskeletal and mental disorders, which are rising in prevalence in countries with long life expectancy (278), the critical outcome is function limitation (181). In recent years, a commonly used measurement has been the burden of disease, which can be described as the combined expression of the number of people carrying the disease and the degree of the severity of the disorder. It is thus affected by factors such as incidence, survival and treatment efforts, including those that do not cure the disorder but may only relieve the problem (90). Since 1990, the WHO has been conducting a project (the "Global Burden of Disease" project, GBD) that assesses the global burden of disease and offers comprehensive estimates of both mortality and morbidity. The latter is quantified in terms of "loss of health", which is meant as a determination of functioning in different health domains, such as mobility and cognition (280), because of disabling conditions, e.g. depression, hearing loss, osteoarthritis and rheumatoid arthritis. The GBD has estimated that 40% of the measured global burden of disease is attributable to "loss of health" function (181).

Parallel to trends in general public health, trends in oral health worldwide have been noted. During the last few decades, marked decreases in the prevalence of caries, periodontal diseases and edentulism, as the main indicators of oral health, have been reported from various parts of the world (44,208,230). Improvements in oral hygiene and continuous preventive work have contributed to these positive trends. However, the demographic changes, with a growing ageing population with preserved dentition, imply obvious effects on the oral health panorama. Barmes (13) discussed the plausible expectations, related to these positive trends, of an intact, well-functioning dentition lasting for life, no matter how long lifetime becomes, and he underlined the importance of adequate policies when disabling disease occurs and of continuous research and updated information in order to ensure equal opportunities to access cost-effective oral health care.

In the World Oral Health Report in 2003 (279), the WHO stated that, during the latter part of 20th century, an "unmatched in history" transformation with remarkable achievements was noted not only in general health but also in oral health. The report especially emphasised the significant changes in international health noted during the 1990s by the recognition of the importance of social, economic, political and cultural determinants of health, thereby expanding the global understanding of the causes and consequences of ill-health (279). Subsequent publications have underlined the persistent impact of social (105) and economic (64) inequalities in oral health. The WHO report presented oral diseases as major public health problems and called for consideration of the impact of pain and suffering, impairment of function and effect on quality of life (279).

Public health in Sweden – "An ill-health paradox"

The global trends mentioned above have also been noted in Sweden, with a reduction in fatal diseases and an increase in life expectancy, particularly for middle-aged and elderly people (207,266). The first national public health report by the Swedish National Board of Health and Welfare, in 1987, showed that, during the first half of the 1980s, life expectancy increased by one year, the most notable increase during the post-war period, and the fifth report published in 2001 showed a continuous increase (207). At the same time, persistent health differences between social groups were noted. Persistent large social ef-

fects were also marked in oral health, which had, however, improved remarkably during the past 25 years, mostly related to a decrease in caries prevalence in children and decreasing rates of edentulousness in older age groups (110,205, 207,266).

The 2001 public health report indicated that middle-aged and older individuals had experienced the most favourable health development, according to self-rated health rates, during the past twenty-year period (207). On the other hand, these rates decreased for individuals 16–44 years of age during the 1990s, mainly related to an increase in mental ill-health, such as anxiety, worry, fatigue and sleeping problems (240,266). Swedish children and young adults, although presenting in international reports as the healthiest and most satisfied with life among their counter-parts in other European countries, have been found, since the mid-1980s, to suffer increasingly from psychosomatic symptoms, such as headache, stomach ache and sleep disturbances (19,207). At the same time, it was noted that various types of pain had become much more common, especially among women and individuals born abroad, and musculoskeletal conditions had increased substantially, as 50% of men and 70% of women reported back, neck, shoulder, leg or knee pain (207,266). The rates for worry/anxiety, sleeping problems, longstanding fatigue and severe neck/shoulder pain increased in a similar way among both men and women during the period 1994-2005 (241). However, the highest increase rates were noted for worry/anxiety and sleeping problems among women aged 16–24 and 25–44 years (241).

Despite the earlier mentioned general positive trend in public health, a remarkable increase in sick leave, mainly related to musculoskeletal pain conditions and mental ill-health (15,81,94,115,178,226), was observed in Sweden during the 1990s – the so-called "ill-health paradox" (210). The rates of sick leave, among both women and men, showed a similar fluctuation over time as the rates for stress symptoms, the latter defined as at least one of the symptoms of worry/anxiety, longstanding fatigue or severe neck/shoulder pain (241). A Swedish study also showed a relationship between sleeping problems and the risk of longstanding sick leave in the next two years (6). Changes in the social structure of the industrialised societies, in life-style and in the occupational environment during the last few decades have been identified as the main reasons for the phenomenon of the striking rise in sick leave rates that radically affected the national public health and insurance system (160,178).

At the beginning of the 1990s, Sweden was exposed to the worst economic crisis in 60 years and it resulted in radical changes in the labour market. Downsizing, outsourcing and lay-offs were very common, leading to increasing unemployment, job insecurity, early exit from the labour market and social gaps (91). The importance of the psychosocial work environment was increasingly acknowledged as a major determinant of ill-health, mostly expressed as burnout problems (115). Burnout was primarily related to psychological, mental and musculoskeletal symptoms. A study of 3,719 health-care workers in 2002 revealed that reports of depression, anxiety, sleep disorders and neck-back pain were the health indicators that were able to discriminate employees with burnout reported from other study categories as disengaged and non-burnout workers (209).

A rising working tempo, reorganisations and cutbacks in chiefly female-dominated occupations, such as the care and educational sectors, resulted in a deterioration in the work environment and in well-being (100,207,211). In 2001, the National Institute for Working Life reported on a growing work pace and time pressure, increasingly stressed work, especially for women, increasing computer work, changes in occupational structure, with just-in-time employment becoming more common, and a deterioration in self-rated health, particularly among those with employment, after 1993 (100). Extensive surveys conducted by Statistics Sweden showed that stress-related complaints and psychological ill-health rose to a similar degree for employed and unemployed people during the crisis and it was speculated that this was related to insecure or temporary employment (91).

The rate of sick leave increased from 1997 until 2004, where it peaked at a level of 42 days per year and employee of 16–64 years of age (81) and a total cost to the state of about 125 billion Swedish crowns (178). In an extensive anthology about the reasons for sickness absence, the National Institute of Working Life, the National Institute of Public Health, the Institute of Psychosocial Medicine and the Insurance Office concluded that changes in the population's state of health could only partially explain the increase in sick leave, which was also thought to be related to changes in the psychosocial environment in a changing society and changes in political, social and economic structures (178).

Stress and ill-health

The health of a population has been increasingly conceptualised not only as the summation of risk factors and the health status profile of population members but also as a collective characteristic of cultural, economic, psychosocial, behavioural and environmental factors (186). Occupational status, social relationships and support, living conditions, psychosocial work factors, mainly work stress, health behaviours, social and economic policies, health care systems, the so-called social determinants of health, interact over the life course with biological, genetic, psychological and environmental factors to determine the individual and population health (33,126).

Psychosocial factors, defined as measurements of psychological phenomena that relate to specific social environments, as well as other social determinants, operate through stress reactions (33). Matthews (182) defines stress as the processes and responses associated with adaptation to demanding or challenging environments, but stress is also commonly conceived as any stimulus to which the organism is not adapted (245). Stress implies a stressor (the stimulus) and a response. A stressor may be physical, i.e. tissue injury, or a psychological experience, such as life events or conflicts, and the responses are both physiological and behavioural, such as changes in lifestyle in order to manage the stressor. At the biological level, stress responses mainly involve the hypothalamic-pituitary-adrenocortical axis (HPA) and the autonomic nervous system, resulting in the increased release of catecholamines and glucocorticoids (36,67,245). These functions are vital to the survival and protection of the organism trying to maintain the health equilibrium, but, in the event of prolonged stress, the responses may result in a deterioration in normal function and may elicit a disease process (36,185). Prolonged cortisol output seriously suppresses the immune system and may lead to bone, muscle and neural tissue destruction, thereby producing the conditions for the development of different kinds of chronic pain (188).

Stress and pain are associated in a delicate, complex and still not fully understood manner. Stress may suppress the perception of pain (stress-induced analgesia) by the activation of the adrenocortical axis or opioid release, which can be seen in direct tissue injury, but it may also result in the increased perception of pain (stress-induced hyperalgesia), which is regarded as a centrally mediated disturbance (36,245). Ongoing stress activates major parts of limbic systems,

such as the amygdala and hippocampus that are essential mediators of cognitive and emotional processes, affecting the perception of nociceptive information (188).

In addition to the perception of pain (152), the course and the transition of acute to chronic pain has been found to be closely related to psychological factors, such as emotional distress, anxiety and depression (36,89,158). In the neuromatrix theory of pain, Melzack (188) presented a theoretical framework for prolonged psychological stress as a sufficient cause of chronic pain, which is currently applied in integrative medicine. Chronic pain and/or fatigue have also been found to co-exist with other stress-related disorders, suggesting a common pathomechanism through the dysregulation of the HPA axis (138).

Psychological distress also in conjunction with TMD has consequently been considered (49,123,140,193,225,239,265) and a frequently disclosed association has been reviewed (23,220). The relationship between TMD symptoms and cortisol response to stress, as a sign of a dysfunction in the HPA axis, has also been studied and was shown not to be simple but mediated by psychological determinants and biological predisposition (121,196). Different autonomic responses to stress in TMD patients than in controls have also been reported (172), but not all studies have been conclusive (50). The dysregulation of the HPA axis and an increase in sympathetic nervous system activity, as a response to stressors, have been proposed as factors mediating the onset or persistence of TMD (172).

Epidemiology in health research

The science of epidemiology, originally defined in ancient Greek as the study of the distribution of a condition in the population (Greek: epi = on, upon + demos = community, people + logos = study, word, discourse), has been a significant instrument in health research. In its first application by Hippocrates, it was used to describe epidemics, conditions that occurred occasionally in a population. The initial aim of measuring the frequency of a disease in the community, often assessed as prevalence, has successively expanded to describe also the determinants, features and natural history of disease in both general and specific (clinical) populations. In spite of this, epidemiological research has sev-

eral further applications, such as assisting in the planning of health care resources, as it provides information on treatment need and treatment used, to assess the effectiveness of care systems and to contribute to the search for causes of disease and prevention strategies, even if the biological mechanisms are poorly understood, which is the case in many pain conditions (45,59).

Epidemiological studies can be experimental, i.e. clinical trials, or observational, such as cohort studies, case-control studies, cross-sectional studies, or ecological studies (222). Non-experimental studies may have a prospective or retrospective perspective and a "hypothesis-generating" or analytical approach (222). The science of epidemiology experienced an enormous expansion in the second part of 20th century, when some important surveys resulted in milestones in health research, and it has continued to develop, mainly in its scientific background and its gradually more sophisticated methodology during the last few decades (45,222).

Since the global health panorama is becoming progressively multifaceted and the burden of disease is becoming increasingly more complex (278), there have been urgent calls for continuous measurements of health status trends, including reports on functional health status and a broad spectrum of health-related data, at both national and international level, allowing for cross-population comparability (181). In order to document the burden of a disease or condition in the population at a given time point, cross-sectional studies have most frequently been applied (145).

In 1984, in conjunction with the WHO's "Health for all by year 2000" strategy, the Swedish national Care Commission presented a model for a systematic description of the population and its health risks, problems and facilities (266). As a result, the National Board of Health and Welfare undertook the task of regularly studying and reporting on health status, resulting in Public Health Reports published every three to five years. One of the main aims has been to disclose psychosocial determinants of health and to prevent ill-health (266).

Epidemiological research has also played a central role in the field of oral health. Extensive population surveys have been systematically performed in different parts of the world and they have generated essential information relating to the oral health status of the population and its determinants, time trends

in the presence of different oral conditions and the efficacy of care systems applied (44,64,110,230,286).

TMD in the general population

A plethora of epidemiological, mainly cross-sectional, studies have revealed that TMD symptoms and signs are very common in the population (for reviews see 27,54,97). It has been estimated that symptoms are reported by almost every third individual and 44–67% of the population present with clinical signs (27,54,97). However, a remarkable disparity in prevalence figures for TMD symptoms and signs can be seen in the various investigations, reflecting differences in study populations, definitions, criteria and methodology used. The presence of TMD has previously often been based on the presence of at least one symptom or sign, which has probably contributed to the varying prevalence findings, as some symptoms and signs, like jaw tiredness and TMJ sounds, are mild and common in the population, while others are more rarely reported. For example, pain in the face, which in the last few decades has most commonly been used as a TMD indicator in epidemiological research, has been estimated to have a prevalence of around 10% (145), whereas TMJ clicking is reported three times more frequently (190). Whether the diverging prevalence figures have also been affected by the different time points at which the various investigations were performed, and thereby by the different social contexts in the studied populations, is unknown.

The majority of the more recently published population-based surveys have revealed differences in TMD prevalence between different age groups, but the results have not always been conclusive (27,62). Symptoms have more commonly been reported by younger and middle-aged individuals than by children or elderly persons (171,204,224). Despite a decrease in reported TMD symptoms by older individuals, an increase in the prevalence of clinical signs with advancing age has been found (223, 224,254). It appears that, when pain symptoms are used as the main TMD indicator, the peaking age is lower than when a combination of symptoms and signs signifies the presence of TMD (99). A clear definition of the examined condition is thus crucial for the correct interpretation of prevalence research.

TMD symptoms and signs are already present in children and adolescents, although various studies report highly inconsistent prevalence figures (199). In a comprehensive review of 40 epidemiological surveys, Nydell et al. (199) discussed multiple methodological issues, especially the uncritical use of examination methods designed for adults in children, as one plausible reason. TMD symptoms are already reported at pre-school age, but most individuals have mild and infrequent symptoms, which appear to increase in prevalence with increasing age (165,195,198). However, TMD pain is rare in children of prepubertal ages (145). LeResche (145) speculated that the absence of risk factors, the possible necessary exposure time to them and a greater adaptive capacity at early ages were possible reasons for the low prevalence of pain symptoms before puberty. Longitudinal studies have, furthermore, provided important information about the development of TMD over time in children and adolescents and have shown a significant and unpredictable fluctuation in signs and symptoms, with no tendency towards spontaneous deterioration (135,169,269).

Differences across *genders* (in the present thesis regarded as the biological and physiological characteristics that define men and women and are usually referred to as *sex*) have been found in studies of both general and clinical populations, pointing to a predominance of women (27,97,118). The differences are more pronounced when it comes to TMD pain symptoms (117,145). No clear gender disparity has been noted in childhood (195), but studies have reported a higher prevalence and greater severity of signs and symptoms in girls than in boys during adolescence (198,265). Biological factors related to pain modulation by oestrogens (145), genetic, behavioural, social and psychological factors, such as health consciousness, anxiety and control, have been presented and discussed as plausible explanations (48,225), but the issue of the female predominance in TMD merits further research.

It has been stated that TMD fluctuate over time and are remitting or self-limiting conditions (9). A few longitudinal epidemiological studies examining the fluctuation in TMD symptoms and signs have been conducted. The variation observed over a two-year period was not large (140), but a substantial fluctuation in both reported symptoms (65) and clinical signs over a 20-year period, without any progression to severe pain and dysfunction, was demonstrated (169). Gender differences in the fluctuation patterns of TMD were found in a 10-year follow-up survey, as symptoms were more consistently reported by women than men (272). Moreover, different TMD symptoms appear to follow

different long-term patterns. In a five-year follow-up study, myogenous conditions displayed a frequently recurring pattern (217), whereas TMJ pain showed a higher remission than maintaining rate during a four-year period (122). It has also been shown that untreated TMD patients do not improve spontaneously (16), while treated patients report significant and lasting improvements (17,217, 276).

TMD have been identified as a major cause of orofacial pain of non-dental origin (9). The WHO has emphasised the importance of being free of chronic orofacial pain as a clear prerequisite for oral health, as well as the negative effect of functional problems, such as chewing and eating, on the individual's well-being and daily living, making them determinants of oral and general health (278). Individuals with TMD symptoms have been found to seek different care providers (263) and utilise the health care system to a greater degree (234,277), as well as being more frequently on sick leave (7,140) than subjects without these conditions. TMD patients consequently experience a considerable negative affect on their quality of life (47).

Assessment of TMD

For decades, the assessment of TMD has been performed using different index systems. The first attempt at a systematic evaluation of these conditions was made by Helkimo (96) in the early 1970s and it resulted in a system that consisted of three dysfunction indices, the Anamnestic Dysfunction Index (Ai), the Clinical Dysfunction Index (Di) and the Occlusal Index (Oi). The Helkimo Indices were constructed as a criteria system assessing the presence and severity of TMD symptoms and signs and were intended for utilisation in epidemiological research and for longitudinal comparisons (99). The Ai, assessing subjective symptoms, and the Di, evaluating the clinical recorded signs, have been used since the 1970s both in Scandinavia and worldwide in a large number of epidemiological studies.

Over the years, several other assessment systems, like the Craniomandibular Index (79) and the TMJ scale (161), have also been established. Ohrbach & Stohler (201) reviewed nine different index systems and concluded that they all had some disadvantages. In another review, Carlsson & DeBoever (26) stated

that "it is a complex and probably impossible task to construct an ideal index which can encompass the many specific disorders of TMD".

