An Evaluation of Changes to the Referral Base of One Orthodontic Specialist Over a 24-Year Period.

by
Dr. Emily Trohatos

A thesis submitted to the Faculty of Graduate Studies of the
University of Manitoba in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Dental Diagnostics and Surgical Sciences
University of Manitoba

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

*****

COPYRIGHT PERMISSION PAGE

An Evaluation of Changes to the Referral Base of One Orthodontic Specialist Over a 24-Year Period.

BY

Dr. Emily Trohatos

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree of MASTER OF SCIENCE

Acknowledgments

There are several individuals who have contributed to the project. Without their assistance, the project would not have been possible.

I would like to express my sincere appreciation to the members of my advisory committee: Dr. Chris Lavelle (Supervisor), Dr. William A. Wiltshire (Internal Advisor), and Dr. Archie McNicol (External Advisor) for their guidance, insights, encouragement and enthusiasm throughout the project.

Outside of my committee, I would like to thank Mrs. Mary Cheang, and Dr. Tom Hassard, for their biostatistical advice. I would also like to express my deepest appreciation to Dr. Allan Baker and Mrs. Rochelle Baker for their generosity and the key to their home allowing unlimited access to the stored records used in this project.

Finally, I cannot express the extent of my gratitude to my family in Toronto, my parents George and Panagiota, and my siblings Helen and Louis, who have made financial sacrifices and provided the emotional support and encouragement required for the successful attainment of my goals.

I thank you all for the important contributions which you have made.

Table of Contents

Page

List of Figures

List of Tables

List of Appendices

Abstract

Accurate predictions of orthodontic market changes are serious concerns for the specialist. For instance, in addition to increases in the provision of orthodontic services by general dentists, recent decades have witnessed progressive increments in the supply of specialist manpower. The impact of such changes, however, together with fluctuations in the overall economy has yet to be subjected to systematic evaluation.

In order to address some of these concerns, random 25% annual samples of the referral base of one orthodontic specialist was investigated over a 24-year period in order to test the following null hypothesis: *That no significant changes occurred in the referral base of the orthodontic practitioner over the 24-year period*. The need for orthodontic services for this 1156 case sample was then assayed by computation of the Dental Aesthetic Index (DAI), based on the consensus that this index comprises the most appropriate summary of service need. When this index and its component parameters were subjected to multivariate and univariate statistical analyses, fluctuations in the orthodontic service need of the referral base were noted over the study period: mean DAI scores decreased over the 24-year period ($r=-0.69$, $p<0.001$), mean Modified DAI scores decreased over the 24-year period ($r=-0.77$, $p<0.001$), and the percentage of cases considered to have no need or elective need for treatment showed a significant increase over time ($r = 0.65$, $p < 0.001$). Of the 10 component parameters, only "crowding", "spacing", "maxillary overjet", and "molar relationship" showed statistically significant trends with time. Data analysis also indicated some significant trends insensitive to the

DAI, such as a positive correlation of canine impactions with time ($r = 0.53$, $p<0.01$) especially after 1985, ($r=0.89$, $p<0.001$), and a positive correlation of the percentage of cases with serial extraction leading up to 1985 ($r=0.73$, $p<0.01$). These data were considered together with the economic and demographic data for the province of Manitoba over the 24-year period.

The data indicate that there were fluctuations in the specialist market over the 24-year period although further development is needed to improve the DAI as an assay of orthodontic service need. Clearly further data are required not only to quantify the determinants of the orthodontic market, but also to define a more appropriate index of orthodontic service need.

1.0 Synopsis

Orthodontic services were previously considered the exclusive domain of orthodontic specialists, whereas competition for this market has been greatly exacerbated by their increased provision by non-orthodontists. This investigation was undertaken to assay the impact of such market changes on the referral base of an orthodontic specialist over the 1974-97 period. Based on random 25% annual samples from this referral base, the orthodontic service needs of the 1156 case sample was assayed by computation of their Dental Aesthetic Index (DAI) scores (Cons et al 1986). Subsequent univariate and multivariate statistical analyses of these data showed a 5.9% reduction in their annual mean DAI scores over this 24 year period, associated with significant reductions in crowding, maxillary overjets and molar relationship scores. By contrast, the results also showed that this period was characterized by an increase in spacing within the anterior segments, together with higher proportions of impacted maxillary canines, especially in the 1986-97 period.

The results from this investigation therefore revealed marked declines in the severity of the malocclusions referred to this specialist over the 1974-97 period. Since these changes coincided with an 18.6% reduction in the 7-19 year old "orthodontic" population group, a 109% increase in the number of orthodontists and a 56% increase in the number of non-orthodontists, there is overwhelming evidence that this market has become progressively competitive. The fact that this specialist was able to maintain a consistent referral case-load showed the advantages of maintaining stable sources of case-referrals in highly competitive markets. Further development is, however, required

to improve the effectiveness of the DAI as an assay to define the service needs of patients with different malocclusions.

2.0 Introduction

Financial resources will never be sufficient to provide unlimited healthcare service demands, amongst other, dental care. This particularly threatens continued market growth for specialist orthodontic services, since their increasing provision by general dentists and paedodontic-trained specialists encroaches on the traditional exclusive domain of the orthodontist. Increases in auxiliary utilization by orthodontic specialists, in addition to the influx of additional new orthodontic specialists into local markets further exacerbate these threats. The recent introduction of market-driven healthcare reforms such as Healthcare Management and Preferred Provider Options represent the most serious potential threats to this market, however, since limitations to specialist access are so integral to their fiscal restraint strategies. Although recent increases in orthodontic service demands may have variably countered these market threats, their impact on the demands for specialty orthodontic services remains obscure. This investigation was therefore undertaken as a pilot study to address this informational deficiency. The particular focus of the current investigation was to evaluate the impact of these market threats from examination of the pretreatment referral base of a single orthodontic specialist over a 24 year period. The primary objective was to use such evaluations to define the impact of these market threats and opportunities and facilitate strategic development to ensure continued growth in demands for specialist orthodontic services.

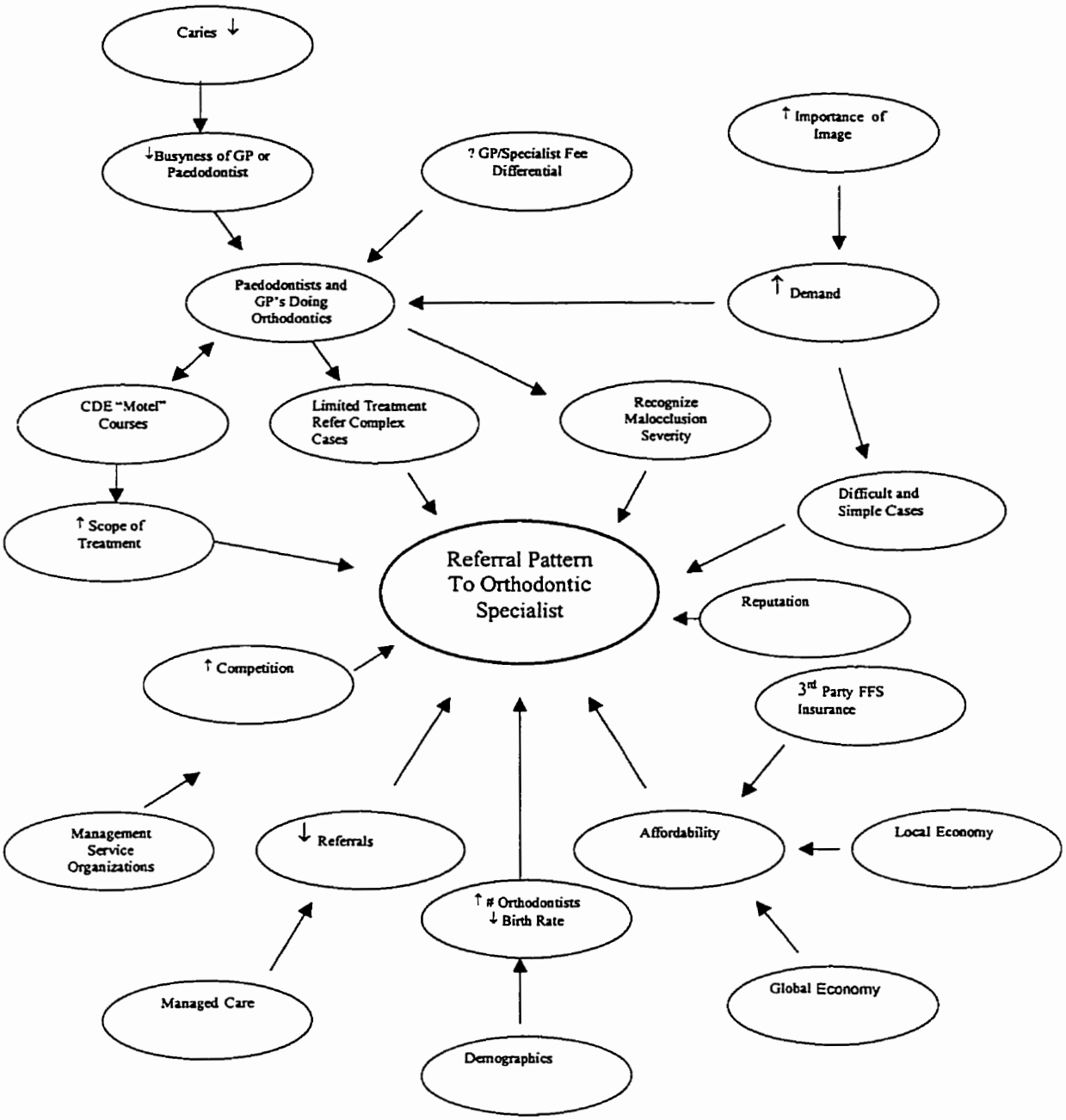
In order to appreciate the significance of this pilot study, this **Introduction** comprises two sections: the first is designed as a synopsis to define the principal external threats and opportunities, in addition to the internal strengths and weaknesses that characterize the competitive domain of the orthodontic specialist. This is then followed by an analysis of techniques to assay changes in the pretreatment referral base of an