In the last few decades, diagnostic systems, such as the Research Diagnostic Criteria for TMD (RDC/TMD) (63) and the American Academy of Orofacial Pain diagnostic criteria (9), have been developed with the aim of assisting the standardisation of the diagnosis and definition of the most common subtypes of TMD. The RDC/TMD system (63), which has a "dual-axis" approach, with an Axis I evaluating physical findings and an Axis II assessing pain-related disability and psychosocial functioning, has been used increasingly worldwide in both population investigations and clinical research. Despite various dissimilarities in the rationale and construction, both early established index systems, like the Helkimo Indices (96), and diagnostic instruments developed at a later stage (9,63) have been based on the assessment of certain common symptoms and signs that have been used as core variables in these systems.

However, none of the above-mentioned instruments has included the assessment of headache symptoms. Most recently, specific criteria for diagnosing headaches associated with TMD have also been presented and have been found to have better diagnostic accuracy than those previously suggested by the International Classification of Headache Disorders (229).

Treatment need for TMD

The issue of the need for TMD treatment in the population is challenging and important for health economics (56). In spite of this, there is no generally accepted appraisal method for it. Estimations of the need for TMD treatment have most frequently been based on information obtained from epidemiological data relating to the presence and severity of TMD conditions in the population. As a result of the large variation in the prevalence figures reported by different studies, the estimates made for TMD treatment need have also varied noticeably. Furthermore, the criteria that have been used have also diverged. Some studies have utilised individuals' own appraisals (2), whereas many other surveys have been based on the presence of symptoms (157) or signs (254) or a combination of them (53) and some have been based on the clinician's judgement (167,195). Kuttila et al. (140) suggested a system of classification of

treatment need introducing the concepts of active and passive treatment and prevention need. Wänman (271) and De Kanter (53) also reported on treatment need, describing it in other than dichotomised terms. The estimates have thus ranged between 1-30% (28) and a meta-analysis study estimated the treatment need for TM disorders in adult non-patients to be 16% (8).

The estimates of need for TMD treatment in child and adolescent populations are lower than those in adults. It has been proposed that the few individuals who consistently have symptoms and signs of TMD at follow-ups constitute a high-risk group that might display a demand and need for treatment. This high-risk group has been estimated to be 3% among Finnish adolescents (135). Similar figures have been reported in a study of Swedish adolescents aged 12-18 years (265). Seven per cent of this group reported pain in relation to TMD and, of these, 50% required treatment, i.e. 3.5% of the whole group. For younger children, a need for treatment not exceeding 1% of the population has been reported (11).

TMD in clinical populations

Despite the relatively high estimates of treatment need for TMD in the population (8), the figures for demand for treatment are much lower (167,271), revealing a discrepancy between subjects judged to be in need of treatment and those seeking treatment. Factors such as the character, intensity, severity and persistence of symptoms experienced (242,55), the availability and attitude of the dental-care system (28), knowledge relating to TMD treatment (167), concurrent stress experience (140), as well as the individual's own demand (28) have been discussed as potential determinants of the demand expressed. Pain symptoms have been found to be the most frequent reason for seeking TMD care (155,285).

Clinical populations differ in terms of gender distribution compared with unselected populations. An even higher female predominance with a ratio of 3–9:1 has been reported from studies of clinical samples (62, 147, 238) and patients in the 2nd to 4th decades of life have dominated (17,97,183). The combined effect of psychosocial and hormonal factors on pain modulation mechanisms has

been discussed as a possible reason for this specific demography of clinical populations (43,48).

The diagnostic process relating to the subtypes of TMD is assisted by data collected through history taking, clinical examination of the masticatory system and sometimes complementary tests, such as radiographic examination (9). In earlier clinical research, the International Classification of Diseases (112) has often been used for descriptive and statistical purposes, although it does not provide any specific diagnostic criteria for the specified TMD subtypes. Despite these limitations, clinical materials have reported on a wide range of diagnoses and diagnostic subgroups, where the most prevalent are disc displacements, myalgia, arthritis, osteoarthrosis, headaches, as well as other forms of orofacial pain (46,164,238). Limited knowledge of the cause and natural progression of these disorders has been regarded as an obstacle to the establishment of a broadly accepted classification system (63). In the last few decades, efforts have been made to obtain a comprehensive diagnostic classification of the most common TMD (9, 63) and an increasingly more broadly utilised diagnostic criteria system, the RDC/TMD (63), has been established. The RDC/TMD Axis I (63) classifies TMD into three main categories, muscle diagnoses, disc displacements and arthralgia/arthritis/arthrosis.

According to several investigations, the majority of TMD patients, irrespective of the specific TMD diagnosis, achieve good relief of their symptoms with conservative therapy (39,66,218,238). Long-term follow-up studies have also shown good consistency of symptom relief for a large percentage of patients (187,203). These results lend support to the opinion that conservative TMD treatment often has a favourable prognosis. The most commonly used treatment modalities: counselling, modification of daytime parafunctional behaviour, interocclusal appliances, jaw exercise programmes and some kind of medication have a documented good effect in reducing symptoms and signs of TMD, often when used in combination and on an individual basis (9,46). The majority of TMD patients can be treated by general dental practitioners, but some patients who do not respond to this form of management need to be referred to and treated at specialised TMD clinics, where a multidisciplinary approach and treatment modalities are sometimes necessary (232).

A minority of patients, however, remain without any improvement, despite efforts and clinical time consumed (86). Several studies have examined various

characteristics, such as gender, age, socio-demographic issues and diagnostic subgroup, as factors that may correlate, or predispose, to either treatment success or failure (16,232,238). Other investigations have focused on psychosocial elements as being more relevant to patient response to therapy and relationships to factors, such as health locus of control and major life events (56), different coping strategies and illness behaviour (246), as well as sense of coherence (236) have been found.

It has been estimated that 10% of TMD patients account for more than 40% of the cost of the whole TMD group (277). It would therefore be helpful for the clinician to be able to identify responders and non-responders to a specific therapy, so that the most optimal treatment could be selected for the individual patient for the best treatment outcome, thereby facilitating both a reduction in individual suffering and the enhancement of the use of public resources.

AIMS

Data providing information on the historical progression of TMD prevalence in the population are lacking (59,145). It has been speculated that the prevalence of temporomandibular pain has been stable or declining since the 1960s (145). The question of whether TMD follow the pattern of other musculoskeletal pain conditions that are becoming more prevalent in many countries, or of stress-related disorders that increased in the Swedish population during the 1990s, or that of other oral health conditions, which have decreased during the last few decades, has been ambiguous and was the rationale for conducting the present research.

The overall aim of the thesis was to acquire knowledge relating to possible time trends for the presence of temporomandibular disorders in the population and factors that are feasibly associated with these conditions.

The specific objectives were

- to assess the prevalence of symptoms and signs indicative of TMD in a Swedish population on three occasions with a 10-year interim period (Studies I–III)

- to study possible changes over time in the prevalence of TMD-indicative symptoms and signs in the population over a 20-year period (Studies I–III)

- to estimate the treatment need for TMD in the same population over the observation period (Studies I, III)

- to explore possible associations between TMD-indicative symptoms and signs and factors such as age, gender, reported bruxism and perceived healthiness (Studies I–III)

- to study a clinical sample of patients examined and treated at a specialist TMD clinic for changes during an eight-year period of time with regard to age, gender, diagnoses and treatment features (Study IV)

- to explore possible predictors of treatment outcome in a sample of patients treated at a specialist TMD clinic (Study IV).

MATERIAL AND METHODS

Studies I–III are based on a series of repeated cross-sectional population-based investigations. Study IV is a retrospective survey of a clinical sample with both a descriptive and a partly analytical approach. The methodological framework of Studies I–IV is illustrated in Table 1.

Table 1. Overview of the study design, number and age of subjects included, investigation time and source of data collection in the studies included in the thesis.

Study	Design	n	Age	Time	Data source
I	Repeated cross-sectional, population-based	1,248	3–15	1983, 1993, 2003	Questionnaire, interview, clinical examination
II	Repeated cross-sectional, population-based	1,704	20–70	1983, 1993, 2003	Questionnaire, interview
III	Repeated cross-sectional, population-based	1,693	20–70	1983, 1993, 2003	Clinical examination
IV	Retrospective, clinical sample	3,194	9–90	1995–2002	Patient records

Studies I–III

Participants

The samples consisted of individuals 3–70 years of age included in the so-called Jönköping studies performed in 1983, 1993 and 2003. These studies are cross-sectional, stratified-by-age, population-based investigations that have aimed to explore oral health and oral health-related factors among citizens living in Jönköping, Sweden, initiated in 1973 and repeated every 10 years. Jönköping is a medium-sized Swedish city and the administrative centre of Jönköping County. In 2003, the municipality of Jönköping had around 120,000 inhabitants with similar rates of foreign-born citizens (11%, www.scb.se) and of ill-health (39%, www.forsakringskassa.se) as the county as a whole (12%, www.scb.se and 43%, www.forsakringskassa.se, respectively).

Each investigation year, a random sample of 130 individuals in the age groups of 3, 5, 10, 15, 20, 30, 40, 50, 60 and 70 years, with birth dates between March and May, were selected from the inhabitants of four specific parishes (Järstorp, Kristine, Ljungarum and Sofia) within the city of Jönköping. The three samples were independent of one another. The randomisation process was conducted by the administrative board of the county council.

All the selected individuals received a mailed personal invitation to participate in an oral health examination. Detailed information about the study and its purpose was included in the letter. Individuals were also informed that they would be examined clinically, would be asked to answer some questions and fill in a questionnaire and that the examination would be free of charge. No compensation for participation was offered.

Non-responders and drop-outs

A number of individuals invited to enrol in the investigations did not agree to participate. Among the different age groups, 15–25% in 1983, 12–29% in 1993 and 15–36% in 2003 declined to take part. The total rate of non-response was 21% in 1983, 22% in 1993 and 29% in 2003. The populations examined consequently comprised 1,024, 1,007 and 926 individuals in 1983, 1993 and 2003 respectively.

Non-participants were asked about their reason for not taking part, which was registered. The most common reasons in all three examinations were lack of interest or time, that the person had moved from the area, could not be reached or due to no specific cause. Details describing non-response rates and reasons have been reported in earlier publications (107–109).

A few subjects in each investigation were excluded from the analyses because of missing data. The number of non-responders and drop-outs, as well the gender distribution of participants per age group for each year of investigation are shown in Figure 1. The study material thus comprised 1,248 individuals in Study I, 1,704 in Study II and 1,693 in Study III.

Procedures

Data were gathered using a self-administered questionnaire, an interview and a clinical examination, which were performed during the same session in the above-mentioned sequence. The interview and the clinical examination were conducted by seven (1983 and 1993) or eight (2003) experienced dentists. Two of them have been the same in all three examinations and two others have contributed on two occasions. Children and adolescents were examined by specialists in paediatric dentistry. In 1983 and 1993, the investigations were completed within 12 months, whereas the 2003 investigation was completed within 14 months.

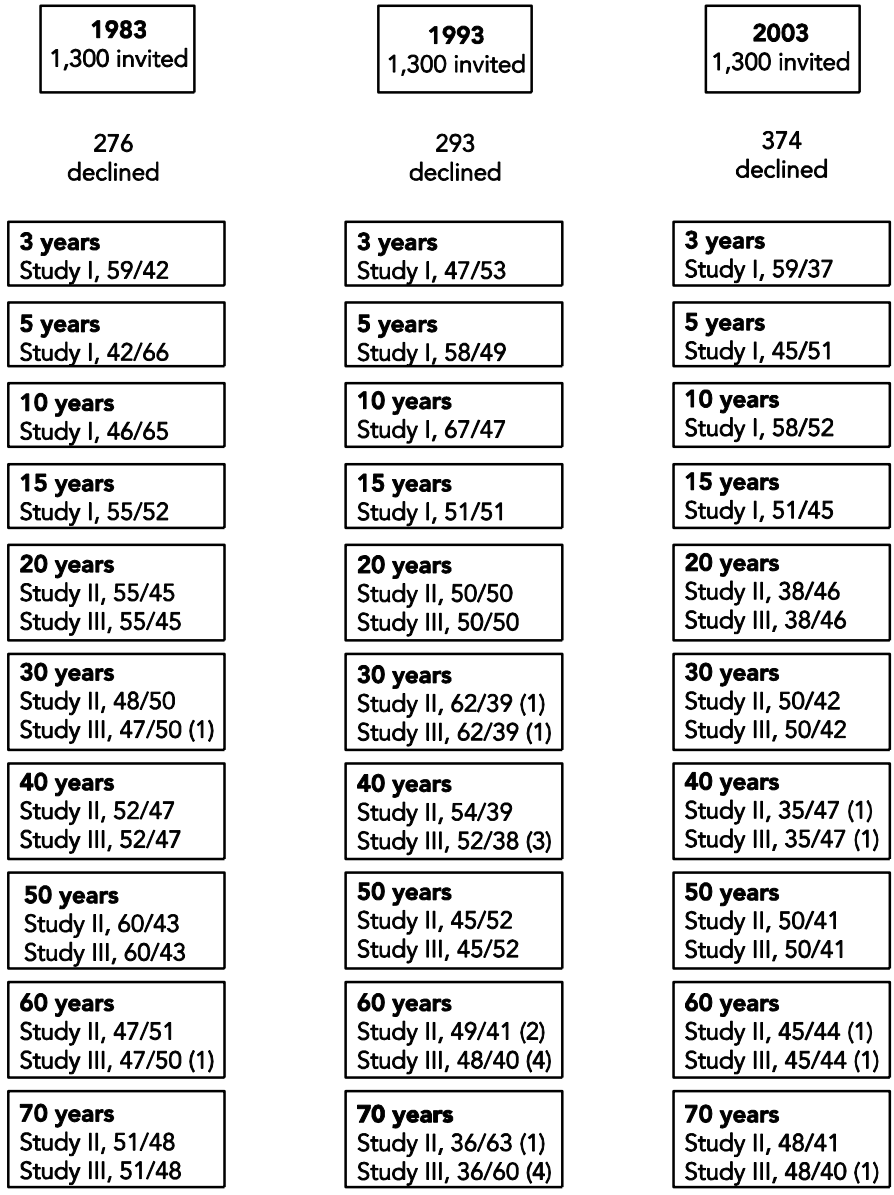

Figure 1. Non-participants, drop-outs (in parentheses) and gender distribution (female/male) by age and year of investigation of the participants in Studies I–III.

Questionnaire

All the participants were asked to fill in a questionnaire including questions on general and oral health and some socio-demographic issues (Appendix I). The wording was somewhat different for children than for adults, while maintaining the same content. The questionnaires for the 3- and 5-year-old children were answered by their parents.

Two questions relating to the function of the masticatory system were addressed to individuals 3–15 years of age, specifically whether the child/adolescent had pain or discomfort during chewing and whether the child/adolescent had pain or discomfort when opening his/her jaw.

One question dealt with oral parafunctions. Adults were asked about awareness of tooth clenching/tooth grinding. The same question was also addressed to children and adolescents in 2003. No questions regarding oral parafunctions were addressed to the 3–15 year age groups in 1993 and to the groups making up the 3- and 5-year age groups in 1983.

General health questions regarded on-going medical treatment, any regular medication and self-perceived healthiness were addressed to all age groups.

The alternative answers to all questions were "yes" or "no".

Interview

Prior to the clinical examination of the individuals 10–70 years of age, the dentists addressed some specific questions regarding TMD-indicative symptoms and recorded the presence or absence of the following: tiredness in the jaws on awakening or during chewing; clicking sounds or crepitations from TMJs; locking/catching of the mandible; luxation of the mandible; reduced jaw movement capacity; pain during jaw movements; other pain conditions in the jaws or in the TMJ regions. Based on the answers to these questions, the Anamnestic Dysfunction Index (Ai) according to Helkimo (96; Appendix II) was assessed.

The participants aged ≥ 10 were also asked whether they experienced headaches once a week or more often. This question was not registered as a positive

answer if anything other than tension-type headache had been medically diagnosed.

In 1983, individuals aged 10 and 15 years were asked about nail biting and participants aged ≥ 10 years were asked about previous trauma to the face. In 2003, the same age groups were asked to report on any on-going TMD treatment with interocclusal appliances.

Clinical examination

A functional examination of the masticatory system was performed in all participants except for children aged 3 and 5 years. The registrations were carried out in a clinical setting with the subjects sitting in an upright position in a dental chair. The dentists were calibrated in terms of the clinical TMD signs to be registered before the start of each investigation by an experienced TMD specialist.

The TMD signs to be registered were those making up the Clinical Dysfunction Index by Helkimo (96; Appendix II) and are related to five main domains of the function of the masticatory system as follows.

A) Jaw movement capacity (maximum jaw opening including vertical overbite, maximum laterotrusion to the right and to the left and maximum protrusion scoring 0, 1 or 5 points; see mobility index in Appendix II).

B) TMJ function (normal function: 0 point, deflection on jaw opening of > 2 mm/TMJ clicking or crepitations: 1 point, TMJ locking or TMJ luxation: 5 points). In 2003, no separate registration was made for TMJ sounds, but their presence was recorded as non-normal TMJ function.

C) Pain on jaw movement (no pain on movement: 0 point, pain on one movement: 1 point, pain on more than one movement: 5 points).

D) Muscle pain (no muscle pain: 0 point, pain on palpation in 1-3 sites: 1 point, pain on palpation in > 3 sites: 5 points). The muscle sites to be digitally palpated were the anterior origin and the insertion of the temporal muscle, the superficial masseter muscle, the medial pterygoid muscle (extraorally) and the region of the lateral pterygoid muscle. The medial pterygoid muscle was not palpated in 10- and 15-year-olds. The palpation was performed bilaterally.

E) TMJ pain (no joint pain: 0 point, pain on lateral palpation of one or both joints: 1 point, pain on posterior palpation of one or both joints: 5 points).

In 1983, a modified version of the Di (Di* in Study III) was used as the criterion for domains C, D and E were partly different compared with 1993 and 2003. For C, the criterion of "pain on more than one movement" was altered to "pain on opening ≤ 20 mm or on horizontal movement of ≤ 3mm". The criteria for muscle and TMJ pain scoring 1 and 5 points respectively were "tenderness on palpation or side difference" and "pain provoking a palpebral reflex".

The clinical registrations were combined to produce a dysfunction score (96; Appendix II) and, according to this score, the Di was calculated in 1993 and 2003. In 1983, the Di (Di* in Study III) was calculated after the aforementioned modifications.

The agreement between the C, D, E, Di and C*, D*, E*, Di* was tested on 32 consecutive adult patients referred to the Department of Stomatognathic Physiology, The Institute for Postgraduate Dental Education, Jönköping, Sweden. The registrations were performed by one examiner (AAK) applying the criteria for C, D, E and C*, D*, E* in a switching sequence. The dysfunction points were found to agree in 63% (20/32) of the cases regarding pain on jaw movement, in 84% (27/32) for muscle pain and in 72% (23/32) for TMJ pain, whereas the agreement for Di as a whole was 53% (17/32).

Finally, an empirical estimate of the need for TMD treatment (TNest) in the age groups of 10 and 15 years and in adults was made. Adults reporting frequent headache or severe symptoms, viz. Ai II (96; Appendix II), who had also been registered with a Di*/Di II/III, were regarded as being in need of TMD treatment (TNest* in 1983 and TNest in 1993 and 2003). The estimates of treatment need in children of 10 years of age and adolescents aged 15 years were based on the presence of both severe symptoms (Ai II) and moderate to severe clinical signs (Di II or Di III).

Study IV

Population

The study refers to data for consecutive patients referred to and examined at the Department of Stomatognathic Physiology, The Institute for Postgraduate Dental Education, Jönköping, Sweden, during the time period 1995–2002. The Department of Stomatognathic Physiology operates as a referral and care centre for health providers within the County of Jönköping, which had about 330,000 inhabitants in 2003. The referrals were initiated by private and public general dental practitioners, specialist dentists, as well as family doctors and medical specialists. During the eight-year period, 3,630 patients were referred to the department. Of these, 3,194 presented for a clinical evaluation and were all included in the study. The flow of patients who comprised the study material is illustrated in Figure 2.

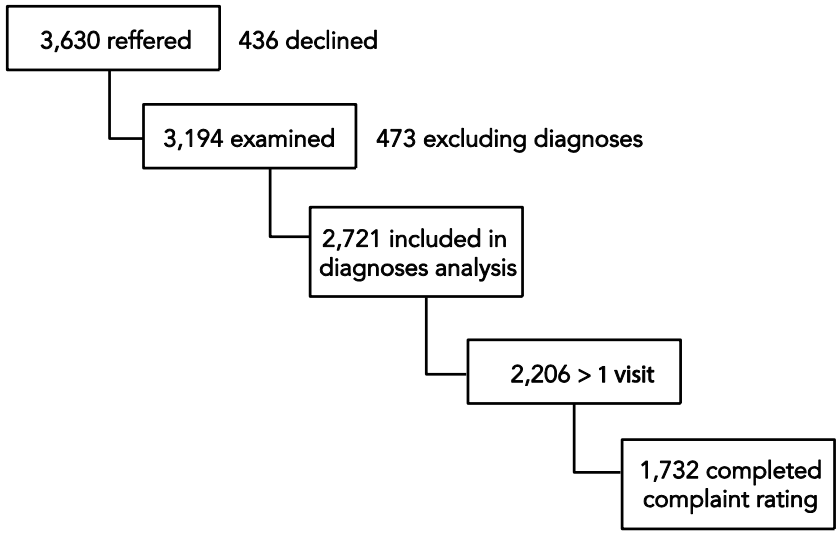

Figure 2. Flow chart for the population in Study IV.

Procedures

Before the clinical examination, patients were asked to complete a questionnaire that provided information on their socio-demographic situation, general

health status, past and present symptoms, as well as a subjective assessment of pain and/or discomfort (henceforth called complaints) according to a verbal scale. This is a 5-grade scale where the steps are: 1 = no or insignificant symptoms, 2 = mild symptoms, 3 = moderate symptoms, 4 = fairly severe symptoms and 5 = very severe symptoms.

On the first visit, all patients were examined in accordance with the clinical routines at the department (29) by a specialist in TMD or a specially TMD-trained dentist. Radiographic examinations were made when judged necessary. Each patient was given one or more diagnoses consistent with the Swedish version of the International Classification of Diseases, 9th Revision (ICD-9) (112). In some cases, however, it was not possible to label a diagnosis according to this system.

Detailed information about symptoms, the tentative diagnosis and possible aetiological factors was given to all patients. When a TMD was judged to be present, the normally benign character of the disorder was stressed. Patients were also urged to be observant of possible oral parafunctions in the daytime and to try to avoid them, if present. When indicated, different treatment modalities, often in combination, were offered. The most commonly applied modalities were interocclusal appliances, therapeutic jaw exercises, pharmacological agents, i.e. NSAIDs or analgesics, intra-articular and intramuscular injections, selective occlusal adjustment, physical therapies and acupuncture.

After the completion of treatment, patients were again asked to rate any remaining complaints according to the same verbal scale as before treatment. Based on the scale assessments, a variable for treatment outcome could be measured for each patient. The outcome was expressed, in a dichotomous way, as overall improvement or no improvement in initial complaints.

Data analyses and statistics

Studies I–III

The main outcome variables were the separate symptoms and signs, the Ai, the Di/Di* and the estimated treatment need. Their prevalence for each age group, gender and year of investigation was presented applying descriptive statistics. The dysfunction points "0" and "1" for all domains and statistical comparisons in Study III were pooled together with the aim of focusing on only the more severe dysfunction signs. The Clinical Dysfunction Index degrees II and III (Studies I and III) and degrees 0 and I (Study III) were combined to Di II/III and Di 0/I respectively, so as to facilitate the statistical analyses.

Binary logistic regression analyses (Appendix III) were performed in order to assess any associations between the main outcome variables as dependent variables and each of the studied background factors as independent variables: age group, gender, self-perceived impaired health, trauma (1983), reported oral parafunctions, use of complete dentures (Study III) and the year of investigation. The independent variables that reached a significant association with dependent variables in univariate regression (UR) were included in forward stepwise multiple regression analyses (MR). The results were presented as the odds ratio (OR) and 95% confidence interval (CI). In Study III, the MR analyses were performed with adjustment for age and gender. In Study I, a chi-square test (χ^2) was used to test for possible associations between the prevalence of symptoms and signs and the year of investigation.

All data analyses were executed in a statistical package (SPSS versions 13.3–19). A p-value of < 0.05 indicated a statistically significant result.

Study IV

All information about the patients was selected retrospectively from patient records via an electronic database. The data that were obtained related to age, gender, diagnosis or diagnoses given, treatment modalities applied, number of visits and assessment of complaints before and after treatment. Information on the total number and source of referrals to the department was also collected.

Descriptive statistics were performed on the study variables of age, gender, diagnoses, treatments, number of visits and complaint assessment before treatment for each year separately and for the total eight-year period as a whole. To make further comparisons possible, the numerous different diagnoses were pooled together to create diagnostic groups. Likewise, the many different ages of patients were combined to produce four age groups; ≤ 20, 21–40, 41–60 and > 60 years.

Statistical analyses of possible associations between the study variables were performed with the χ^2 test for contingency tables or Fisher's exact test. Binary logistic regression models (Appendix III) were applied in order to investigate possible explanatory associations between the study variables and the treatment outcome and the results were presented as the odds ratio (OR) and 95% confidence interval (CI). P-values of < 0.05 were regarded as statistically significant. All statistical analyses were performed using a statistical package (SPSS, version 11.5.1).

Ethical considerations

Studies I–III

The ethical principles for medical research involving human subjects according to the Helsinki Declaration (52) were followed throughout the studies.

Individuals selected for the studies received an information letter including specific information that they could withdraw from participation at any time without any personal consequences and that their individual anonymity was guaranteed. Parents of children aged 3–10 years who were invited to participate were responsible for the decision to participate or not. The involvement of children in research always raises questions related to personal integrity and autonomy, as children's autonomy cannot be guaranteed by themselves. However, the interview and the clinical examination of the children who participated in the present investigations were conducted by dentists with proficiency in child management.

Appointments in the evening were offered if daytime was inconvenient and transportation, when necessary, was organised in order to ensure fairness in the opportunity to participate. The welfare of the research subjects was guaranteed by competent investigators. Possible positive findings in the clinical and anamnestic examination were presented to participants who, when judged appropriate, were recommended to contact their dentist for suitable management.

The three fundamental ethical principles of respect for persons, distributive justice and beneficence/non-maleficence (42) were thus applied as far as possible. The investigation in 2003 was, moreover, approved by the Ethics Committee at the University of Linköping, Linköping, Sweden (ref. no. 02-376).

Study IV

The study was designed and performed as a retrospective survey of records of patient cases that had been completed and did not include any data relating to patients receiving on-going TMD treatment. Data processing and analyses were carried out at group level without referring to individual patient cases. The patients involved and, consequently, the individual case management were not affected in any way by the investigation.

The Head of the Institute for Postgraduate Dental Education, Jönköping, Sweden, was informed about and gave permission to perform the survey.

RESULTS

Prevalence of symptoms and signs

Complaints of pain in connection with the function of the masticatory system were very rarely (0–2%) reported by the parents of children 3- and 5- years of age.

In both 10- and 15-year-olds and in adults, TMJ clicking, frequent headache and jaw tiredness were the most prevalent symptoms in all three investigations. The prevalence rates for frequent headache by age group and investigation year are shown in Figure 3.

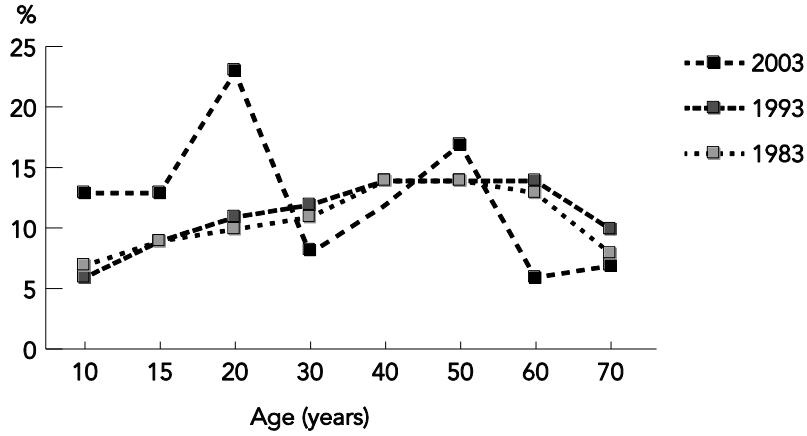

Figure 3. Distribution (%) of the prevalence of frequent headache by age group in the three investigations.

According to the Ai, approximately 84%, 90% and 84% of 10-year-olds, 79%, 74% and 74% of 15-year-olds and 73%, 67% and 62% of adults, examined in 1983, 1993 and 2003 respectively, were identified as being without symptoms (Ai 0). Mild symptoms (Ai I) were reported by around 12%, 5% and 6% of 10-year-olds, 12%, 17% and 21% of 15-year-olds and 16.5%, 17% and 22% of adults in 1983, 1993 and 2003 respectively. Severe symptoms were reported by approximately 4.5%, 5.5% and 9% among children aged 10 years, 8%, 9% and

6% among adolescents aged 15 years, while the corresponding frequencies for adults were 10.5%, 16% and 16% in 1983, 1993 and 2003 respectively. The rates for the Ai degrees are shown in Figure 4. The age distribution of the Ai II was similar in the three investigation years (Figure 5).

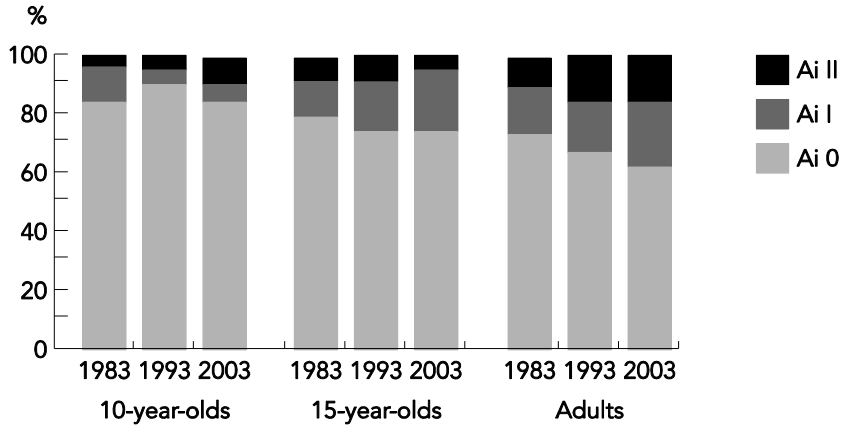

Figure 4. Prevalence frequencies (%) of the Ai degrees in children, adolescents and adults in the three investigations.

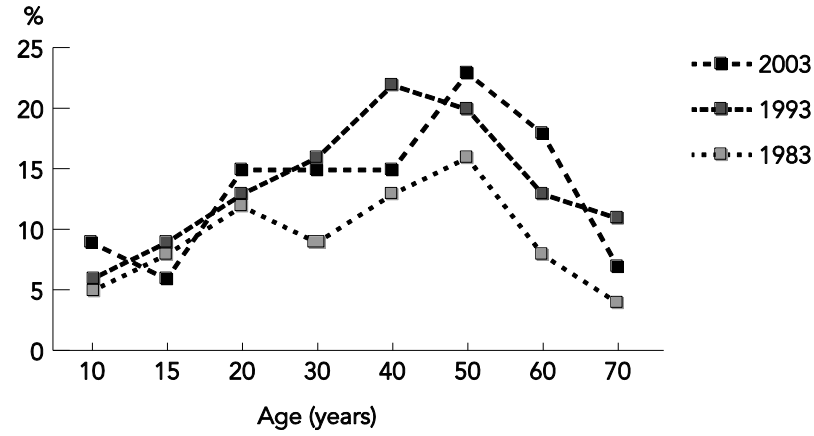

Figure 5. Distribution (%) of the Ai II by age group in the three investigations.

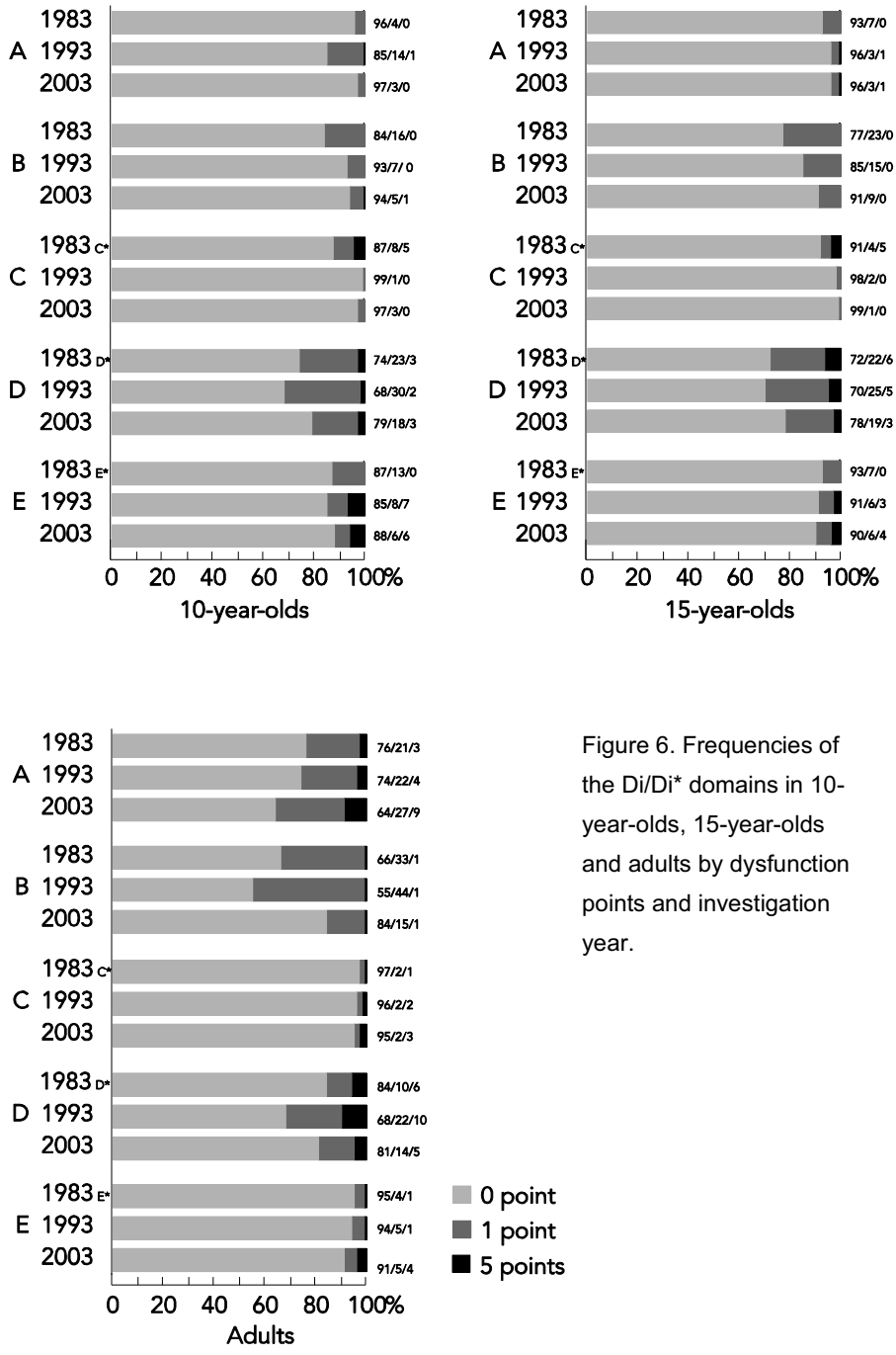

Figure 6. Frequencies of the Di/Di* domains in 10-year-olds, 15-year-olds and adults by dysfunction points and investigation year.