orthodontic specialist. The prime objective of this pilot study was therefore to facilitate strategic development to ensure continued growth in service demands from orthodontic specialists.

2.1 The competitive domain of the market for specialty orthodontic services

In common with other, predominantly private, domains for the provision of healthcare services, those associated with orthodontic specialists comprise 'competitive' small businesses. Regional (geographic) discrepancies may be expected to characterize such competitive domains, although their continued service demands require strategic development to accommodate their external threats and internal weaknesses, while exploiting their potential internal strengths and external opportunities. As illustrated in **Figure 2.1**, the principal determinants of this domain are not only more complex than traditionally envisaged, but the lack of information on their relative significance also precludes the development of strategies for their improvement. This section of the introduction is therefore designed to primarily evaluate those considered most pertinent to the pretreatment referral base of specialist orthodontists, although others may later be defined from a subsequent national survey.

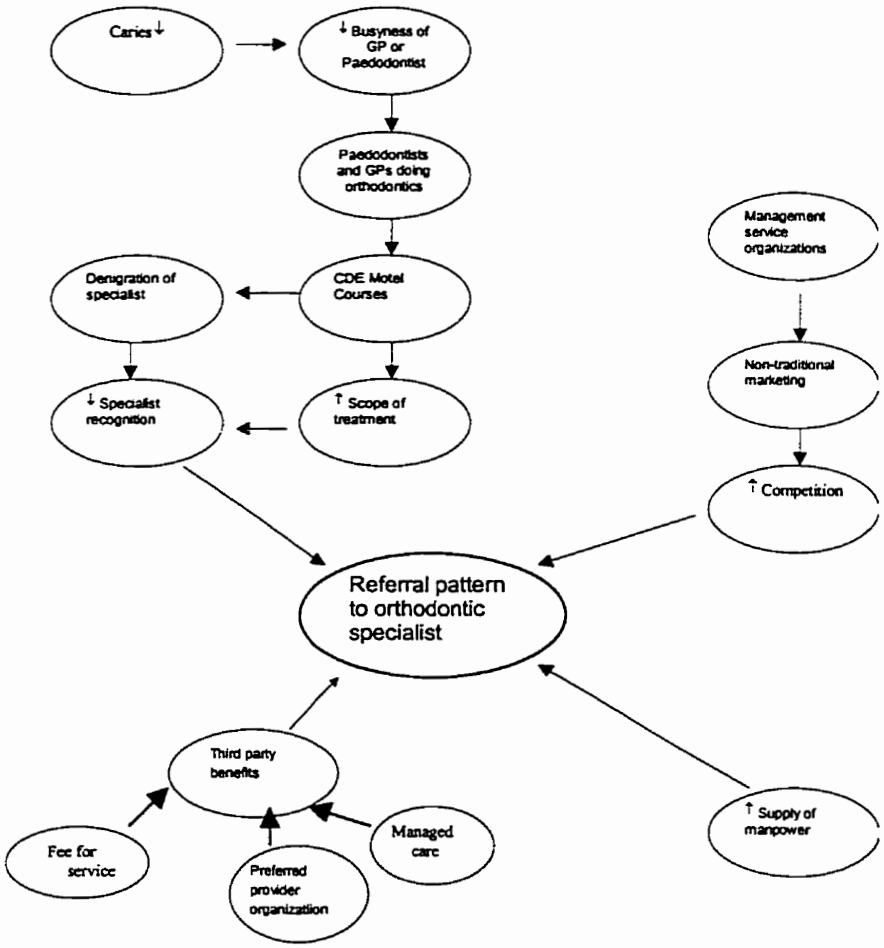
Figure 2.1: Factors Affecting the Orthodontic Referral



2.1.1 External threats

As illustrated in **Figure 2.2**, the market domain for specialist orthodontic services is subjected to a number of potential threats, although only those considered most important to the current investigation are addressed in this section.

Figure 2.2: Potential External Threats to the Orthodontic Specialty Market



2.1.1.1 The provision of orthodontic services by non-orthodontists

As recent declines in dental caries prevalence (Graves, 1985; Ibikunle, 1985; Kunzel, 1987; Petersson and Bratthall, 1996) are potential threats to the economic aspirations of many dentists, they have been compensated by the increased provision of orthodontic services by generalists and paediatric-trained dentists (Gottlieb, 1984; Moorrees, 1984; Koroluk et al, 1988). The proliferation of 'week-end courses' in orthodontics is mainly responsible for such trends. These are illustrated by the advertising literature for one particular course, that refers to the potential for 25-100% additional income to be derived by incorporating practical orthodontic therapy into a practice (e.g. 24 cases x $4,000 a case = $96,000). The principal threat to the domain of the specialist orthodontist stems from the lack of scientific support for the most basic premises of these courses (Chate, 1994). These deficiencies are illustrated by the unsubstantiated and obscure statement that the removal of the relapse pressures on teeth at the start of a service is correlated with an up to 50% reduction in the time required for active therapy. As these trends are linked to a perceived revolution in orthodontic service provisions, their inferred denigration of those provided by orthodontic specialists seriously threaten their market domain. A 1988 survey that showed 62% of 66 paedodontists and 17.9% of 364 general dentists from Indiana provided orthodontic services, underscore the impact of the market threats, especially since 33% of the paedodontists reportedly spent 25% of their chairside time in their provision (Koroluk et al, 1988). Moreover, these concerns are not confined to one region. For instance, a 1989 survey of 728 general dentists in Iowa showed that 66.1% provided some form of orthodontic service, with 20.4% providing such services to 10% of their patients (Jacobs et al, 1991). Outside of North America, the numbers are just as staggering with 75% of all dentists in Switzerland and 45% in Scotland practicing some form of orthodontics (Kunzel, 1987). A more recent survey from Michigan further confirmed this trend,

indicating that 76% of 675 general dentists provided orthodontic services, with 19.3% providing comprehensive orthodontic services (Wolsky and McNamara, 1996). Thus, the principal market threat not only stems from the increased provision of orthodontic services by non-orthodontists, but also progressive blurring of the distinction between the services provided by non-orthodontists and orthodontists. As there are undoubted limitations to the overall size of the orthodontic service market, progressive increases in their provision by non-orthodontists are serious concerns. Clearly the provision of high quality services is the most appropriate strategy to combat such threats to the specialist domain, although the complex task of strategic development to translate such benefits to potential patients is outside the scope of the current investigation.