One or more clinical signs were registered in 34–48% of examined 10-year-olds, 36–49% of 15-year-olds and in 55–68% of adults. Muscle tenderness on palpation was the most frequent TMD sign in children and adolescents, whereas impaired TMJ function was the most commonly found sign in adults. The rates for the dysfunction points relating to the separate clinical signs and for the Di*/Di degrees in the different investigation years are presented in Figures 6 and 7. The age distribution of the combined degree group Di*/Di II/III is illustrated in Figure 8.

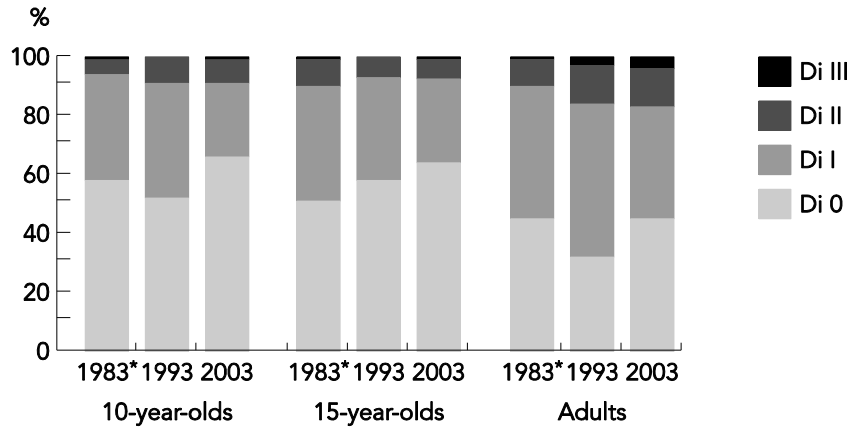

Figure 7. Prevalence frequencies (%) of the Di (1993 and 2003) and Di* (1983*) degrees in children, adolescents and adults.

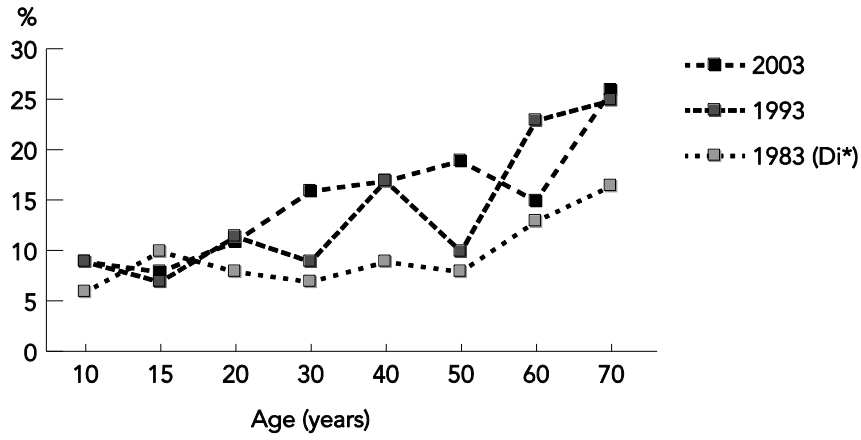

Figure 8. Distribution of the Di/Di* II/III by age group and year of investigation.

Time trends

The prevalence rates for symptoms reported by the samples fluctuated between the different examination years, but the variation for most of the symptoms did not reach statistical significance. However, the reports of TMJ clicking in adults increased to a statistically significant degree and were found to be time dependent (Table 2). On the other hand, reports of clicking were more common among 10-year-old subjects in 1983 compared with the same age group examined on the next two occasions ($p = 0.006$).

Reports of jaw tiredness in 15-year-old adolescents (4% in 1983, 9% in 1993 and 7% in 2003) and adults (8% in 1983, 10% in 1993 and 12% in 2003) increased during the 20-year study period, but the rise was not statistically significant.

Pain in the face and pain on jaw movement were more frequently reported by 10-year-olds in 2003 (4% in 2003 compared with 1% in 1983 and 1993; and 5% in 2003 compared with 3% respectively), resulting in a numerical increase in the rates for the Ai II. A rise that did not reach statistical significance was also noted for the Ai I in adolescents.

In adults, the prevalence figures for both the Ai I and II for the whole sample increased to a statistically significant degree during the studied time period. When it came to the Ai I, the increase was significant in 2003 compared with 1983 (UR, OR = 1.6, CI: 1.2–2.2, $p = 0.003$) and, for the Ai II, a similar relationship was noted for both 1993 and 2003 (Table 2).

Analyses of the age groups showed that 20-year-olds in 2003 were almost three times more likely to report frequent headache than participants of the same age in 1983 (UR, OR = 2.7, CI: 1.2–6.1, $p = 0.020$). This symptom was also numerically more frequently reported by 10- and 15-year-olds in 2003 (13% for both age groups) in comparison to 1983 (7% and 9% respectively) and 1993 (6% and 9% respectively), but the increase was not statistically significant.

Table 2. Background factors (independent variables) that reached significant associations with symptoms, awareness of bruxism and the Ai (dependent variables) in adults in univariate (UR) and multiple (MR) regression analyses.

Dependent	Independent	UR (OR, CI, p)	MR (OR, CI, p)
Recurrent	Age group	ns	
headache	20	1.8, 1.0-3.0, 0.034	
	50	1.8, 1.1-3.1, 0.025	
	Awareness of bruxism	2.8, 2.0-3.9,<0.0001	2.7, 1.9-3.7, <0.0001
	Not totally healthy	3.2, 2.3-4.3, <0.0001	3.0, 2.2-4.2, <0.0001
Jaw tiredness	Age group	p = 0.037	ns
	40	2.2, 1.2-4.0, 0.009	
	50	2.2, 1.2-4.0, 0.007	
	Female gender	1.6, 1.1-2.2, 0.006	1.6,1.1-2.3, 0.009
	Awareness of bruxism	6.0, 4.2-8.4, <0.0001	5.6, 3.9-8.0, <0.0001
	Not totally healthy	2.4, 1.7-3.4, <0.0001	2.4, 1.7-3.5, <0.0001
Pain in	Age group	ns	
the face/jaws	50	3.3, 1.2-9.0, 0.023	
	Awareness of bruxism	5.3, 3.1-8.9, <0.0001	4.9, 2.9-8.2, <0.0001
	Not totally healthy	3.5, 2.1-5.9, <0.0001	3.3, 2.0-5.6, <0.0001
TMJ clicking	Year of investigation	p= 0.002	p= 0.006
	1993	1.4, 1.0-1.9, 0.025	ns
	2003	1.7, 1.3-2.3, <0.001	1.7, 1.2-2.3, 0.001
	Age group	p= 0.016	p= 0.011
	30	1.8, 1.2-2.8, 0.004	2.1, 1.3-3.4, 0.002
	40	ns	1.6, 1.0-2.7, 0.049
	Awareness of bruxism	1.8, 1.3-2.4, <0.001	1.5, 1.1-2.0, 0.010
	Not totally healthy	1.4, 1.1-1.9, 0.012	1.7, 1.2-2.3, 0.001
Locking/catching	Age group	p= 0.017	ns
	20	3.0, 1.2-7.6, 0.024	
	30	3.6, 1.4-9.1, 0.006	
	50	4.6, 1.9-11.3, 0.001	
	Awareness of bruxism	3.1, 2.0-4.7, <0.0001	3.1, 2.0-4.7, <0.0001
Ai II	Year of investigation	p = 0.004	ns
	1993	1.7, 1.2-2.4, 0.004	
	2003	1.8, 1.2-2.5, 0.002	
	Age group	p= 0.001	p= 0.010
	20	2.0, 1.1-3.5, 0.018	ns
	30	2.2, 1.3-3.9, 0.006	2.3, 1.2-4.5, 0.009
	40	2.7, 1.6-4.8, <0.001	2.5, 1.3-4.7, 0.004
	50	3.2, 1.8-5.4, <0.001	3.0, 1.6-5.5, <0.001
	60	1.8, 1.0-3.2, 0.047	ns
	Awareness of bruxism	4.9, 3.5-6.7, <0.0001	4.3, 3.1-6.1, <0.0001
	Not totally healthy	2.1, 1.5-2.9, <0.0001	2.4, 1.7-3.5, <0.0001

Dependent	Independent	UR (OR, CI, p)	MR (OR, CI, p)
Awareness of bruxism	Year of investigation	p= 0.001	p < 0.001
	1993	1.4, 1.0-1.9, 0.049	ns
	2003	1.8, 1.3-2.5, <0.001	2.0, 1.4-2.7, <0.0001
	Age group	p< 0.0001	p < 0.0001
	20	3.0, 1.8-5.3,<0.0001	3.9, 2.2-6.9, <0.0001
	30	2.7, 1.5-4.7,<0.001	3.4, 1.9-6.1, <0.0001
	40	4.0, 2.3-6.9, <0.0001	5.1, 2.9-8.9, <0.0001
	50	2.8, 1.6-4.9, <0.001	3.2, 1.8-5.7, <0.0001
	60	ns	1.8, 1.0-3.4, 0.047
	Not totally healthy	1.5, 1.1-2.0, 0.005	2.0, 1.5-2.7, <0.0001

Year of investigation: "1983", Age group: "70", Gender: "male", Awareness of bruxism: "no", and, Self-perceived health impairment: "totally healthy" were used as referents. UR= univariate regression analysis, MR= multiple regression analysis, ns= not significant.

Reports of tooth clenching or grinding among adults increased gradually (1983: 14%, 1993: 18%, 2003: 23%) and statistically significantly during the 20-year study period and showed significant time dependence (Table 2). Individuals aged 20, 30 and 40 years examined in 2003 were two to three times more likely to be aware of these oral parafunctions compared with participants of the same ages examined in 1983.

Among the clinical signs, in adults, severely impaired jaw movement capacity was statistically significantly more frequently registered in 2003 compared with the 1983 investigation (Table 3). Analyses of the subgroups showed that the increase in this sign was only statistically significant for women (OR = 4.0, CI: 1.8–8.5, $p < 0.001$) and that the variance could be primarily explained by differences in the horizontal movement capacity (Table 4).

The prevalence figures for domains C, D and E, as well as for the Di, in adults, were only tested for significant changes between 1993 and 2003. TMJ pain on palpation posteriorly was found to have increased statistically significantly in 2003 compared with 1993, whereas pain in > 3 jaw muscle sites was more frequently registered in 1993 compared with 2003 (Table 3). Differences across genders were observed for both these signs, but the increase in the former was only significant in women (OR = 5.2, CI: 1.7–15.6, $p = 0.003$), while the variance in the latter was only related to the male population (OR = 0.2, CI: 0.9–0.5, $p < 0.001$). Statistically significant changes during this 10-year period were found neither for pain on ≥ 2 jaw movements nor for the Di degrees.

Table 3. Background factors (independent variables) that reached significant associations with clinical signs and the Di*/Di (dependent variables) in adults in univariate (UR) and multiple (MR) regression analyses.

Dependent	Independent	UR (OR, CI, p)	MR (OR, CI, p) Adjusted for gender and age
Impaired jaw movement capacity (A) (1983ˣ-2003)	Investigation year	<0.001	<0.001
	2003	3.0, 1.7-5.2, <0.001	3.2, 1.8-5.8, <0.001
	Age group	0.001	
	40	9.6, 2.2-42.0, 0.003	
	50	7.1, 1.6-31.2, 0.010	
	60	12.3,2.9-52.7, 0.001	
	70	13.4,3.1-57.4, <0.001	
	Not totally healthy	1.7, 1.1-2.9, 0.030	ns
	Denture wearer	3.6, 2.0-6.2, <0.001	2.4, 1.1-5.3, 0.035
Pain on jaw movement (C) (1993ˣ -2003)	Awareness of bruxism	3.2, 1.5-6.7, 0.002	3.0, 1.3-6.6, 0.008
	Not totally healthy	4.8, 2.3-10.1, <0.001	4.4, 2.0-9.7, <0.001
	Denture wearer	3.3, 1.2-9.0, 0.017	ns
Muscle pain (D) (1993ˣ -2003)	Investigation year		
	2003	0.4, 0.2-0.6, <0.001	0.3, 0.2-0.6, <0.001
	Age group	0.017	
	70	2.0, 1.0-4.9, 0.048	
	Awareness of bruxism	2.0, 1.2-3.3, 0.006	2.5, 1.4-4.2, 0.001
	Not totally healthy	2.4,1.5-3.9, <0.001	1.8, 1.1-3.1, 0.024
	Denture wearer	3.6, 1.9-6.9, <0.001	3.1, 1.3-7.9, 0.015
Muscle pain (D*) (1983)	Female gender	3.1, 1.4-7.0, 0.006	
	Not totally healthy	4.5, 2.2-9.1, <0.001	4.0, 1.8-8.8, 0.001
TMJ pain (E) (1993ˣ -2003)	Investigation year		
	2003	3.2, 1.4-7.2, 0.005	3.5, 1.5-8.3, 0.005
	Female gender	2.4, 1.1-5.3, 0.029	
	Awareness of bruxism	2.6, 1.2-5.5, 0.013	2.3, 1.1-5.1, 0.032
Di (1993ˣ -2003)	Age group	0.003	
	60	1.9, 1.0-3.4, 0.043	
	70	2.8, 1.6-4.9, <0.001	
	Female gender	1.5, 1.1-2.1, 0.011	
	Awareness of bruxism	1.8, 1.3-2.7, 0.001	2.1, 1.4-3.1, <0.001
	Not totally healthy	2.6, 1.8-3.8, <0.001	2.2, 1.5-3.2, <0.001
	Denture wearer	4.4, 2.6-7.6, <0.001	3.4, 1.6-7.3, 0.002
Di* (1983)	Female gender	2.5, 1.4-4.6, 0.002	
	Not totally healthy	2.5, 1.4-4.4, 0.001	2.0, 1.1-3.7, 0.027
	Denture wearer	2.5, 1.3-4.8, 0.009	ns

UR= univariate regression analysis, MR= multiple regression analysis, ns= not significant. C*, D*, E* = modified (C), (D), (E) domains in 1983; Di* = modified Di in 1983.

Investigation year: "x", Age group: "20", Gender: "male", Awareness of bruxism: "no", Self-perceived health impairment: "totally healthy", and, Denture wearer: "no" were used as referents.

Slightly impaired jaw movement capacity in children aged 10 years was statistically significantly increased in 1993 compared with the other two investigations years ($p < 0.001$). Impairment of TMJ function was more frequently registered in 1983 compared with the other two examinations in both the 10-year-olds ($p = 0.017$) and in the 15-year-olds ($p = 0.029$). Some variation, even if it was not statistically significant, over time was noted for the signs C, D and E and the Di degrees in both children and adolescents.

Table 4. Percentage distribution of impaired jaw movement capacity in adults by dysfunction points and investigation year.

Jaw movement	1983 0/1/5	1993 0/1/5	2003 0/1/5
Maximum opening	89.7/9.9/0.3	92.8/6.5/0.7	90.4/9.6/0.0
Maximum laterotrusion, right	94.0/5.5/0.5	90.4/8.1/1.6	85.8/10.7/3.5
Maximum laterotrusion, left	93.8/5.5/0.7	94.4/5.1/0.5	83.2/13.5/3.3
Maximum protrusion	84.1/13.7/2.2	84.6/13.2/2.3	73.1/21.9/5.0

Background factors

Age

Symptoms and signs showed differentiated age patterns in adults. Dissimilarities were also found among various symptoms, as pain complaints and tiredness in the jaws were related to older age groups than TMJ clicking and locking/catching (Table 2). In general, reports of severe symptoms (Ai II) increased gradually, peaked at 40 or 50 years and decreased in the older age groups (Figure 3, Table 2). Likewise, awareness of bruxism was more frequently reported

by young and middle-aged subjects than older adults (Table 2). Almost the same pattern as that for severe symptoms was also noted for frequent headache in the investigations in 1983 and 1993. In 2003, however, a change in the relationship to age was observed, as the symptom showed its highest prevalence in the youngest age group, that of 20 years (Figure 2, Table 2). Moderate to severe clinical signs (Di II/III), on the other hand, increased somewhat with increasing age but rose sharply after 50 years to peak at the oldest examined age group, that of 70 years (Figure 4, Table 3). Individuals of ≥ 40 years of age ran a much higher risk of having severely impaired jaw movement capacity than younger subjects and muscle pain in > 3 sites was statistically significantly associated with the age group of 70 years (Table 3).

Among children and adolescents, both symptoms and signs increased gradually with advancing age. Individuals in the 10 and 15 year age groups reported pain/discomfort on chewing six times more frequently than the parents of 3-year-olds (10-year-olds: OR = 6.0, CI: 1.3–26.6, p = 0.019; 15-year-olds: OR = 5.5, CI: 1.2–25.0, p = 0.026). Adolescents aged 15 years reported tiredness in the jaws on waking or on chewing (OR = 2.4, CI: 1.1–5.2, p = 0.033), TMJ clicking (OR = 2.9, CI: 1.7–5.1, p < 0.001) and catching/locking of the mandible (OR = 6.7, CI: 1.5–30.6, p = 0.013) statistically significantly more frequently than 10-year-olds. Similarly, slightly impaired TMJ function was registered more frequently among subjects aged 15 years compared with 10-year-olds (OR = 1.8, CI: 1.1–2.9, p = 0.021).

Gender

Some symptoms and signs in adults were found to be gender dependent. Jaw tiredness (Table 2), TMJ pain upon posterior palpation and muscle pain upon palpation provoking a palpebral reflex (Table 3) were statistically significantly more commonly found in women than in men. A similar relationship was shown for Di II/III (Table 3).

Moreover, frequent headache was related to female gender in children and adolescents (MR; 1983: OR = 3.3, CI: 1.1–10.0, p = 0.038, 1993: ns, 2003: OR = 5.0, CI: 1.7–14.6, p = 0.004) and in 20-year-olds (UR, OR = 2.1, CI: 1.0–4.1, p = 0.043).

Awareness of bruxism

All TMD symptoms in adults, with the exception of TMJ crepitations, were strongly associated with an awareness of tooth clenching/grinding. Table 2 shows the associations for recurrent headache, jaw tiredness, pain in the face/jaws, TMJ clicking and locking/catching. Other TMD symptoms were dependent on reported bruxism as follows: luxation (UR/MR: OR = 3.9, CI: 1.8–8.3, $p < 0.001$); difficulty in jaw opening (UR: OR = 3.1, CI: 2.0–5.0, $p < 0.0001$; MR: OR = 3.1, CI = 1.9–4.8, $p < 0.001$); pain on jaw movement (UR: OR = 5.2, CI: 2.7–9.9, $p < 0.0001$; MR: OR = 4.9, CI: 2.5–9.3, $p < 0.0001$). A similar relationship was found for the Ai I (UR: OR = 2.6, CI: 1.9–3.6, $p < 0.0001$; MR: OR = 2.4, CI: 1.7–3.3, $p < 0.0001$) and the AI II (Table 2). Furthermore, the only factor that was able to discriminate statistically significantly between subjects with Ai I and Ai II was awareness of bruxism (UR/MR: OR = 1.9, CI: 1.3–2.7, $p = 0.001$).

Adults reporting bruxism were registered two to three times more frequently with pain on jaw movements and on palpation of jaw muscles and TMJs and were therefore also more commonly classified as having a moderate to severe clinical dysfunction, viz. Di II/III (Table 3). A statistically significant relationship between awareness of bruxism and Ai II was, moreover, found in the age groups of 10- and 15-year-olds (MR: OR = 6.9, CI: 1.8–26.9, $p = 0.005$).

Among children and adolescents, reports of oral parafunctions were generally common. In 2003, 23% and 19% of the parents of the children in the age groups of 3- and 5-year-olds had noticed that their child used to clench or grind his or her teeth. In the same year, 12% of the examined 10-year-olds and 11% of the 15-year-olds were aware of tooth clenching and/or grinding. Furthermore, 47% of the 10-year-old children and 44% of the 15-year-old adolescents examined in 1983 reported nail biting.

Wearing of complete dentures

A declining percentage of the adult samples wore complete dentures in one or both jaws: 13% in 1983, 8% in 1993 and 3% in 2003. Denture wearers were found not to differ from non-denture wearers in terms of any symptoms or reported bruxism, but, as expected, they had a higher median age than non-wearers (65 ± 7.2 years and 43 ± 16.6 years respectively). On the other hand,

individuals wearing complete dentures ran a higher risk of having impaired jaw movement capacity, muscle palpation pain and Di II/III than non-wearers (Table 3).

Trauma

No statistically significant associations between reported trauma to the face and any particular symptoms or clinical signs, the Ai or the Di as a whole, could be revealed.

General health aspects

In adults, all TMD symptoms, except for locking/catching and luxation of the mandible, were found to be dependent on self-perceived health impairment. The associations for recurrent headache, jaw tiredness, pain in the face/jaws, TMJ clicking and locking/catching are shown in Table 2. Other TMD symptoms were associated as follows: TMJ crepitations (UR/MR: OR = 2.8, CI: 1.6–5.1, $p < 0.001$); difficulty in jaw opening (UR: OR = 2.0, CI: 1.2–3.1, $p = 0.004$; MR: OR = 1.9, CI: 1.2–3.1, $p = 0.006$); pain on jaw movement (UR: OR = 2.4, CI: 1.3–4.7, $p = 0.009$; MR: OR = 2.2, CI: 1.1–4.4, $p = 0.019$). Consequently, a similar relationship was found for the Ai I (UR: OR = 1.7, CI: 1.3–2.3, $p < 0.001$; MR: OR = 2.2, CI: 1.6–3.1, $p < 0.001$) and the Ai II (Table 2). Furthermore, individuals perceiving health impairment were more frequently registered with pain on jaw movements, muscle pain and a higher degree of clinical dysfunction (Table 3).

Children on regular medication reported pain or discomfort on chewing three times more frequently compared with those who were not receiving any regular medication (OR = 3.0, CI: 1.1–8.1, $p = 0.033$). Subjects aged 10 and 15 years who were receiving medical treatment ran a higher risk of reporting jaw tiredness (OR = 3.3, CI: 1.2–8.9, $p = 0.021$) and problems with catching or locking of the jaw (OR = 5.5, CI: 1.6–18.8, $p = 0.006$). Moreover, it was observed that children and adolescents who had a clinical dysfunction of Di II or III reported that they were on medical treatment statistically significantly more frequently than those who had a clinical dysfunction of Di I (OR = 3.5, CI: 1.4–8.8, $p = 0.008$).

Estimated treatment need

Among children 10 years of age and adolescents aged 15 years, only 1-3 subjects (1–2%) in each age group and at each examination fulfilled the criteria for treatment need.

Among adults, in 1983, 2.5% of men and 7.5% of women (5% total) met the criteria (TNest*). In 1993 and 2003 respectively, the figures for TNest were 7% for men and 8% for women (7.5% total) and 5% for men and 11% for women (8% total). The female predominance was statistically significant in both TNest* (OR = 3.2, CI: 1.3–7.5, p = 0.009) and TNest (OR = 1.6, CI: 1.0–2.5, p = 0.047).

Patient and treatment characteristics

Of 3,194 subjects examined, 74% were females and 26% were males. For both genders, the mean age was 42 years (range: 9–90 years). The most common diagnosis was disc displacement (29%), with (18%) or without (11%) reduction, followed by tension-type headache (19%), myo-arthralgia (18%), arthritis (14%), myalgia (11%), osteoarthrosis (OA) in TMJs (10%), orofacial pain of unspecified origin (6%), henceforth called orofacial pain, and rheumatic disease affecting the TMJs (4%). Some diagnoses were found to be associated with gender and age group. The combined diagnosis of myo-arthralgia was related to female gender ($p < 0.001$), while disc displacement with reduction was more frequently diagnosed among males ($p < 0.001$). Disc displacement with and without reduction was related to the age group of < 21 years ($p < 0.001$), whereas orofacial pain was a less common diagnosis among these patients ($p < 0.05$); myo-arthralgia ($p < 0.001$) and tension-type headache were diagnosed more frequently among patients aged 21-40 ($p < 0.001$) and OA in TMJs was associated with the age group of > 60 years ($p < 0.001$).

In 2,594 patients, 4,984 registrations of performed treatment modalities had been made (mean: 1.9/patient). Three of four patients had been instructed to perform therapeutic jaw exercises, while 1,450 patients (56%) had received some kind of interocclusal appliance. Ninety-one per cent of the appliances

were made of hard acrylic and the most common type was the stabilisation appliance. Selective occlusal adjustment had been performed to a varying extent in 765 cases (29%), while 319 (12%) had been prescribed some kind of medication, mostly analgesics or NSAIDs.

A higher proportion of women than men ($p < 0.001$) visited the clinic more than 8 times. The patient's age was also related to the number of visits ($p < 0.001$); comparatively, a smaller proportion of patients > 60 years made more than 8 visits.

Treatment outcome

In 1,732 of the 2,206 patients (79%) who had visited the clinic on more than one occasion, notes of the degree of complaints had been made on both the first and last visit. More than half the patients rated their initial complaints as fairly severe or very severe. After treatment, 85% of the patients reported an improvement, and three of four rated their residual complaints as mild or insignificant (Figure 9).

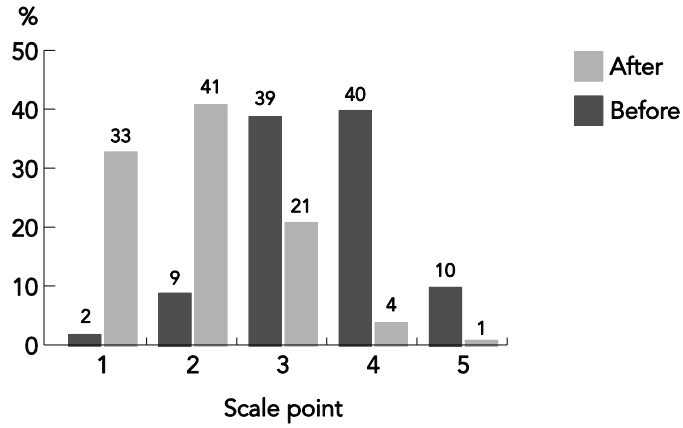

Figure 9. Rating of subjective complaints before and after treatment according to a 5-point scale (1= no or insignificant, 2= mild, 3= moderate, 4= fairly severe, 5= very severe) in 1,732 patients.

The variable improvement was statistically significantly associated with the patient's gender ($p < 0.05$) and with symptom severity before treatment ($p < 0.001$). Proportionally more women than men reported an improvement and those patients who initially rated their complaints as fairly severe or very severe reported an improvement more frequently than those who rated them as moderate or as lower than that. No relationship between age, diagnosis or number of visits and the dichotomous variable of improvement/no improvement was found.

When defining improvement as a difference of at least one scale point on complaint assessment after treatment, no statistically significant associations between any of the studied variables and the treatment outcome could be found using regression analyses. However, if improvement was defined as at least a two-step change on the scale, three diagnoses, disc displacement without reduction, arthritis and myalgia, were all statistically significantly associated with a favourable treatment outcome (OR = 2.1, CI: 1.5–2.9; OR = 1.9, CI: 1.4–2.6; OR = 1.8, CI: 1.2–2.7 respectively), while one diagnosis, orofacial pain, was correlated to a negative one (OR = 0.6, CI: 0.4–1.0).

Time trends (Study IV)

None of the studied variables, number of referrals, patient's gender and age group, diagnoses, treatment modalities, initial degree of complaints, number of visits, or treatment outcome, showed any variations between years or over time that could disclose any time trends.

DISCUSSION

Methodological considerations

Studies I–III

To the best of our knowledge, the present series of investigations, with its repeated cross-sectional design, is the first to focus on possible time trends in the prevalence of TMD symptoms and signs in the population over a long period of time. There are many inherent difficulties in a task of this kind when it, first and foremost, comes to methodological considerations. The once chosen outcome variables, method and instrument used, and sometimes even the study rationale, are prone to, and challenged by, ongoing research progress during the time that has elapsed since the investigation was designed. On the other hand, the longitudinal approach allows for unique observations and the information that is derived can be extremely valuable, especially in planning and allocating public health resources.

The present research design, examining certain age cohorts that cover almost the whole age span in certain time spans, allows for control of age, cohort and time effects (227) and has been thought to contribute to improved forecasts of future health panoramas (90). Age effects are attributed to various processes in the biological, behavioural and psychological sphere related to ageing (3); cohort effects represent the historical interplay between life conditions, such as economic, demographic, political or environmental, and socialisation (221); while time or period effects disclose the consequences of the events, physical or social, that have taken place during the studied period of time and that are common to the entire population (3). The present studies have only explored the effects of age and time, using a mainly cross-sectional and, to some extent, time lag (227) approach, also called time-sequential analysis (227). The present results may have been confounded by cohort effects that have not been considered. The difficulties when attempting to disengage age, cohort and time effects have been discussed (3) and caution has been suggested when interpreting cross-sectional data (150).

Cross-sectional studies, which have been widely used worldwide in public health research, aim to describe a whole population at the time of ascertainment, usually based on representative samples of this population (222), and can provide significant information on factors associated with the risk of disease (129). However, they are unable to disclose causation because of the presence of confounders and the fact that they do not offer information on the temporal association between the condition and possible risk factors examined, although they can provide a strong basis for generating hypotheses about these relationships (129). The present results therefore only consider associations between studied variables and should not be interpreted as evidence of causal relationships.

Drangsholt & Leresche (59) stated that "determining trends in the prevalence of TMD pain will not be easy" and suggested the use of the same definitions and methods in similar population years at a later stage as critical factors. These factors have mainly been followed in the present series of studies. However, inconsistency in the registrations of clinical signs compromises the validity of the present results in terms of trends for signs. The criteria for three of the Di domains were somewhat altered in 1983. This has probably affected the results regarding the prevalence of these domains and of the Di* as a whole in this year. For this reason, no statistical comparisons were made between the prevalence figures for these three domains and the index degrees in 1983 and the next two investigations and separate regression analyses were applied to these altered variables. Moreover, a less than optimal registration of TMJ sounds in the 2003 study might have had some bearing on the documented prevalence of the "impaired TMJ function" domain and of the Di degrees in 2003. Some caution is therefore recommended when interpreting differences in the prevalence of this domain and of the Di degrees between the examinations.

In order to be able to extrapolate the findings of an epidemiological survey, the sample has to be representative of the population and the participation rate must at least be acceptable. The present samples were random age-stratified selections from the inhabitants of the city of Jönköping and an overall participation rate of 68–77% is acceptable and comparable to figures reported in other epidemiological surveys (14, 118,122,262). The response rate in the present series of investigations was somewhat lower in 2003 than on the two previous examinations. However, the reasons for not participating were similar on all

three occasions (107–109) and to reasons described by others (14). Furthermore, in 2003, the demographic composition of the city of Jönköping was similar to this for the country as a whole, particularly with regard to rates of foreign-born citizens (www.scb.se) and of ill-health (www.forsakringskassa.se). We therefore assume that the present findings can be regarded as representative of the Swedish non-patient populations from which the samples have been extracted and that the investigations have good generalisability.

One common concern in epidemiological research is the validity and reliability of the method used to assess the presence of a disorder. Questionnaires are a very common data source and are generally regarded as reliable (122), although their validation is not easy. The present questionnaire, produced in the early 1980s, was not validated before the start of the study. However, these questions remained basically unchanged throughout the investigation in order to facilitate the comparison of longitudinal data. Further information was collected using a structured interview conducted by experienced dentists. One inherent disadvantage of an interview is that the answers can be biased by the face-to-face communication with the interviewer. Another disadvantage is that the information that is given may vary between different interviewers. In this study, all the included items were described in written form in detail in order to be formulated and, if needed, explained in the most standardised manner possible.

The two questions used in the questionnaires addressed to children and adolescents, "Do you have pain or discomfort in your jaws on chewing?" and "Do you have pain or discomfort in your jaws on opening your mouth?", have been widely used but have not been validated. It is well known that questions relating to pain may be difficult to apply to children at different stages of cognitive development (170). Children's ability to think in an abstract manner is not fully developed until the age of 12 (82) and, as a result, they may lack the ability before that age to relate or express their pain in a conventional way. As a result, only the two above-mentioned questions were addressed to the youngest individuals of 3 and 5 years of age and they were answered by their parents. Nevertheless, information about pain experience in children and adolescents is of importance and may have an impact on predicting pain later in life. In a longitudinal study of 335 children aged 8-14, Brattberg (15) found that reports of pain in childhood and early adolescence are associated with reports of pain in early adulthood and she recommended that "more attention should be given to problems of pain and ill-health in childhood, especially among young girls".