On the other hand, general dentists are well within their legal boundaries when providing orthodontic care. The justification lies in the fact that orthodontics is a discipline taught in the dental schools at the undergraduate level, not unlike the other dental specialties. Dentists are expected to provide prosthodontic, endodontic, periodontic and oral surgical procedures to some degree. It is therefore not unreasonable to expect the general dental practitioner to offer orthodontic therapy in the overall care of their patients. In fact, interceptive orthodontic procedures provided by the general dentists are important in the development of the dentition and are welcomed by the profession. Perhaps dentists were once precluded from providing orthodontic services to due to their busyness in all other disciplines and the decline in caries rates may be looked upon as an opportunity for general dentists to take on orthodontic patients. However, similar to the other areas of dentistry that are also recognized specialties, it is left up to the self-discipline of the general dentists to recognize their limitations and to treat or refer appropriately. So long as the non-orthodontists are aware of their clinical limitations when providing these services there will be no cause for concern with respect to patient care issues. For instance, there are cases in which functional appliances should never be used (Woodside, 1998) while others are quite simple to treat by the non-orthodontist.

2.1.1.2 Changes in Third Party benefits

Serious political and economic concerns for the inflationary trends in healthcare service expenditures (Wahner-Roedler et al, 1997) were inevitably responsible for some form of rationalization, regardless of their mode of financing. The serious threats to dental provider domains resulting from the introduction of market-driven healthcare reforms (e.g. Managed Care Options [MCOs], Preferred Provider Organizations [PPOs], etc.) cannot be overstated, since third-party payments have been mainly responsible for recent growth in the overall market (Leake et al, 1993). Moreover, these threats not only relate to the constraints to the provision of dental services but also the tendency to abandon traditional fee-for service coverage by contracting out services to various preferred providers. Since the strategic objectives of these healthcare reforms is the provision of services at reduced costs (Miller, 1988; Iglehart, 1992; Miller and Luft, 1995), they potentially endanger the case-load and accordingly, revenue expectations of specialists. This is because they include various constraints and incentives to modify healthcare professional behaviors through utilization reviews (profiling), financial incentives and other management systems (Grembowski et al, 1998). Moreover, MCOs and PPOs are not only likely to increase progressively in the future, but also involve all healthcare (including orthodontic) services. The potential ramifications of such strategies to control healthcare service expenditures may be illustrated if MCOs are assumed to enroll the majority of a market's population. A central strategic cost-controlling feature of these approaches involve the restriction of patient access to specialist (more expensive) services, in addition to limiting specialist participation in their networks (Grembowski et al, 1998). As a result, specialists will become increasingly dependent on MCOs for both their patients and revenues (Kassirer, 1994). Such MCO proposals to seek less costly substitutes for specialists also raises the question whether too many specialists in urban markets are partly responsible for the inflationary trends in healthcare service expenditures (Wennberg et al, 1993; Hurley, 1993).

The impact of the changes identified above may exacerbate existing trends for Third Party benefits to include the provision of orthodontic services. This trend is underscored by a 1981 report from California, where 55% of all orthodontic services provided under prepayment programmes were delivered by dentists other than orthodontic specialists (Dugoni et al, 1981). The Farran Report (Farran, 1995) exacerbates these concerns, since "75% of the orthodontic services billed last year to third-party payment programmes in Michigan were billed by General Dentists; nearly the same percentage was billed in California. In Canada, more than 80% of all orthodontic services are performed by General Dentists". Moreover, dentists who provide comprehensive orthodontic services are less likely to refer patients to orthodontists (Gottlieb, 1984; Jacobs et al, 1991; Wolsky and McNamara, 1996). Clearly, the provision of orthodontic services is not the primary threat to the domain of the specialist, as are the third-party payments for their provision.

2.1.1.3 Decline in specialist recognition

Patient referrals to orthodontic specialists signify general dentists' decisions to classify their service needs into generalist (e.g. restorative) and specialist (e.g. orthodontic) components, with such jurisdictional boundaries defined by clinical and normative criteria (Freidson, 1975). The significance of these criteria is, however, being continually eroded. For instance, the clinical criteria for specialist referrals are generally functions of scientific evidence and previous educational training, both of which depend on the premise that they lead to improved outcomes for services that require knowledge and techniques outside the scope of a general practitioner. Unfortunately, the impact of these criteria have been eroded by scientific reports on relapse following orthodontic services (Little et al, 1991) in addition to marked discrepancies between different orthodontists regarding the most appropriate technique to resolve a particular malocclusion discrepancy (Bowman, 1998). By contrast, normative criteria for referral generally rely on the social conventions for a particular locale, which will vary with both

time and market competition. As continued expansion of professional manpower and auxiliary use has coincided with marked declines in dental disease prevalence in most western industrialized countries, the resultant increased market competition has clearly eroded such normative referral criteria, leading to the progressive provision of orthodontic services by generalists rather than orthodontic specialists. This means that traditional boundaries between generalist and orthodontic specialist functions are not only dependent on market competition, but also the opinions of other dentists in the locale and the strategies adopted by the insurance programme administrators.

2.1.1.4 Management service organizations

The recent influx of Management Service Organizations (MSOs) into the United States and Canada (e.g. Apple Orthodontix, Orthodontic Centers of America (Oppenhuizen, 1997) pose further market threats, especially due to the involvement of 5% of the 8500 North American orthodontic specialists. The principal threat stems from the use of financial resources of these corporations to encourage low-fee competition, derived from mass marketing and reduced overheads, to undercut the conventional professional service fees of private orthodontic specialists (Oppenhuizen, 1997). Additional concerns relate to their associated advertising techniques, which many consider to be serious threats to the well-established status of specialists (Gottlieb, 1984) and the dental profession as a whole.

2.1.1.5 Increases in the supply of specialist manpower

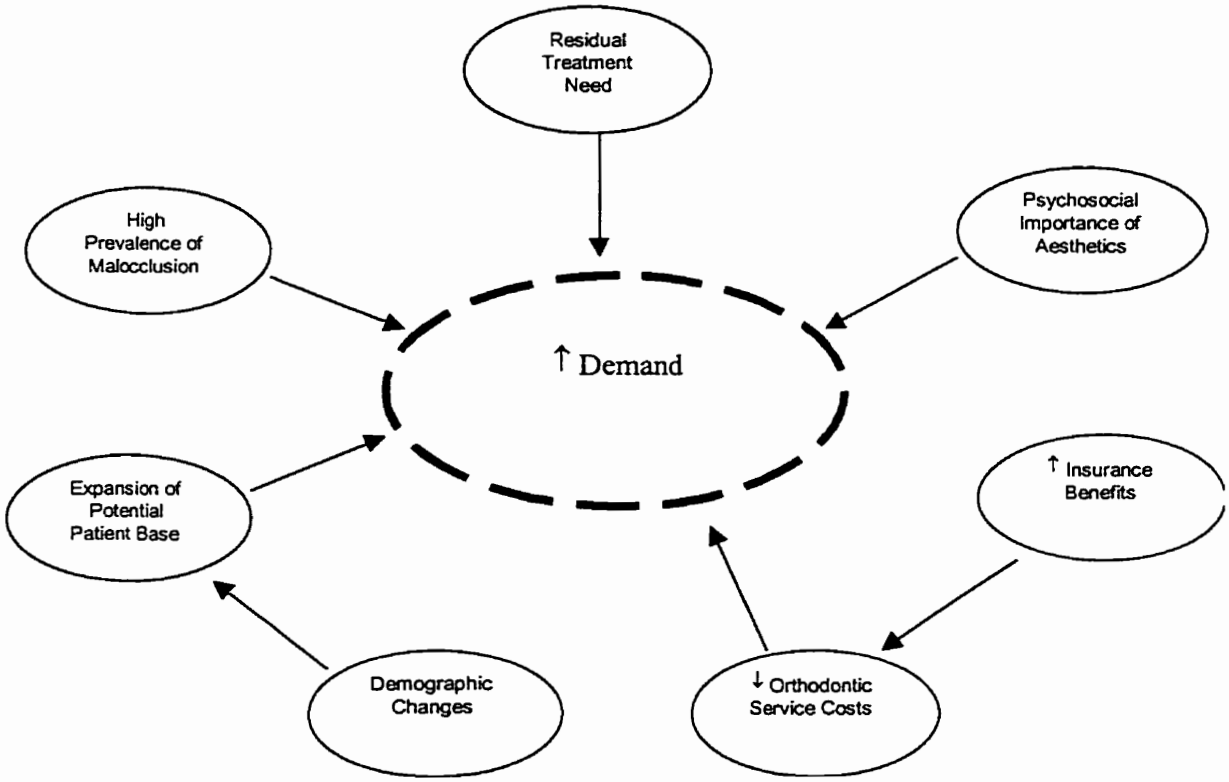
In the 1980s, there was a general perception that excessive numbers of graduates were enrolled in North American orthodontic specialty programmes (Sinclair and Rudolph, 1991). This contributed to a 26% reduction of class sizes enrolled in Faculty-based orthodontic programmes over the 1977-1983 period and a further 18% reduction in the 1983-89 period (Sinclair and Rudolph, 1991). More recent evidence indicate that the reduction in class sizes by 12.5% of North American Faculties had, however, been