The potential influence of inter- and/or intra-observer variability on the reliability of the results is also a common methodological question for many population studies, especially those on a larger scale, where clinical examination is included. Earlier research has shown that variability between observers in the clinical registrations of some TMD signs, particularly those related to palpation findings, can be high and that it is generally greater than intra-observer variability (24,136,265). It has therefore been suggested that registrations in longitudinal studies should be performed either by the same observer (24) or by selected examiners undergoing repeated training and calibration (153). In the present series of investigations, the subjects were examined by seven (1983 and 1993) or eight (2003) experienced dentists. Two of them were the same in all three examinations and two others contributed on two occasions. Although the examiners were calibrated in terms of the clinical TMD signs to be registered before the start of each investigation, no particular estimation of inter- or intra-observer variability was made. Consequently, the registration of clinical signs and estimations of the resulting Di might have been affected by examiner variations.

In the present investigations, the Helkimo Indices (96) were applied for assessments of TMD symptoms and signs in the examined samples. These indices have been widely used since the 1970s in both epidemiological and clinical research and have previously been regarded as the "gold standard" in the assessment of TMD. The constructed validity and utility of the indices have been discussed and criticised (86,261). However, an international workshop in 1998 on the epidemiology of temporomandibular disorders concluded that "Core variables of anamnestic symptoms are: pain in the masticatory muscles and temporomandibular joints, mouth opening restrictions, as well as TMJ clicking and crepitation. Core variables of clinical signs are: palpatory and movement pain related to the masticatory musculature and TMJs, the movement capacity of the mandible, as well as TMJ clicking and crepitation" (119). These are the same core variables on which the anamnestic and clinical dysfunction indices are built, indicating a reasonable clinical relevance of the index system (99).

However, there are certain shortcomings when it comes to using the Ai and the measurement of the point prevalence of the symptoms is one of the most important ones. It has been shown that prevalence figures are highly dependent on the methodology used, i.e. questions on point prevalence or over a period of

time or in combination with features relating to intensity and frequency result in distinctly different prevalence rates (244). The individual queries used in the present material considered neither the frequency nor the intensity of the symptoms, factors that have been shown to affect prevalence estimates and have been said to increase the reliability and the clinical relevance (244). The more frequent and intense a symptom is, the greater the perceived impairment and, possibly, the more probable the presence of the disorder to be measured. This additional kind of information would therefore greatly improve the reliability of the measurement.

It can moreover be argued that the present investigations have not used the RDC/TMD, diagnostic criteria that were subsequently established and are frequently applied nowadays and that also include the assessment of psychosocial and behavioural factors (63). However, the validity of these criteria has also been criticised (243) and efforts have been made to improve it (228). It has to be remembered that the Helkimo Indices were constructed as a criteria system, assessing the presence and severity of TMD symptoms and signs, and not as a diagnostic instrument, which fits the purpose of the present studies that was to assess the prevalence figures of reported complaints or registered clinical signs commonly associated with the presence of TMD and not to diagnose specific TMD categories in the population. The consistent application of the same index system has also been important for the comparability of the data in a longitudinal perspective.

The use of the Di made it possible to select and focus on severe signs as outcome variables in Study III. The main reason for this selection was that mild TMD signs, e.g. TMJ sounds and muscle palpation pain in < 3 sites, are very common in the population and do not always relate to pathology and are thereby of less clinical relevance. In addition, these signs are more susceptible to spontaneous fluctuations which can affect the point prevalence derived from the clinical registration on one occasion. In general, the use of a severity index of this kind is valuable in documenting the burden of TMD symptoms and signs in the population and it probably provides a more correct description than the use of prevalence figures for separate symptoms and signs themselves (145).

Study IV

One main consideration when it comes to the methodology in this survey is the lack of application of standardised diagnostic criteria system. The use of ICD taxonomy has been common in clinical settings worldwide during the past few decades, although it does not provide any diagnostic assistance and instead functions as a tool for the statistical arrangement of diagnoses. The diagnoses applied in the present survey have been based on the findings in the history taking, the clinical examination and, when judged necessary, radiographic examination, according to diagnostic procedures (29) employed at the Department of Stomatognathic Physiology, The Institute for Postgraduate Dental Education, Jönköping, Sweden.

The clinical examinations and the applied treatments have been performed by different dentists, who were either TMD specialists or dentists undergoing specialist training and were thus calibrated to the educators. The examiner variability, however, has not been estimated and may have affected the reliability of the results.

Another issue is the validity of the outcome measurement on the basis of a global symptom assessment performed through the application of a verbal rating scale. This Likert scale has been shown to have good precision and sensitivity when grading TMD pain (40,171). Global subjective ratings, in general, have been considered useful in the evaluation of treatment outcome, even when multifaceted problems and treatments are included, despite common drawbacks of poor construct validity and reliability and being too general (129). In recent years, and after the completion of the present study, a more comprehensive system for measuring treatment outcome in clinical trials of chronic pain has been established [IMMPACT] (256), suggested for and nowadays frequently applied in TMD-pain research (58,92,197). According to IMMPACT recommendations, core domains for assessing treatment outcome should be pain, physical and emotional functioning, adverse events and participant disposition as well as participant rating of improvement. Furthermore, the present study has solely estimated the short-term treatment outcome and provides no information about any consistency in the observed symptom reduction over time.

Reflections on the results

Time trends

To the authors' knowledge, no previous information is available regarding time trends for the prevalence of TMD symptoms and signs for almost the entire age span and over a long period of time. It has been stated (59), and it was shown here, that disclosing time trends is not an easy task.

Among children and adolescents, no obvious trends relying on statistically significant changes in the prevalence of TMD symptoms and signs in overall terms could be identified during this period. In adults, the prevalence of a few separate symptoms reported by individuals in specific age groups and the overall reported symptoms, expressed as Ai I and II, increased to a statistically significant degree. The increase in the rates of the Ai I probably reflects the significant increase observed in reported TMJ clicking. No statistically significant changes in the prevalence of any specific symptoms included in the Ai II were shown. For this reason, the increase in this index degree could be explained by an overall rise in most of the involved symptoms. Whether this result is also influenced by inherent shortcomings of the index used is not known.

A Swedish epidemiological study (258) of two cohorts of 50-year-old subjects found that orofacial pain symptoms and reported bruxism increased significantly during a 10-year period (1992–2002) that is chronologically very close to the second half of the present surveys (Studies I-III). The authors (258) concluded that the observed increase in symptoms was concurrent with social and structural changes in society, probably reflecting increased levels of stress for individuals. For decades, psychosocial elements have been considered in TMD etiology (74,77,123,191,194). Factors, such as anxiety, depression (74,219,239), neuroticism (74), perceived stress and mood (239) and perception of control (225) have been in particular found to be related to temporomandibular pain and reports have also shown a relationship between stress and headaches (284). During the 1990s, an increase in stress-related disorders and sick leave was noted in Sweden (115). Stress connected to health and work-related issues has been found to be associated with pain but also with work performance (247) and potentially with increased sick leave (5). Moreover, a significant increase in other pain symptoms during the last few years has been noted. An almost two-fold

increase in the prevalence of neck-shoulder-arm pain with concurrent psychological distress was found among adults in the county of Stockholm, Sweden, between 1990 and 2002 (143). In the same population, an increase in low back pain with psychological distress, especially among women, was also found between 1990 and 2006 (144). The present findings of an increase in both the Ai degrees over a 20-year period, as well as reports of an increase in orofacial pain symptoms (258), could be seen in the same context.

One striking observation in the present material was that of a prevalence of frequent headache in young individuals aged 20 years in 2003 that was more than twice as high as it was 20 or 10 years earlier. In this age group, this symptom was found to be related to female gender. Data (72) based on the same populations as the present investigations (Studies I–III) point to a similar and proportional increase in loneliness among women in this age group during the same time period. Information on any time trends in headache prevalence in the adult population is sparse, but a Danish study of 25- to 36-year-olds found that the prevalence of frequent tension-type headache in particular increased significantly during a 12-year period and that female gender was a risk factor (162). A dramatic increase in tension-type headache was also disclosed in a study of subjects > 15 years during a six-year-period in Hong Kong (35). On the other hand, a survey of almost 40,000 adult Norwegians found a small decrease in the prevalence of non-migrainous headache during an 11-year period (149).

Frequent headache was more commonly reported by 10- and 15-year-olds in the present 2003 investigation compared with the two previous examinations, but the differences did not reach statistical significance. However, there is evidence supporting an increasing prevalence of headaches in children and adolescents (141). In the Health Behaviour in School-aged Children survey, a cross-national survey conducted by the WHO, analyses of the Swedish data have shown that the proportion of 15-year-olds reporting headache at least once a week rose from 24% to 42% during the last two decades, from 1983/1984 to 2005/2006 (151). A significant increase in the prevalence of recurrent (30% to 35%) and tension-type (19% to 22%) headache was also found during a four-year period, 1995–1997 to 1999–2001, among individuals aged 16–20 years in an extensive population survey (HUNT) in Norway (116). Furthermore, in a series of cross-sectional studies of 23,871 Danish children aged 11, 13 and 15 years, an increase in the medication used for headaches from 5% to 41.5% was

found from 1988 to 2006 (106). The same report concluded that there was an overall increase in psychological problems and medication for different kinds of ache (106). In a Swedish longitudinal study of 1,908 9-, 12- and 15-year-olds, Brun Sundblad et al. (19) found that, in the case of girls, stress was significantly related to pain complaints, including headaches and musculoskeletal pain, and to perceived health. Lindgren & Lindblad (151) discussed the observed gradual deterioration in self-reported health and well-being among Swedish youth in what they called the "enigma of the welfare state" and concluded that it might be "a late adverse effect of welfare society and its inherent values". The same authors discussed some society-related factors, such as what they called a "stress panic" phenomenon, as possible mediators but they also related to reports of increased frequent stress among adolescents of school age from 1997 to 2003 (151).

Some trends in the prevalence of severe clinical signs were noted in adults examined in the present studies. The finding of increased severely impaired jaw movement capacity, especially in women and only relating to horizontal movements, is difficult to explain, as the vertical jaw movement capacity had not changed to a statistically significant degree during the 20 years (1983-2003) and the prevalence of pain on jaw movement did not vary between the last two examinations (1993 and 2003). Moreover, the elapsed period of twenty years is probably too short to allow for hypothetical evolutionary changes in the TMJ anatomy to be expressed as reducing jaw mobility in the population. In addition, the present investigations do not provide information on the exact position and function of the articular disc or the function of the ligaments of the TMJs, which are anatomical elements that also regulate jaw mobility.

The interpretation of the observed increase in the prevalence of pain on distal TMJ palpation in women in 2003 compared with 1993 is also challenging, as no changes were noted in palpation of the TMJ laterally. Likewise, there is no simple explanation for the finding of a higher frequency of muscle palpation pain in men in 1993 than in 2003. These results might represent actual and feasibly temporary changes in the palpation sensitivity of the TMJ and jaw muscles. However, the validity of palpatory findings can also be questioned because of methodological shortcomings related to unknown observer variation and a probable lack of precision in the examination procedures that were applied. The changes over time that were found in the prevalence of the above men-

tioned TMD signs in the examined populations therefore deserve to be followed up in future investigations.

The estimates of treatment need in adults rose from 5% in 1983 to 8% in 2003, primarily reflecting the increase in prevalence figures for the Ai II. However, great caution is recommended in interpreting this result, as inconsistency in the Di component between the years jeopardises any direct comparisons. The overall estimates of treatment need in 1993 and 2003 were very close to one another, but the rates showed different courses across genders. In 1993, it was estimated that an almost equal percentage of the examined men and women were in need of TMD treatment, whereas, in 2003, the need for treatment among women was estimated to be twice as high as that among men. Although it is unknown whether this trend is permanent, this finding might imply a specific gender composition of future patient populations and this should be considered in planning TMD care in the future. However, in the present clinical sample, trends over the eight-year observation period could not be found in the number of referrals, age and gender distribution of the patients examined or in the diagnoses applied. Differences in the time frame between the Jönköping studies and the clinical survey may be one reason for this result. Issues related to the selected examined population at the specific TMD clinic and to the diagnostic methodology that was used may also have been other plausible explanations.

The present investigations also disclosed a significant increase in terms of awareness of bruxism among adults during the 20-year study period, concurring with a previous report on another Swedish population (258). Increased individual reports of tooth clenching or grinding may be related to an actual increase in the presence of these oral parafunctions in the study population, but it also may reflect an increased awareness of these phenomena among health care personnel, in the media and in society in general. Whether there is an etiological link between the observations of an overall increase in TMD symptoms and of increased bruxism reports or whether both are related to other, not studied, factors is unclear and remains to be proved by further research.

In general, it is possible to speculate about the reasons for the presently observed time trends. Leijon & Mulder (143) discussed changes in risk factors or changes in symptom reporting as plausible explanations for the observed increase in prevalence of low back pain. The authors considered the role of media

reports in cultural changes, including a greater awareness of musculoskeletal symptoms and of the impact of psychological well-being, and, as a result, a greater willingness to report these symptoms and underlined the need of further research in this aspect. Both above-mentioned possible reasons may account also for the present findings, as TMD is considered as musculoskeletal disorders conceivably related to psychosocial stress and an increase of the reported bruxism, which is thought to be a potential risk factor, was also noted.

As was mentioned earlier in this thesis, TMD are closely related to other ill-health, and especially pain, conditions and both are linked to the psychosocial well-being of the individual. The previously described changes in Swedish society during the 1990s could be one factor that may partly account for the deterioration in different aspects of the health documented here and in other reports. It has been shown that, in general and except for the direct consequences, the burden of illness associated with behavioural, socioeconomic and psychosocial risk factors extends beyond the shortening of life to poorer trajectories of health over decades (125). The global relationship between health and economic crisis was analysed by Kaplan in a comparative study of the socioeconomic structures of three countries, the United Kingdom, Sweden and the United States (126). The author concluded that economic crises might not have the same effect in these countries, but that impacts may lead to vicious circles of risks with potential cumulative effects later in life. Recently, it was shown that both depression and somatic complaints, including TMD symptoms, increased during a period of deep financial recession (68, 127).

On the other hand, it has been stated that it is very difficult to forecast the permanence of changes in population health (90), as many health determinants are increasingly dependent on factors affecting not only the national but also the global society. Economic and labour market changes on a national level are often temporary and therefore mainly affect the incidence of disease with a short latency time (90). TMD might be partly regarded as such. On the other hand, the Public Health Report from the Swedish National Board of Health and Welfare has predicted that continuously increasing demands for occupational performance, in combination with a stricter work environment, will continue to increase the risks of psychosocial effects in the future (90).

Associated factors

Age

In the present investigations, TMD symptoms and signs were found to be associated with age in different ways. In overall terms, severe symptoms, presented as Ai II, increased steadily from childhood and adolescence up to the age of 40–50 years and then clearly decreased at older ages. This pattern corresponds to the results of previous population surveys pointing to a general symptom reduction with advancing age (202,224,262). However, separate TMD symptoms have shown differentiated age influences. TMJ clicking was related to the age groups of 30 and 40 years, which is in fairly good agreement with reports by Kamisaka et al. (122) concluding that younger individuals, under 40 years of age, run a greater risk of having precipitating TMJ noises. On the other hand, pain-related symptoms, such as jaw tiredness and pain in the face/jaws, were associated with somewhat older ages of 40 and 50 years. Frequent headache also peaked at 40–60 years of age in two of the three present investigations, which is a somewhat higher age than that reported in a Norwegian survey pointing to a peak of 30–39 years for tension-type headache (149).

Similar to frequent headache, and on a national level, severe pain complaints from the neck and shoulders are reported more frequently at the ages of 45–64 years (241). It appears that some, at least regional, pain symptoms display similar age patterns, which would be seen in the light of current evidence of comorbidity of pain conditions from trigeminally and spinally innervated areas (180). However, in a study of TMD pain symptoms in relation to age and different ethnic backgrounds based on data from a National Health Interview Survey of 30,978 US adults, Isong et al. (114) concluded that age appeared to play a larger role in women than in men.

A different relationship with age than that for symptoms was found for TMD signs in this material. In general, the frequency of more severe signs, expressed as index group Di II/III, was associated with the oldest examined ages of 60 and 70 years, which is in good agreement with reports in other population studies (84,223,224). A more complex age effect, due to interactions with gender, has also been discussed, however (223). At the same time, this relationship appears to change in the oldest elderly individuals. In a longitudinal investigation

of three cohorts of 70-year-old subjects, Österberg et al. (204) found a decrease in severe dysfunction signs with advancing age from 70 to 83 years.

In overall terms, it is probable that the observed relationship between age and TMD symptoms and signs is not solely a consequence of ageing, but rather a synergistic effect of various factors, including psychosocial and biological components. With advancing age, general health problems increase in both frequency and severity and may obscure the importance and consequences of TMD symptoms in daily life. Feasible neurobiological and hormonal changes with age could be other factors that may speculatively and partly explain a reduction in reported symptoms despite the increase of signs of dysfunction.