compensated by an equal number of programmes with increased class sizes (Rudolph and Sinclair, 1997). Unfortunately, such demographic data are difficult to interpret, since they provide no information relative to changes in the proportions of male or female graduates, their relative use of auxiliaries or the number of specialists who have retired or participate in part-time employment. The general potential threat from the increased supply of specialist manpower is therefore difficult to evaluate, although the significance of the threat to existing specialists by the arrival of new specialists to a specific locale cannot be overstated.

2.1.2 External opportunities

Various concerns have been expressed for the lack of potential opportunities for future growth in the demands for specialist orthodontic services, although **Figure 2.3** identifies multiple developmental opportunities.

Figure 2.3: Potential External Opportunities for the Orthodontic Specialist



2.1.2.1 Prevalence of malocclusion

A review of the data from the third National Health and Nutrition Examination Survey (NHANES III) provides a clear view of the orthodontic service needs of the North American population (Proffit, Fields and Moray, 1998). These data indicate that only 35% of adults have well-aligned mandibular incisors. The irregularities of these teeth are severe enough for 15% of the population to require major arch expansion and/or extractions to resolve such malocclusion. In addition, approximately 20% had deviations from ideal bite relationships, of which 2% were sufficiently severe to require comprehensive orthodontic correction. The application of the Index of Treatment Need to these survey data further confirmed the market opportunities for the provision of orthodontic services, in that 57-59% exhibited a need for some form of orthodontic service. Clearly these data confirmed the potential for significant growth in orthodontic service demands, although their transformation to specialist service demands will provide a challenge.

2.1.2.2 Residual need for orthodontic services

Adolescents with unmet, or residual need for orthodontic services may represent a population with unidentified demand. In a study of 506 fifteen and 16 year-olds in the United Kingdom, 16% were found to be in need of orthodontic treatment, yet had no recollection of any previous advice regarding their malocclusions (Burden et al, 1994). This underscores the importance of the differentiation between treatment need and treatment demand as the numbers may be a reflection of either the patient's decision to decline treatment, or alternately, a malocclusion that failed to be identified as requiring treatment by the general dentist, which may ultimately a representation of an uninformed patient. In addition, an increasing popularity and social acceptance of orthodontic treatment for adults who were untreated as youth (Nattrass and Sandy, 1995) has contributed to an increase in service demands. Furthermore, adults who were unsatisfied with treatment received as adolescents, represent the potential demand for re-treatment.

Out of 121 adults who had previously received orthodontic treatment, forty-one per cent of the patients treated with appliances by general practitioners felt that they could benefit from further treatment, whereas only 16% of those treated by orthodontists felt the same way (Bergstrom and Halling, 1998). These findings indicate that the need for treatment exceeds the present demand, and that the conversion of need to demand is a potential source of potential growth of the specialist market.

2.1.2.3 Psychosocial orthodontic service needs

Orthodontic treatment cannot be justified relative to the traditional risks of non-treatment such as the increased chance of periodontal disease, caries, TMD, and speech impediment due to the lack of evidence in support of these claims. Its justification on the basis of aesthetic concerns or the psychological well-being of the patient has been reported (Dickson, 1970; Shaw et al, 1980; Plunkett, 1997). Demand for orthodontic treatment is escalated by the subjective self-perceptions of aesthetic impairment attributed by the malocclusion and its potential effects on body image (Sergl and Zentner, 1997). Psychosocial effects of malocclusion may include teasing in childhood (Helm et al, 1985, Zammit et al, 1995) and the negative reinforcement of social attitudes which could lead to a lowered self-concept (Helm et al, 1985). In a 1997 study of 60 adult patients, 35.6% with malocclusion attributed their emotional distress and personal insecurity to their dental appearance. Thirty-four per cent considered themselves to have a social handicap (Sergl and Zentner, 1997). These concerns support the idea that the dominating motivation for orthodontic treatment is appearance or aesthetics. However, as the social perceptions and acceptability of aesthetics may vary with time, the resultant demand for orthodontic treatment is expected to be affected accordingly.

2.1.2.4 Orthodontic service costs

As orthodontic service fees have become increasingly more affordable in recent times, they open opportunities for their increased market demands. These trends largely

reflect increases in the eligibility for employment-derived third-party insurance benefits in the United States, i.e. from 30.5%(1980) to 41.1% (1988) (Furino and Douglass, 1990). Although analogous national data for Canada have yet to be published, the introduction of market-driven reforms listed above will undoubtedly impact on these trends. Furthermore, since insurance benefits rarely provide total orthodontic service costs, recent general economic growth is also an important determinant of orthodontic service demands. In a study of 3696 third and fourth grade children, a strong association between treatment demand and socioeconomic status was apparent, with the demand higher (11.7%) in more affluent than in poorer (4.1%) children (Wheeler et al, 1994). Such discrepancies in service demands illustrate the potential opportunities for further market growth from economic improvements, due to the associated increases in the supplies of discretionary funds. This clearly identifies an opportunity for further market growth, provided the increases in discretionary funds can be directed to the provision of orthodontic services rather than other elective services (e.g. clothes, entertainment, etc.).

2.1.2.5 Growth of the overall dental industry

In Canada, a meta-analysis on the growth of the dental industry as a whole, based on economic indicators, has revealed that the dental industry has been in constant, steady growth from 1959 to 1990 (Leake, 1984; Leake et al, 1993). The population of Canada has increased by 9% in the 1980s, and dental prices had increased in concert with the Consumer Price Index. However, dental expenditures in the 1980s increased by 136%, which is much greater than the 9% population and the 70% Consumer Price Index increases (Leake et al, 1993). In Manitoba, the trend was similar to the Canadian averages (Leake et al, 1993). Per capita expenditures for dental services in Manitoba has increased by 125% from 1980 – 1989 (Leake et al, 1993). In the United States, in an 18 year period between 1970 and 1988, the amount of money spent on dentists' fees increased faster than the average consumption of the total products, including food and

clothing (Furino and Douglass, 1990). If these expenditure trends continue, the economic outlook for the specialty market will be promising.