Gender

The present investigations were unable to reveal any significant gender differences for either the individual symptoms, apart from tiredness in the jaws and frequent headache in the age group of 20-year-olds, or the Ai in adults, which is in contrast to previous reports of both more frequent and more severe symptoms in women compared with men (2,54,118,157,272). However, a gender dependence on higher frequencies for women for some, mostly palpation pain-related, signs, which is in accordance with earlier publications (54, 224), and for a more severe overall degree of dysfunction was found. Extensive population surveys in Germany (84) and Finland (223) have shown a general female predominance for all TMD signs, which the present material was unable to confirm.

Nor was any gender preponderance found in TMD symptoms, apart from frequent headache, and signs in children and adolescents. A similarly even distribution across genders has previously been reported (73,282), but several other studies have found the opposite (75,103,198,255,265). Differences in study design and sample sizes could be possible explanations of these conflicting results. In a 20-year longitudinal survey, Magnusson et al. (169) concluded that the gender differences were small in childhood, but, from late adolescence, women reported more symptoms and exhibited more clinical signs than men. In a cross-sectional, population-based survey of 3,101 adolescents (aged 11–17), LeResche et al. (146) found that pubertal development was a better pain predictor than age and that facial pain increased with pubertal development for both girls and boys, although no notable gender differences could be demonstrated.

The female preponderance among individuals with frequent headache at the ages of 10, 15 and 20 years that was observed in the present studies corroborates earlier results (19,141,195,265). Furthermore, Wänman (269) reported that both the frequency and intensity of recurrent headaches were statistically significantly higher in girls than in boys at the ages of 17, 18 and 19 years. Not all studies, however, have been conclusive (73,75,134). A female predominance in TMD pain symptoms, including headache, has often been documented (114, 171,262). There is also some evidence of different courses for TMD pain symptoms in women and men, as women have been found to be more likely to have persistent pain than men (122,179,272).

Gender differences in several aspects of not only temporomandibular pain but also pain in general, including both nociception and perception, have been observed and biological, mainly hormonal or genetic, as well as psychosocial, cognitive and behavioural factors have been reviewed as possible mediating mechanisms (22,48,259,267). It is reasonable that the continuous and intricate interaction of all the above-mentioned components contributes to different courses between genders for the various pain symptoms during the life span (59). Despite of a large number of both experimental and clinical studies in recent decades, the issue of gender inequality in pain still requires further research.

Awareness of oral parafunctions

In the present investigations, an awareness of oral parafunctions was often reported by the children themselves or by their parents as well as by adolescents. Nail biting was reported more often than bruxism by 15-year-olds, which is in agreement with several previous surveys (75,134,135,166,195,268) and is expected, as individuals who bite their nails are almost always aware of their parafunction, whereas awareness of tooth clenching or grinding, even during the daytime, is more scarce. Awareness of tooth clenching or grinding in 10- and 15-year-olds was found to be associated with TMD symptoms, expressed as the Anamnestic Dysfunction Index. Likewise, relationships between oral parafunctions and TMD symptoms (281), including recurrent headache (195,269), as well as clinical signs of dysfunction (134) in childhood and adolescence have been reported in earlier publications. Some studies, however, concluded that parafunctional habits, with the exception of atypical swallowing (32) or "jaw-play" (69), were not determinants of the presence of TMD symptoms and/or

signs. Different ways of collecting data using questionnaires or interviews, asking parents or children, variations in clinical examinations methods applied to children and differences in examined populations could be possible reasons for these inconsistencies.

Awareness of tooth clenching or grinding was also frequently stated among adult participants in the present investigations (14–23%) and this is in close agreement with previous reports (2,157). Furthermore, subjects in the oldest age groups were less frequently aware of bruxism than younger individuals, which also agrees with earlier publications (200,204).

The highly statistically significant association between awareness of bruxism and almost every TMD symptom, the Ai, pain-related clinical signs and the Di II/III disclosed in the present material lends support to evidence from other studies (118,157,192). In a longitudinal prospective study of 402 individuals followed from the age of 15 to the age of 35 years, Magnusson et al. (171) reported that bruxism was a predictor of both symptoms and clinical signs 20 years later but also of the demand for TMD treatment. The same authors also discussed the negative predictive value of bruxism, since the absence of reports of tooth grinding in adolescence was related to a higher probability of not demanding treatment later in life, and they stated that "such parafunctions cannot be ruled out as possible etiologic factors in the development of TMD" (171). Similarly, Ciancaglini et al. (37) stated that "in the general adult population absence of craniofacial pain is often accompanied by absence of bruxism".

The role of bruxism, during sleep and/or while awake, as a factor potentially related to the etiology of TMD and other pain conditions in the craniofacial region has been studied for decades and the complexity of the frequently observed relationship has been discussed in extensive reviews (156,175,251). However, awareness of bruxism, which has been studied in the present thesis, is not identical to the presence of bruxism, as many individuals may have a parafunctional activity without being aware of it and others may have been aware of tooth clenching or grinding that has ceased. The present results therefore relate strictly to individual awareness of tooth clenching and/or grinding and do not discriminate between sleep or wake bruxism.

Psychosocial factors in connection with the etiology of bruxism have been discussed. In a recent review, the authors concluded that the relationship is very

complex, because of various confounders, such as pain symptoms, and stated that wake bruxism, mainly tooth clenching, might be associated with psychosocial factors, a relationship that does not appear to be evident for sleep bruxism (175). There is some evidence pointing to a relationship between oral parafunctions and psychosocial distress. Distress refers broadly to different unpleasant subjective stress responses and is often conceptualised in the form of negative cognitive or emotional states, such as worry, anxiety and depression, but also somatic symptoms (182). Factors or events with the potential to threaten or damage the well-being of the individual can elicit distress, which also relates to personality traits (182). Studies have shown associations between bruxism and a highly stressful life (4,31,200), stressful life events (69), stress sensitivity (174) and anxiety (176,189,200), but no simple relationship between stress and bruxism has been disclosed (212). However, in the present investigations, no measurements of psychosocial stressors in examined individuals have been made, thereby not enabling conclusions about a direct impact by such factors to be drawn.

Perceived health and general health aspects

In the present population-based investigations, significant associations were found between almost all the TMD symptoms studied, including frequent headache, and signs of moderate to severe clinical dysfunction in adults and reports of perceived health impairment. These results corroborate reports from a Swedish epidemiological survey of 50-year-olds, showing that self-perceived poor general health was the strongest risk indicator of reported TMD pain (117) and from a Finnish study, which found an association between TMD signs and intermediate/poor self-rated health and, in particular, multiple pain symptoms (237). Furthermore, TMD symptoms and moderate to severe clinical dysfunction were related to issues associated with general health in the children and adolescents examined in the present studies.

Epidemiological research has frequently documented a co-existence between general health impairment, mostly various pain conditions, and TMD (95,104,265), as well as headache (14,19,23, 244,284). The co-morbidity of orofacial pain and pain symptoms from spinally innervated, but even more remote, areas has often been studied in recent years (120,180). The exact nature of this relationship has not been fully explored, but common underlying biological mechanisms have been discussed (249). However, it is apparent that both bio-

logical and psychosocial issues are probably involved as mediators in the reciprocal relationship between TMD symptoms and signs and the perception of individual health.

Assessments of general health can be made in various, more or less complicated, ways. Global self-ratings of health have been widely used in population health research and have been found to be a valid measure of overall health (159), reflecting an underlying burden of disease (124). Perceived health status has been found to be a strong indicator of morbidity and mortality (111,124). In a Canadian National Population Health Survey of 13,995 responders, it was shown that pain and current health impact were related to self-reported health and, in individuals both with and without chronic illness and disability, chronic stress and high distress were determinants of poor self-rated health (41). Idler & Benyamini concluded a review of 27 community studies, arguing that "the global rating represents an irreplaceable dimension of health status and in fact that an individual's health cannot be assessed without it" (111).

Estimated TMD treatment need

On the basis of a combination of the presence of severe symptoms, including frequent headache, and signs indicating moderate to severe clinical dysfunction, an attempt was made to estimate the need for treatment in the adult populations studied on the three examination occasions. The overall estimates of 7.5% and 8% in 1993 and 2003 respectively are in close agreement with the estimate of a 7–9% need for active treatment found in a two-year follow-up study (140). In accordance with the main findings in the present investigations, the same authors found a clear female predominance, with a two to three times higher need for treatment in women than in men, but they also reported an age dependence tendency towards younger ages (140). In a recent meta-analysis of 17 studies based on 9,454 subjects, Al-Jundi et al. (8) concluded that 16% of the general adult population was estimated to be in need of TMD treatment. The meta-analysis also indicated no clear gender differences, but age differences were noted, as, in the included studies, individuals younger than 45 years were more frequently found to be in need of treatment compared with older ones. This age dependence was not confirmed in the present material, probably reflecting the criteria that were used. The different peak ages for frequent head-

ache, symptoms included in the Ai and clinical signs included in the Di possibly counterbalance one another.

In the age groups of 10- and 15-year-olds studied in the present thesis, the need for treatment for TMD was estimated at 1–2%, which is in close agreement with a Danish report (11). On the other hand, Hirsch & Sehrer (102) concluded that previous investigations of children and adolescents showed a mean prevalence of 7.8% for moderate to severe dysfunction (Ai=II and Di=II or III) when Helkimo Indices where used, pointing to a far greater need for treatment than that estimated on the basis of the same criteria in the present investigation. Furthermore, the same authors stated that "differences in TMD findings between ethnic groups and different parts of the world apparently exist".

The method of estimating treatment need used in the present investigations varied between adults and children/adolescents, as, in adults, the presence of frequent headache was also considered. When the same criteria as those used for adults are applied to prevalence figures for children and adolescents, the estimated treatment need is somewhat higher than reported, at 3–4% for 10-year-olds (2.7% in 1983, 4.4% in 1993 and 2.7% in 2003) and to 2–5% for 15-year-olds (4.7% in 1983, 2.9% in 1993 and 2% in 2003). These estimates of treatment need are close to those presented in other population studies (135,265).

The issue of the need for TMD treatment is challenging and important for health economics (277). Previous studies using diverse criteria, some based on the presence of symptoms or signs and others on the clinician's judgement, have pointed to diverging treatment need estimates (8), most often expressed in a dichotomised (yes/no) way. Some authors, however, have presented methods of assessing and classifying treatment need in more than two categories, taking account of factors such as the persistence of symptoms, the clinician's judgement and the total oral health status and treatment need of the individual (53,140,271). Even though one common application of epidemiological research is to assist the appraisal of need for treatment and the planning of resource allocation for a condition in a population, the estimates of TMD treatment need based solely on prevalence figures have been criticised as not being totally valid and other components, such as the nature of symptoms and concurrent stress experience (140), as well as the individual's own demand (28), have been discussed as additional determinants. The incongruence of estimated

treatment need and actual demand for treatment (167) or treatment provided (271) has been studied and the findings suggest much lower figures for demand for treatment or treatment provided than for estimated need. It has been shown that not all subjects with symptoms seek treatment (262). The presence of severe symptoms (242) and the experience of pain (263) have been found to be critical for seeking TMD care.

TMD patients, diagnoses, treatment received and treatment outcome

The clinical material studied here revealed largely similar demographic characteristics as those reported previously (17,39,147,183,232). The mean age was, however, somewhat higher than that reported by others (147,183) but close to that reported from another large clinical sample (277).

Comparisons of the distribution of different diagnoses with other studies are difficult, as different investigations have used different classification systems. In the present study, most patients could be labelled with a diagnosis according to the ICD-9. Disc displacement with or without reduction, tension-type headache, myalgia, arthritis, and a combination of myalgia and arthralgia were the most common diagnoses applied. In another study, where the same diagnostic classification system was used (46), only half the patients could be given 'strict' TMD diagnoses, but, among those, the distribution of the diagnoses resembles that in the present material. However, and despite the different taxonomies, there was also good agreement with other patient materials (17,187,273), with the exception of headaches, which were much more common in the present patient material. One probable explanation is that other studies only presented the main diagnoses and did not report on tension-type headache as a common sub-diagnosis (46). The distribution of diagnoses applied to children and young adults was also fairly equal to that reported previously (238), with the exception of disc displacement with reduction, which was much more common in the present material. A recent review of studies that have applied RDC/TMD in patient populations has disclosed a large variability in the prevalence of different diagnostic categories and found myofascial pain to be the most common diagnosis (177).

The two most frequently used treatment modalities in the present study, jaw exercises and interocclusal appliances, have been applied worldwide for decades in the management of TMD and tension-type headaches (66,139,163,254). Randomised clinical trials (RCTs) have been suggested as the design of choice in terms of the effectiveness of interventions, but the quality of published RCTs on the efficacy of different TMD treatment modalities has varied (80). Reviews of RCTs and meta-analysis studies (80,154) provide some evidence in favour of the use of interocclusal appliances, jaw exercises, behavioural therapy, acupuncture and some pharmacological modalities, all of which have been employed in the present survey. A fairly large proportion of the patients in the present material (29%) had received some kind of occlusal adjustment as part of their treatment. Current evidence (80,154,226) does not support this modality, which has previously been considered to be beneficial in TMD management (9,78). The potential importance of occlusal factors for the development of TMD is being seriously questioned at the present time (88,216), but their role as contributory factors cannot yet be definitely excluded (142,179). In the present survey, behavioural modalities, such as counseling and information, have not been registered when used in combination with other modalities, although they have been applied as an essential and standard part of patient management at the study department.

In accordance with previous investigations (25,238), the present survey showed an overall good treatment effect, as 85% of patients treated reported an improvement after treatment, but failed to find any strong predictors of treatment outcome. No factors associated with improvement, when this was defined as a positive change of at least one point on the complaint rating scale used, could be found. No bearing of gender on treatment outcome was disclosed, concurring with previous results (56,203). Likewise, outcome was not related to patient age that is in line with some studies (203) but in contrast to others (16,217), which found that younger patients had a better treatment outcome compared with older ones.

However, when improvement was defined as at least a two-step change on the scale, some diagnoses were found to be related to treatment outcome. Patients with the diagnoses of disc displacement without reduction, arthritis and myalgia had a two-fold higher chance of improving two steps compared with patients with other diagnoses, while those with the diagnosis of orofacial pain ran a risk that was almost as high of not improving. Successful treatment results and a

favourable long-term prognosis for internal derangement, disc displacement without reduction, OA and myalgia have been previously reported (25,70). It has been stated that initial TMD diagnoses are not predictive of treatment outcome (39,218). On the other hand, studies have reported that specific diagnoses have influenced the outcome of TMD treatment but when compared with our results, the picture is not conclusive. For instance, in contrast to the present findings, Skeppar & Nilner (238) found that, among patients who did not improve after treatment, the diagnosis of disc displacement (with and without reduction) was the most common, while others (232,276) concluded that patients with intracapsular TMJ dysfunction improved more than patients with myogenous TMD. Furthermore, the "orofacial pain" diagnosis in the present study represented several pain conditions, including neuropathic pain, which have different pathophysiology and consequently deserve different management than common TMD sub-diagnoses. However, a probably secondary TMD condition motivated the applied treatment in patients diagnosed with orofacial pain.

Inconsistency in outcome results between different studies could be partly explained by obvious methodological variations, including differences in studied populations, diagnostic categories, treatment modalities applied and criteria used to assess the treatment outcome. Some investigations have based their assessment on measurements of treatment effect on specific symptoms, mostly pain, often using VAS scale ratings, or of some merely clinical signs, while others have used as outcome measure a global evaluation of treatment effect based on the patient's own evaluation of treatment result, the clinician's subjective assessment, or a combination of these methods, as an outcome measurement. In the present survey, a measurement of outcome based solely on the patient's global experience of current symptoms before and after treatment has been used, thereby ensuring the minor involvement of memory recall and different degrees of improvement, which may mean differences in clinical significance, have been determined and analysed. However, this method implies the influence of many factors that can affect the individual's estimation of current symptom severity at a single time point and in response to question from the care-giver. Psychosocial determinants affecting the current mood state and reporting bias may therefore and among other things have being involved and should be taken into considerations when interpreting results relating to treatment outcome measured with this method. It is generally reasonable to assume that TMD treatment outcome is determined not only by factors related to age,

gender or specific physical diagnoses but also by other components, including various psychosocial and behavioural issues, which have not been studied here.

MAIN FINDINGS

The main findings in the present studies were

- symptoms and signs indicative of TMD were generally common in all three population-based investigations
- the overall prevalence figures for TMD symptoms and signs in children and adolescents did not change statistically significantly from 1983 to 2003
- the overall prevalence frequencies of TMD symptoms and the rates for some clinical signs among adults increased from 1983 to 2003
- in 2003, the prevalence of frequent headache in 20-year-olds had markedly increased
- the reports of bruxism among adults increased from 1983 to 2003
- the estimated treatment need in adults appears to have increased during the study period
- frequent headache in the age groups of 10, 15 and 20 years was associated to female gender
- awareness of bruxism and self-perceived health impairment were associated with TMD symptoms and signs
- no significant changes over time relating to age or gender of patients, diagnoses or treatment outcome were noted in a clinical TMD population during the period 1995–2002
- a favourable treatment outcome was observed for the majority of patients treated at a specialist TMD clinic

- no strong predictors of treatment outcome were found, but three diagnoses (disc displacement without reduction, arthritis and myalgia) were associated with a more favourable treatment outcome, while one diagnosis (orofacial pain) was correlated with a negative one.