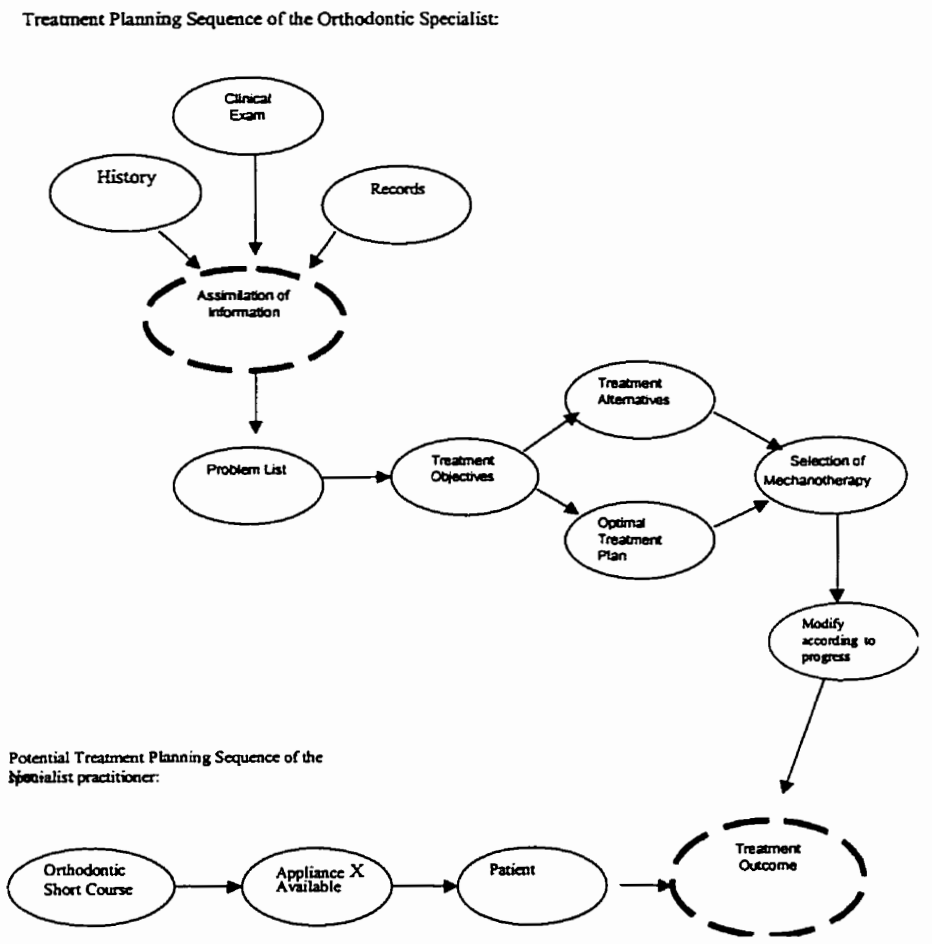
2.1.2.6 Demographic changes

Increases in the proportions of elderly cohorts in North American populations are no longer considered orthodontic market threats, since age no longer constrains the demands for orthodontic services. This is confirmed by a recent survey of patients seeking services from graduate orthodontic programmes in the United States of America (Rudolph and Sinclair, 1997), where the percentage of adults seeking orthodontic treatment increased from 4.6%(1983) to 12%(1994). Due to recent advances in techniques and materials, there are no longer barriers to the provision of orthodontic services to adults (Salama and Sarne, 1993; Nattrass and Sandy, 1995), provided precautions are taken to ensure tooth movements do not exceed the physiological capacity of the supporting tissues (Ong et al, 1998).

2.1.3 Internal strengths

The orthodontic specialist is educationally better equipped to diagnose and provide the most appropriate service to resolve specific malocclusions than general dentists, as illustrated in **Figure 2.4**.

Figure 2.4: Potential Differences in Treatment Philosophies Between the Orthodontist and Non-Orthodontist



2.1.3.1 Potential advantages of services derived from a University-based graduate orthodontic specialty training programme

The difference in the treatment rendered by a specialist as compared to a general dentist lies in the specialist's ability to better recognize the difficulty of the case and to be able to deal with subsequent problems arising during the course of treatment. A student of a three-year specialty programme has learned how to problem solve, in contrast to the registrant of a short orthodontic course, such as a weekend "motel" course, who has only been taught limited orthodontics. The orthodontic specialist is better equipped with the knowledge and techniques to offer the patient the various treatment options available to address the different aspects of the malocclusion and has had the opportunity to have hands-on instruction in the treatment of a variety of malocclusions under the direction of several specialists. In a recent survey of 121 twenty-seven year-olds who had received orthodontic care during childhood or adolescence (Bergstrom and Halling, 1998), individuals treated by orthodontic specialists were found to be more contented than individuals who were treated by general dentists. The same authors also reported that in a sample of 350 patients who had received orthodontic treatment, those treated by orthodontists had a greater degree of success than those treated by general dentists, despite the fact that 73% of the cases treated by orthodontists and only 29 % of the cases treated by the general dentists were considered to be difficult at pre-treatment (Bergstrom et al, 1998).

The university orthodontic specialty training programmes in North America have been accredited by the Canadian and American Dental Associations, while continuing education courses may not be. Furthermore, the graduate of a university-based programme is eligible for the specialty title, and is required to take further continuing education after graduation to ensure knowledge remains current. Furthermore, university-based specialty programmes have stringent course requirements and examinations in place to ensure that the graduate student is considered eligible to

graduate from the programme. Therefore, great efforts have been made by the profession to maximize the quality assurance of the orthodontic treatment rendered by an orthodontic specialist.

2.1.3.2 Relative potential disadvantages of orthodontic services derived from non-specialty trained professionals

In contrast to the stringent training and requirements of earning and maintaining the specialty title for orthodontics, non-specialty trained professionals have not completed courses accredited by the Canadian or American Dental Associations for qualification of the specialty title. Furthermore, continuing education courses specifically in orthodontics are not requirements for proof of qualification to provide orthodontic treatment. A general dentist need only obtain continuing education credits in any combination of disciplines of dentistry.

Major deficiencies in most short courses in orthodontics available to the general dentists have been outlined by Chate (1994). The providers of many of these courses make claims that are not substantiated by scientific research. The general dentists are made to believe in myths regarding treatment of malocclusions. Such myths include the justification of early treatment on the basis of the idea that most developmental jaw discrepancies are manifest before the age of five, or that early treatment reduces overall treatment time, increases the chances of complete correction, and helps to restore normal growth. Other fallacies include the belief that simple appliances can effect orthopaedic changes to enhance the growth of the jaws, leading to much more pleasing facial features than extraction treatment. According to Chate (1994), the non-specialty trained practitioner lacks the scientific knowledge and ability to question the validity of such claims and is easily influenced by them.

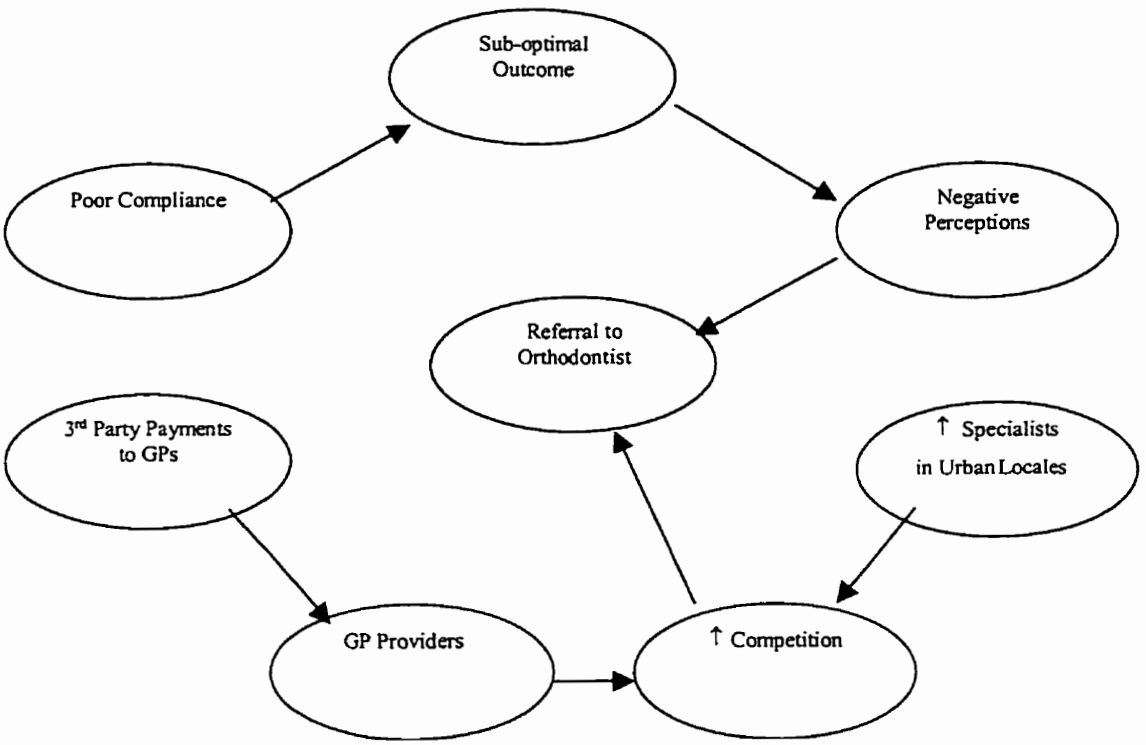
2.1.3.3 Poor correlation between malocclusion severity and complexity of the required orthodontic service

Malocclusion severity and complexity are poorly correlated and there is no objective index available which identifies and classifies malocclusions according to treatment complexity. For example, two malocclusions may seemingly be identical given the study models, such as the anterior openbite (Foster, 1979). In one case, the aetiological factor for the malocclusion may be a thumbsucking habit, which is quite simple to treat with the removal of the cause. However, in the case of a skeletal aetiology for the malocclusion, the treatment is far more complex and the results obtained may be unstable without surgery. A general practitioner who is oblivious to such differences will have done a great disservice to the patient by unknowingly tackling a problem that would have been better left to the specialist.

2.1.4 Internal weaknesses (Figure 2.5)

The perceived outcome of treatment received may negatively affect the future referral to the orthodontist. Sources for referrals have been identified (the dentist, auxiliary staff, patients and their parents, friends and neighbors) and the proportion of each vary through the professional lifetime of the practice (Gottlieb et al, 1997). Therefore, in addition to achieving the standard of care for the patient, the orthodontist must consider that the subjective perception of the patient and others may be influenced by other factors.

Figure 2.5: Internal Weaknesses



2.1.4.1 Determinants of a successful specialty orthodontic office

An orthodontic practice is in essence a "small business" (Hughes et al, 1996) to which typical business principles apply. However, the success of the practice is dependent primarily on the personality traits of specialist, in addition to clinical and business acumen (Hughes et al, 1996). The potential for internal marketing is great, and the specialist can take full advantage by ensuring a positive patient experience at each appointment. This requires a coordinated effort among the entire staff, including the orthodontist. A negative experience can result in detrimental impact on the future success of the practice.

2.1.4.2 The 'art' of orthodontics

Since most orthodontic services have yet to be subjected to controlled clinical trials, their provision may be associated with unfortunate iatrogenic consequences, including root resorption (Brezniak and Wasserstein, 1993a; 1993b; Lupi et al, 1996; Vlaskalic et al, 1998) and relapse (Little et al, 1990;Blake and Bibby, 1998). Orthodontic treatment and root resorption have been associated for many years and there is evidence that root resorption is more likely to occur with uncontrolled, heavier forces (Brezniak and Wasserstein, 1993). In a study of 88 adults, the prevalence of root resorption was found to be much higher following 12 months of fixed appliance therapy (73 %) when compared to the pre-treatment scores (15%) (Lupi et al, 1996).

Relapse following orthodontic treatment is also of real concern when iatrogenic changes of arch form, intercanine and intermolar widths have occurred. Arch length increases were also found to relapse in 20 out of 26 patients, even when the arch length was increased by only 1 mm, compared to the initial malocclusion. Furthermore, 89% showed clinical unsatisfactory alignment of the teeth (Littie, 1990). Some of the effects may not be as a result of iatrogenic active orthodontic therapy. Little et al, (1981) reported a success rate (measured by the irregularity index score) of less than 30% in 65

patients who have had extractions and treatment with full braces, at least ten years after retention. Twenty percent showed marked crowding. A follow-up study indicated only a 10% success rate in an additional 10 years post-retention, using the same criteria for success (Little et al, 1988). These results suggest that closer attention be paid to the retention of the result, with permanent retention highly recommended (Little, 1990).

In addition to the potential iatrogenic effects of orthodontic treatment, there are marked discrepancies in the forms of orthodontic services (e.g. the design and timing of appliances) provided by different specialists for apparently analogous forms of malocclusion (Bowman, 1998). These differences in philosophies of treatment may have a negative effect on the public's trust in the professionals. Accordingly, good patient education and a thorough explanation of the treatment plan, as well as alternatives, is essential.

2.1.4.3 Third party payments for orthodontic services provided by both orthodontists and non-orthodontists

The lack of accepted criteria which distinguish cases that should be preferentially provided by orthodontists is an important factor affecting the specialty market. Without such criteria, the patient presenting with a complex malocclusion beyond the realm of a general dentist, may be inappropriately treated, especially in a preferred provider insurance scheme. Failure in treatment outcome resulting from improper diagnosis, where the provider has not identified the true nature of the malocclusion, is a real concern with the inexperienced, non-orthodontist-trained provider. A common example is the indiscriminant use of certain functional appliances by general dentists in Class II patients, irregardless of the presence of a long lower anterior face height or anterior open bite (Woodside, 1998), resulting in detrimental facial aesthetics. Without recognition of the complexities inherent in the presenting malocclusions, and without limitations imposed by the third party insurance, patients whose treatment should be provided by a specialist may indeed land in the office of an inexperienced generalist.

2.1.4.4 Specialty aggregations in urban areas

Transportation costs for rural patients and their parents may greatly exceed service fees, e.g. $25 000 transportation and accommodation costs for Manitobans residing in a distant rural location (Hechter, 1999). The population of specialists in urban areas continually grows as new graduates enter the profession, which contribute to an increase in professional competition amongst the orthodontists.

2.1.4.5 Patient compliance

Whereas poor compliance may compromise all orthodontic services, the derived adverse publicity for those provided by orthodontists may be detrimental in a highly competitive market. For example, a failed treatment outcome resulting from the failure of a patient to co-operate may not be seen as such by friends, neighbors and the referring dentist. Alternatively, the perception may be one of an inept orthodontist, which, again, may affect the referral of future potential patients.

Clearly the impact of the various parameters listed above will vary not only between different geographic regions, but also with time. This investigation is principally focused on the latter. The fluctuations in the orthodontic market over time need to be assayed in order to plan the future of the profession. It was therefore necessary to assay the malocclusion severity of the referral base, using one of the indices of malocclusion described in the next section. The information derived from this pilot study was considered critical to the design of a more definitive evaluation of the specialty orthodontic domain.

2.2 Assays of malocclusion severity of the referral base for a single orthodontic specialist

Purely descriptive assays of a malocclusion (e.g. categories based on the relative maxillary and mandibular orientation of the first permanent molar (Angle, 1899) or incisors (Ballard and Wayman, 1964) were considered inappropriate for this investigation, due to the subjective nature of the derived data. Similarly, although various indices have been devised for epidemiological surveys such as the Handicapping Labiolingual Deviation (HLD) (Draker, 1960), the Malalignment Index (MI) (Van Kirk and Pennell, 1959), the Occlusal Feature Index (OFI) (Poulton and Aaronson, 1961), Treatment Priority Index (TPI) (Grainger, 1967), the derived data are too generalized for precise assays of malocclusion severity for individual patients. Criticisms may also be leveled at indices designed to assay purely the morphological parameters of a malocclusion, such as the Occlusal Index (OI) (Summers, 1971), Peer Assessment Rating (PAR) (Richmond et al, 1992a), since orthodontic service demands are primarily associated with aesthetic rather than morphological or functional parameters (Brook and Shaw, 1989; Otuyemi and Noar, 1996). Although the American Association of Orthodontists (AAO) considers that malocclusion severity, and therefore service need, is too complex to be summarized by an index, more recently a number of indices have been devised that not only incorporate both morphological and aesthetic parameters, but are also valid and reproducible (Shaw et al, 1991).

2.2.1 Properties of an ideal index of malocclusion

Certain characteristics of an ideal index of malocclusion (for the purpose of this investigation) were identified and are similar to those suggested by Shaw et al, (1991) and include the following:

- **Reliability or reproducibility**
- **Validity**

- **Simplicity and efficiency**
- **Objectivity**
- **Sensitivity to the needs of the patient**
- **Amenable to statistical analysis**

2.2.2 Summary of Indices of Malocclusion

Many different indices to measure the need for orthodontic treatment have been developed for the purpose of establishing treatment priority in a population. Several of those which are more popular are summarized in detail in Appendix A. This section is limited to a brief discussion of each index, as well as a description of the Dental Aesthetic Index.