CONCLUDING REMARKS

The results of the present thesis primarily suggest an increase in the prevalence of symptoms, in general and partly specifically, and in some particular signs indicative of TMD in the adult Swedish population during the period 1983–2003. The markedly increased prevalence in 2003 of frequent headache in 20-year-olds, an age group in which this symptom is mostly present in women, merits special notice and it should be considered in the context of an observed increase in ill-health among young women (207). The observed overall increase in symptomatology in adults in conjunction with previous findings (258) of an increase in the prevalence of orofacial pain symptoms in 50-year-olds in Sweden during a ten-year period (1992–2002) lends support to a conclusion relating to time trends regarding the presence of TMD and orofacial pain conditions in the Swedish population. These trends should be viewed in the light of a rise in musculoskeletal pain conditions and psychological and mental ill-health that occurred during the 1990s and the beginning of the 2000s and which have been related to socioeconomic changes in Swedish society (178). The role of psychosocial determinants of health in general may therefore have been involved in the observed time trends.

It is worth noting that in the studied populations an overall improvement in several aspects of oral health has been documented during the last few decades (110). The prevalence of caries and periodontal diseases has decreased and an increasing percentage of the population are preserving their natural teeth. The current findings imply that TMD do not follow the pattern of other oral disorders and that state of the dentition might not be related to the presence of TMD at population level.

As a consequence of the increased prevalence of symptoms and some signs, the estimates of treatment need for TMD in the Swedish adult population appear to have risen during the study period. The permanence of these trends is currently unknown, however. Future research providing this information could be important when planning health care and resource allocation, especially at times when the public health care systems are struggling with economic problems.

The present result of an overall favourable outcome for treatment provided to patients with the most common TMD sub-diagnoses, which concurs with previous reports (218), also needs to be underlined and taken into consideration in health economics.

The thesis suggests that there is a need of continuous documentation of time trends in common disorders, including TMD, and of factors influencing their presence in the population. A profound understanding of the roll of social determinants of health is essential when planning public health care resources.

Summary in Swedish

Sammanfattning

Under de senaste åren, och främst under 1990-talet, har det i Sverige noterats en dramatisk ökning av stressrelaterad ohälsa och speciellt av muskuloskelettala smärttillstånd. Samtidigt har den orala hälsan, allmänt, förbättrats betydligt under de senaste decennierna. Temporomandibular disorders (TMD) är den engelskspråkiga termen som oftast används för att beskriva funktionsstörningar och olika smärttillstånd i käksystemet. TMD är den vanligaste orsaken till ickedental ansiktssmärta och relateras ofta till andra kroppsliga smärttillstånd. Det övergripande syftet med avhandlingen var att inhämta kunskap om eventuella förändringar över tid av förekomst av subjektiva symtom och kliniska fynd tydande på TMD i en svensk population under en 20-års period.

Materialet är baserat på omfattande tvärsnittsstudier, de så-kallade Jönköpingsundersökningarna, genomförda 1983, 1993 och 2003. Tre olika grupper bestående av cirka 100 slumpmässigt utvalda personer i åldergrupperna 3, 5, 10, 15, 20, 30, 40, 50, 60 och 70 år undersöktes anamnestiskt och kliniskt vid tre tillfällen avseende symtom och tecken tydande på TMD. Resultaten visade att symtomen, totalt sett, och visa kliniska fynd tydande på TMD, framför allt hos vuxna, hade ökat under 20-års perioden. Följaktligen noterades också en ökning av ett uppskattat behandlingsbehov för TMD. Vissa symtom och kliniska fynd var mer vanliga hos kvinnor som också hade ett större uppskattat behandlingsbehov. En anmärkningsvärd ökning av frekvent huvudvärk hos 20-åriga kvinnor noterades i 2003 års undersökning. Vidare, konstaterades att rapporter om tandpressning/tandgnissling (bruxism) bland vuxna ökade successivt under åren. Rapporterad bruxism och självupplevd nedsatt allmänhälsa var starkt relaterade till såväl TMD-symtom som kliniska fynd.

I avhandlingen studerades också retrospektivt en patientpopulation som undersöktes och behandlades under perioden 1995–2002 vid avdelningen för Klinisk bettfysiologi, Odontologiska Institutionen i Jönköping. Några tydliga förändringar över tid avseende köns- och ålderssammansättning, diagnoser, behandlingar eller behandlingsresultat kunde inte konstateras i denna population. Ett

gott behandlingsresultat noterades för majoriteten av de behandlade patienterna och inga starka prediktorer för behandlingsresultatet kunde identifieras. Några diagnoskategorier (myalgi, diskförskjutning utan återgång och artrit) var dock relaterade till ett bättre behandlingsutfall och en diagnos (ospecificerad orofacial smärta) till ett sämre utfall.

Sammanfattningsvis indikerar studierna en ökning av subjektiva symtom, totalt sett, och av vissa kliniska fynd tydande på TMD och av det uppskattade behandlingsbehovet för dessa tillstånd hos den vuxna svenska populationen under åren 1983–2003. Fortsatt och systematisk kartläggning av eventuella förändringar över tid av förekomst av frekventa smärttillstånd, inklusive TMD, och av sociala förhållanden i samhället är ett viktigt underlag för en optimal dimensionering av vårdsystemets resurser.

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Appendices I–III

Appendix I

Frågeformulär 3 och 5 år (1983, 1993, 2003)

3 år ☐ 5 år☐ Pojke☐ Flicka☐ Löpnummer ☐ ☐ ☐

Frågor till dig som förälder. Sätt kryss i tillämplig ruta!

Gör det ont eller känner barnet obehag vid tuggning? Ja ☐ Nej ☐

Gör det ont eller känner barnet obehag när barnet gapar eller gäspar? Ja ☐ Nej ☐

Anser du ditt barn vara fullt friskt? Ja ☐ Nej ☐

Står barnet förnärvarande under läkarbehandling eller går barnet på regelbundna kontroller för någon sjukdom? Ja ☐ Nej ☐

Äter barnet regelbundet någon eller några mediciner? Ja ☐ Nej ☐

Är barnet fött i Sverige? Ja ☐ Nej ☐

Enbart 2003: Pressar eller gnisslar barnet tänder?

Ja, det gör han/hon ☐ Nej, inte så vitt jag vet ☐

Frågeformulär 10 och 15 år (1983, 1993, 2003)

10 år☐ 15 år☐ Pojke☐ Flicka☐ Löpnummer ☐ ☐ ☐

Sätt kryss i tillämplig ruta!

Gör det ont eller känner du obehag vid tuggning? Ja ☐ Nej ☐

Gör det ont eller känner du obehag när du gapar eller gäspar? Ja ☐ Nej ☐

Anser du dig vara fullt frisk? Ja ☐ Nej ☐

Står du förnärvarande under läkarbehandling eller går du på regelbundna kontroller för någon sjukdom? Ja ☐ Nej ☐

Äter du regelbundet någon eller några mediciner? Ja ☐ Nej ☐

Är du född i Sverige? Ja ☐ Nej ☐

Frågeformulär 20–70 år (1983, 1993, 2003)

20 år☐ 30 år☐ 40 år☐ 50 år☐ 60 år☐ 70 år☐
Man ☐ Kvinna ☐ Löpnummer ☐ ☐ ☐

Sätt kryss i tillämplig ruta!

Anser du dig vara fullt frisk? Ja ☐ Nej ☐

Står du förnärvarande under läkarbehandling eller går du på regelbundna kontroller för någon sjukdom? Ja ☐ Nej ☐

Använder du regelbundet någon eller några mediciner? Ja ☐ Nej ☐

Pressar eller gnisslar du tänder? Ja, det gör jag ☐ Nej, inte så vitt jag vet ☐

Anamnestisk undersökning 10–70 år (1983, 1993, 2003)

Trötthetskänsla i käkarna vid uppvaknandet eller i samband med tuggning Ja ☐ Nej ☐

Käkledsknäppningar Ja ☐ Nej ☐

Skrapljud Ja ☐ Nej ☐

Låsningar/upphakningar vid tuggning och gapning Ja ☐ Nej ☐

Luxation (ur led) Ja ☐ Nej ☐

Nedsatt rörelsekapacitet/ svårt att gapa stort Ja ☐ Nej ☐

Smärtor vid underkäksrörelser Ja ☐ Nej ☐

Värk/smärta i käkledsregion eller tuggmuskulatur/kinder Ja ☐ Nej ☐

Huvudvärk 1 gång/vecka eller mer Ja ☐ Nej ☐

Enbart 1983: Tidigare trauma mot käken Ja ☐ Nej ☐

Enbart 2003: Använder bettskena Ja ☐ Nej ☐

10 och 15 år:

Enbart 1983: Biter du på naglarna? Ja ☐ Nej ☐

Enbart 2003: Pressar eller gnisslar du tänder?

Ja, det gör jag ☐ Nej, inte så vitt jag vet ☐

Klinisk undersökning 10–70 år (1983, 1993, 2003)

A. Rörelsekapacitet

Max gapning	> 40 ☐	30-40 ☐	<30 ☐
Max höger	> 6 ☐	4–6 ☐	<4 ☐
Max vänster	> 6 ☐	4–6 ☐	<4 ☐
Max protrusion	> 6 ☐	4–6 ☐	<4 ☐

B. Käkledsfunktion

Normal	Ja ☐	Nej ☐
Deviation > 2 mm	Ja ☐	Nej ☐
Knäppningar (*1983,1993*) och/eller skrapljud	Ja ☐	Nej ☐
Låsning	Ja ☐	Nej ☐
Luxation	Ja ☐	Nej ☐

C. Rörelsesmärta

Smärtfrihet	Ja ☐	Nej ☐
1993,2003: Smärta vid en maximalrörelse	Ja ☐	Nej ☐
1983: Smärta vid extremrörelse	Ja ☐	Nej ☐
1993,2003: Smärta vid två eller flera maximalrörelser	Ja ☐	Nej ☐
1983: Smärta inom funktionsområdet	Ja ☐	Nej ☐

D. Muskelsmärta

Smärtfrihet	Ja ☐	Nej ☐
1993,2003: 1–3 ömma ställen	Ja ☐	Nej ☐
1983: Subjektiv ömhet vid palpation	Ja ☐	Nej ☐
1993,2003: 4 eller flera ömma ställen	Ja ☐	Nej ☐
1983: Ömhet med palpebralreflex	Ja ☐	Nej ☐

E. Käkledssmärta

Smärtfrihet	Ja ☐	Nej ☐
1993,2003: Ömhet enbart lateralt ifrån, ena eller båda lederna	Ja ☐	Nej ☐
1983: Subjektiv ömhet vid palpation	Ja ☐	Nej ☐
1993,2003: Ömhet posteriort ifrån, ena eller båda lederna	Ja ☐	Nej ☐
1983: Ömhet med palpebralreflex	Ja ☐	Nej ☐

Appendix II

The Anamnestic Dysfunction Index, Ai (Helkimo, 1974)

Ai 0

No symptoms are reported

Ai I

One or more of the following symptoms and none of the symptoms given under Ai II are reported:

Feeling of fatigue or stiffness of the jaws on awakening or on movements of the lower jaw

Temporomandibular joint sounds

Ai II

One or more of the following symptoms are reported as common:

Difficulties in opening the mouth wide

Locking

Luxations

Pain on movement of the mandible

Pain in the region of the temporomandibular joint or of the masticatory musculature (cheeks)

The Clinical Dysfunction Index, Di (Helkimo, 1974)

A. Impaired jaw movement capacity/mobility index

Normal range of movement	0
Slightly impaired mobility	1
Severely impaired mobility	5

B. Impaired TM-joint function

Smooth movement without TM-joint sounds and deviation on opening or closing movements ≤ 2 mm	0
TM-joint sounds in one or both joints and/or deviation ≥ 2 mm on opening or closing movements	1
Locking and/or luxation of the TM joint	5

C. Muscle pain

No tenderness to palpation in masticatory muscles	0
Tenderness to palpation in 1–3 palpation sites	1
Tenderness to palpation in 4 or more palpation sites	5

D. Temporomandibular joint pain

No tenderness to palpation	0
Tenderness to palpation laterally	1
Tenderness to palpation posteriorly	5

E. Pain on movement of the mandible

No pain on movement	0
Pain on 1 movement	1
Pain on 2 or more movements	5

F. Sum A+B+C+D+E dysfunction score (0-25 points)
G. Dysfunction group 0-5, according to code
H. Clinical dysfunction index, Di, according to code

Code:

0 point = dysfunction group 0 = clinically symptom free = Di 0
1–4 points = dysfunction group 1 = mild dysfunction = Di I
5–9 points= dysfunction group 2 = moderate dysfunction = Di II
10–25 points = dysfunction group 3–5= severe dysfunction = Di III

Mandibular mobility index

A. Maximal opening of mouth*

≥ 40mm	0
30–39 mm	1
< 30 mm	5

B. Maximal lateral movement to the right

≥ 7 mm	0
4–6 mm	1
0–3 mm	5

C. Maximal lateral movement to the left

≥ 7 mm	0
4–6 mm	1
0–3 mm	5

D. Maximal protrusion

≥ 7 mm	0
4–6 mm	1
0–3 mm	5

E. Sum A+B+C+D

F. Mobility index according to code

Code

0 points = mobility index 0 = normal mandibular mobility

1–4 points = mobility index 1 = slightly impaired mobility

5–20 points = mobility index 5 = severely impaired mobility

* maximal distance between the edges of incisors + vertical overbite

Appendix III

Dependent and independent variables in Studies I–IV

Study I

Dependent variables

Pain on chewing: no, yes.

Recurrent headache: no, yes.

Jaw tiredness: no, yes.

TMJ clicking: no, yes.

TMJ crepitations: no, yes.

Locking/catching: no, yes.

Pain on jaw movement (reported): no, yes.

Pain in the face/jaws: no, yes.

Ai: 0, I; 0, II; I, II.

Impaired jaw mobility: 0, 1/5.

Impaired TMJ function: 0, 1/5.

Pain on jaw movement (registered): 0, 1/5.

Muscle pain: 0, 1/5.

TMJ pain: 0, 1/5.

Di: 0, I, II/III.

Independent variables

Year: 1983 (referent), 1993, 2003.

Age group: 3 (referent), 5, 10, 15; 10 (referent), 15.

Gender: male (referent), female.

Awareness of bruxism: no (referent), yes.

Regular medication: no (referent), yes.

Trauma to the face (only 1983): no (referent), yes.

Study II

Dependent variables

Recurrent headache: no, yes.

Jaw tiredness: no, yes.

TMJ clicking: no, yes.

TMJ crepitations: no, yes.

Locking/catching: no, yes.

Luxation: no, yes.

Difficulty with jaw opening: no, yes.

Pain on jaw movement: no, yes.

Pain in the face/jaws: no, yes.

Ai: 0, I; 0 , II; I, II.

Awareness of bruxism: no, yes.

Independent variables

Year: 1983 (referent), 1993, 2003.

Age group: 20, 30, 40, 50, 60, 70 (referent).

Gender: male (referent), female.

Awareness of bruxism: no (referent), yes.

Self-perceived healthiness: totally healthy (referent), no totally healthy.

Trauma to the face (only 1983): no (referent), yes.

Study III

Dependent variables

Impaired jaw mobility (A): 0/1, 5.

Pain on jaw movements (C): 0/1, 5.

Muscle pain (D/D*): 0/1, 5.

TMJ pain (E): 0/1, 5.

Di (/Di*): 0/I, II/III.

Estimated treatment need (TNest/TNest*): no, yes.

Independent variables

Year: In analyses of (A): 1983 (referent), 1993, 2003. In analyses of (C), (D), (E): 1993 (referent), 2003.

Age group: 20 (referent), 30, 40, 50, 60, 70.

Gender: male (referent), female.
Denture wearer: no (referent), yes.
Awareness of bruxism: no (referent), yes.
Self-perceived healthiness: totally healthy (referent), no totally healthy.
Trauma to the face (only 1983): no (referent), yes.

Study IV

Dependent variables

Treatment outcome: improvement, no improvement.

Independent variables

Age group: ≤ 20 (referent), 21–40, 41–60, >60.
Gender: male (referent), female.
Diagnosis, disc displacement with reduction: no (referent), yes.
Diagnosis, disc displacement without reduction: no (referent), yes.
Diagnosis, myalgia: no (referent), yes.
Diagnosis, myalgia + arthralgia: no (referent), yes.
Diagnosis, tension-type headache: no (referent), yes.
Diagnosis, arthritis: no (referent), yes.
Diagnosis, osteoarthrosis: no (referent), yes.
Diagnosis, rheumatic disease: no (referent), yes.
Diagnosis, orofacial pain: no (referent), yes.
Treatment modality, jaw exercises: no (referent), yes.
Treatment modality, interocclusal appliance: no (referent), yes.
Treatment modality, occlusal adjustment: no (referent), yes.
Treatment modality, pharmacological therapy: no (referent), yes.
Treatment modality, other treatment: no (referent), yes.
Number of visits: 1–4 (referent), 5–8, > 8.
Initial complaint rating: 1 (referent), 2, 3, 4, 5.