2.2.2.1 Handicapping Labiolingual Deviation Index (HLD)

This index was devised by Draker (1960) for the assessment for orthodontic treatment need. Draker identified 9 components that were of importance and assigned weightings according to their contribution to the overall assessment. Limitations of this index include the following:

- The weightings assigned to the components were subjective and arbitrary.
- Other components, such as missing teeth, spacing, and transverse discrepancies are not measured.
- The reliability of the HLD was found to be lower than the IOTN and the HMAR (Younis et al, 1997).
- The index resulted in under-recommendation of treatment (Younis et al, 1997)

Therefore, this is not the index best suited for this investigation.

2.2.2.2 Treatment Priority Index (TPI)

Grainger's Treatment Priority Index (Grainger, 1967) was developed to objectively express the severity of malocclusion and therefore provide a measure of treatment-need based on ten component parameters. Unfortunately, the following limitations of the index are apparent:

- Crowding, spacing, and midline deviations are not considered.
- The TPI cannot depict crowding of the unerupted permanent canines and premolars (Ghafari et al, 1989) in the mixed dentition cases, without performing a mixed dentition analysis, which increases the length of time required to apply the index.
- The weighting of each component is arbitrary (Helm et al, 1975)
- Non-incisor and non-congenitally missing teeth are not scored.
- Although its reliability was measured as good (Scivier et al, 1974), the index was designed to assess the presence and degree of malocclusion for epidemiological purposes.
- Although statistically significant, the validity of the index was found to be only moderately good (Slakter et al, 1980), with a correlation coefficient of 0.42, when considering the measurement of treatment need.
- The validity of the index in discerning varying degrees of malocclusion severity was lacking in evidence (Grewe and Hagan, 1972)

Based on the critisism of the above mentioned authors, the TPI is only of limited use.

2.2.2.3 Handicapping Malocclusion Assessment Record (HMAR)

The Handicapping Malocclusion Assessment Record (HMAR) was developed by Salzmann (1968) in order to priorize treatment-need, according to malocclusion severity. The following are limitations of this index:

- The weightings assigned to the components are subjective and arbitrary
- The index is useful only in the permanent dentition
- The components are either all or none, that is there are no severity levels of the individual components.
- Molar deviations are recorded only if there is a full cusp discrepancy.

- The validity and reliability of the HMAR was found to be lower than other indices (Grewe and Hagan, 1972)

Based on the study of Grewe and Hagan, it was therefore deemed that the HMAR is not suitable for the purpose of this study.

2.2.2.4 Occlusal Index (OI)

The Occlusal index was devised by Summers (1971), based on the work of Grainger (1967). Although the OI scored highest in validity and reproducibility compared to other indices, such as the HMAR, TPI, and HLDI (Grewe and Hagan, 1972), there are inherent deficiencies evident:

- The index is very complex and not simple to use
- It was found to under-estimate orthodontic treatment-need (Tang, 1995)
- It does not measure interproximal spacing, other than a maxillary diastema.

Accordingly, the Occlusal Index is not ideal for the purpose of this investigation.

2.2.2.5 Malocclusion Severity Index (MSI)

The Malocclusion Severity Index (MSI) (Hill, 1992) was developed by applying a series of weighted scores to 9 occlusal measurements. This index has the following inherent deficiencies:

- The weightings assigned are subjective
- The validity was similar, but not as high as other indices, and tested by the same author who developed it (Hill, 1992).
- Midline deviations are not assessed.

Therefore, this index is inadequate for the purpose of this investigation.

2.2.2.6 Index of Orthodontic Treatment Need (IOTN)

The IOTN was developed at the University of Manchester (Brook and Shaw, 1989). This index has several limitations:

- The measurements are reported as categorical data, and therefore cannot be subjected to statistical analyses

- The severity of the cases within each severity level cannot be rank-ordered according to relative severity.
- Since only the worst trait determines the category, several minor irregularities of the different occlusal features do not necessarily add up to score high enough to indicate treatment need (McGuinness and Stephens, 1994).
- The aesthetic component takes account of only the teeth and not the teeth within the face.

Clearly this index is not suitable for the purpose of this investigation.

2.2.2.7 Peer Assessment Rating (PAR)

Although the PAR index was designed to measure the results of orthodontic treatment and is not an index of treatment need, it may be used to assess the severity of the malocclusion. It was based on the opinion of a panel of ten experienced orthodontists in 1987 (McGuinness and Stephens, 1994).

The disadvantage of the PAR index is that it was designed to evaluate treatment results, not treatment need, and that there is no account of the inclination of the crowns of the teeth. Furthermore, the PAR index was validated by 74 British orthodontists and reflects contemporary British orthodontic opinion. More studies are required to evaluate its validity on North American populations, by North American-trained orthodontists.

Therefore, this index is not suitable.

2.2.2.8 The Dental Aesthetic Index (DAI)

The DAI was developed in Iowa (Cons et al, 1986), based on the public's perceptions of dental aesthetics, the motivating factor for treatment. Its purpose was to measure the prevalence of orthodontic treatment need in populations, to allow ranking of treatment priority, to measure the potential demand for orthodontic treatment in a population, and to aide administrators to ration resources in funded orthodontic treatment programmes (Cons and Jenny, 1988). The premise underlying the DAI is that the higher the score, the more likely the person will have social handicaps and will require

orthodontic treatment. There is a high correlation between dental aesthetics, need for treatment and the severity of malocclusion (Lewis et al, 1982). The DAI involves the measurement of 10 components of malocclusion and the application of a regression equation involving the 10 components, their weightings and a constant (Jenny and Cons, 1996a).

The components of the DAI are listed in the following table:

Components of the DAI	Regression Coefficients	
	Actual Weights	Rounded Weights
1. Missing Visible Teeth	5.76	6
2. Crowding	1.15	1
3. Spacing	1.31	1
4. Diastema	3.13	3
5. Largest Anterior Irregularity (upper)	1.34	1
6. Largest Anterior Irregularity (lower)	0.75	1
7. Anterior Maxillary Overjet	1.62	2
8. Anterior Mandibular Overjet	3.68	4
9. Vertical Anterior Openbite	3.69	4
10. Antero-Posterior Molar Relation	2.69	3

*Jenny and Cons, 1986.

The DAI has the following advantages over the other indices:

- Since the main benefit of orthodontic treatment to the patient is improved aesthetics and possibly social-psychological well-being, the index of treatment need should have an aesthetic component. (Brook and Shaw, 1989, Otuyemi and Noar, 1996). The DAI is based on public perception of dental aesthetics and assesses the social acceptability of dental appearance, and is therefore sensitive to the needs of the patients.

- DAI can rank order cases, according to severity of malocclusion (Jenny and Cons, 1996).

- The DAI has been found to have a high level of reliability (Cons et al, 1986; Otuyemi and Noar, 1996) and validity, and the DAI scores were found to be significantly associated with the perception of treatment need by students and their parents (Cons et al, 1987).

- The DAI has the advantage of speed and simplicity (Otuyemi and Noar, 1996).

- The weightings of the components of the DAI were statistically derived via regression analysis and were not the result of individual, subjective opinion.

- The suitability of the standard DAI equation has been studied extensively. The standard DAI equation is suitable for at least eleven different ethnic groups. That is, a separate ethnic group-specific DAI equation is not necessary (Cons and Jenny, 1994, Cons et al, 1994) as the social norms for dental aesthetics do not differ significantly in developing and industrialized countries (Cons et al, 1989)

- Although initially designed for the evaluation of the permanent dentition, modifications have been proposed that allow the DAI to be applied to malocclusions in the mixed dentition.

- The score derived by the DAI is on a continuous scale, representing a wide range of malocclusion severities and is amenable to statistical analyses.

Therefore, the DAI is suitable for the purpose of this investigation.

2.2.3 Rationale for the approach to the current investigation

The evaluation of changes in malocclusion severity of the referral-base of a specialist orthodontist over time was based on the premise that the derived data would provide invaluable assays of the impact of changes to the specialty domain. Clearly other assays could have been used to achieve this objective (e.g. economic, service outcomes, patient satisfaction, etc.), although the assay selected in this investigation was considered to provide the most objective data for future strategic planning to ensure continued market growth.

The approach for the current investigation was justified based on the following premises:

- that orthodontic service referrals to a specialist had been predominantly pre-screened by a generalist (i.e. frivolous service demands had been eliminated from the referral base);
- that orthodontic service acceptances provided more comprehensive assays of the specialty domain than the initial referral base, since service acceptance/refusal is integrally associated with the specialty domain;
- that a multi-component index provides adequate data to statistically evaluate the changes in domain determinants over time.

As this investigation was designed as a pilot study to evaluate changes in the domain of orthodontic specialists, changes may be anticipated following analyses of the derived data.

Purpose

To summarize, the market for specialist orthodontic services is influenced by multiple parameters, which may vary in impact between different geographic locations. There may also be discrepancies between the markets for individual specialists, although

the extent of this variability has yet to be documented. As the lack of published data on such market variables constrains their comprehensive evaluations, the present investigation was primarily designed as a pilot study centered on one particular aspect: an evaluation of changes to a specific local market assayed by the examination of changes to the case-referrals of a single orthodontic specialist.

Hypothesis

The null hypothesis states that no significant changes occurred in the referral base of the orthodontic practitioner over the 24- year period.

Other more broadly-based investigations will therefore be required to encompass other parameters that affect this market (e.g. service prescriptions and service outcomes), to provide a more comprehensive appraisal.

3.0 Materials and Methods

In this investigation, further refinements to evaluate changes to the local market hinged on two principal potential options:

- A cross-sectional examination of the referral case samples for a significant proportion of the local market specialists over a short period of time.
- A longitudinal examination of referral case samples for a single specialist over a longer time period.

The latter option was selected for this investigation, based on the following potential advantages:

- The individual specialist had meticulously maintained and catalogued dental records before (A) and after (B) treatment, for a period of 24 consecutive years; a period of sufficient duration to encompass the impact of recent market changes in orthodontic service supplies and demands in the region;
- The alternative option was associated with a number of potential disadvantages: these included variation in the time spent by different specialists in the region, variation in record storage (i.e. multiple patterns of record storage by different specialists) and variation in service philosophies of different specialists (i.e. discrepancies between their service techniques and timings).

This investigation was undertaken as a pilot study for future more comprehensive market evaluations.

3.1 Case selection

Initial review of the case-storage for this orthodontist showed that there were records (study models, photographs, radiographs, case-notes, etc.) for approximately 5000 patients serviced over the 24 year (1974-1997) period that the office had been fully operational. Since detailed evaluation of the pretreatment records for all these case records could clearly not be accomplished over the allotted time period for this investigation, some form of random sampling was imperative.

An initial evaluation of the pretreatment case-records for another specialist in a different region was therefore undertaken, where considerable replication in the type and severity of malocclusion of cases referred in a single year was evident. Following the advice of an experienced biostatistician (Dr. T Hassard, Faculty of Medicine, University of Manitoba), the definitive investigation was based on 25% random annual samples of the stored case-records of the orthodontist. Random sampling was facilitated by the segregation of the chronological case-storage by case number, where the sample was defined by 25% of the total number of cases. An annual sample was then defined by selecting every nth case, where the sum of these cases equaled 25% of the annual case storage. Due to the meticulous storage system, no further refinement was required to accommodate deficiencies in specific case-records.

3.2 Case evaluation

This investigation of the pretreatment referral base of a single orthodontist necessitated a numeric evaluation of the case records. As the accuracy of such numeric (quantitative) descriptions was so critical to the success of this investigation and for reasons reported in the Introduction, section 2.2.2 the DAI was the chosen index for the assay of malocclusion severity.

3.2.1 Case evaluations by the DAI

The records upon which the DAI was applied included the pre-treatment study models (A) of 1156 cases referred to the orthodontic specialist for treatment.

Measurements on each of the study models were taken in accordance to the published method for using the DAI (Cons and Jenny, 1986) with the following modifications:

- Teeth not present on the study models were counted as "missing" unless:-
  - there was 4 or more millimeters of space available for its eruption, and
  - the missing tooth is a reflection of the normal exfoliation/eruption pattern of the mixed dentition (within 2 years of expected eruption dates).
  - the contralateral tooth was just emerging through the gingiva.
  - the space available for it was "zero".
  - The deciduous tooth was retained where congenitally missing second bicuspids were suspect
- Teeth not present on the study models were counted as missing if:-
  - there was any residual space in a previous extraction site (serial extraction cases).
  - the second bicuspids were missing and the E's were submerged.
  - canines were not present, whether or not C's were retained.
  - the deciduous teeth had exfoliated prematurely (greater than 2 years ahead of normal eruption pattern)
- Where a subjective judgement was required to assess the presence of a succedaneous tooth, due to the dental age of the patient, then the pretreatment radiographs were consulted.

Individual measurements were entered onto separate score sheets for each set of models. One examiner scored all 1156 cases. Approximately 100 cases were scored at each session. Prior to the start of each session, the guidelines on the use of the DAI were reviewed. All millimeter measurements were made with the same stainless steel ruler. Data from the individual score sheets were then entered on an Excel spreadsheet designed to calculate the DAI and Modified DAI (Danyluk, 1998) scores from the individual

component measurements. The entries were checked for errors. The scoring methods are described in detail in Appendix B.

In addition to scoring the study models with the DAI, the proportion of cases with impacted canines, serial extractions prior to referral, and missing teeth were recorded for each year. Furthermore, the DAI scores were filtered according to the following malocclusion severity levels:

Score	Severity Level
≤ 25	Normal or minor malocclusion No need or slight treatment need
26-30	Definite malocclusion Treatment elective
31-35	Severe malocclusion Treatment highly desirable
≥ 36	Handicapping malocclusion: Treatment mandatory

*Jenny and Cons 1996, Jenny et al 1993.

3.2.2 Reliability of DAI appraisals

Although the reliability of the DAI has been well established (Spencer et al, 1992; Cons et al, 1986), it was necessary to ensure that the examiner for this investigation was scoring the casts correctly. In order to calibrate the investigator to ensure proper application of the DAI to the study models, a sample of 5 study models were randomly selected from the records of the graduate orthodontic clinic of the University of Manitoba. The records were independently scored by the investigator as well as a graduate student who was knowledgeable and experienced in the use of this index. Paired t-tests were performed to evaluate the inter-examiner reliability, and correlation coefficients were calculated. Furthermore, the original measurements by the examiner of this investigation were re-taken a period of 1 month following the original scoring and the reliability was similarly calculated.

The results of the paired Student t-test indicated no significant differences in the scores between the examiners ($t = 0.167$, $p>0.5$) and a high degree of correlation (Pearson Correlation Coefficient = 0.975). This was in concordance with the high score for inter-examiner agreement in a previous study by Danyluk (1998) at the University of Manitoba.

When the same sample was re-evaluated 1 month following the initial evaluation by the examiner for this investigation, a high degree of agreement between the two sets of scores was evident (Pearson Correlation Coefficient = 0.99, $p < 0.05$). Therefore, the competency of the examiner had been demonstrated. The DAI scores for each examiner are presented in table 3.1.

Table 3.1: Summary of Interexaminer and Intraexaminer Agreement with Respect to DAI Scores

Case	Examiner A	Examiner B (T1)	Examiner B (T2)
1	51	55	55
2	33	31	30
3	61	59	58
4	52	53	54
5	43	41	43
t-test	t = 0.167, N.S.		t =-0.34, N.S.

N.S. = Non-Significant

Furthermore, the inter-examiner agreement of 6 graduate students was measured in a previous related study (Danyluk, 1998). The results indicated a correlation coefficient of 0.99 ($p<0.05$), indicating an extremely high level of inter-examiner agreement in DAI scores (Danyluk, 1998).

3.3 Analysis of the local orthodontic service market

Third-Party insurance benefits contribute to the professional fees required for specialist orthodontic services, although they also require variable payments from discretionary funds. As orthodontic services must therefore compete with other discretionary fund demands (e.g. vacations, entertainment, food, clothing etc.), their demands are functions of local economic factors, competition from other specialists and non-specialists in the region, in addition to changes in the demographics of potential patients. As there is potentially a vast volume of data available, advice from an experienced economist indicated that information derived from the CANSIM (CANadian Socioeconomic Information and Management Database, University of Toronto) and Manitoba Dental Association data-bases would provide adequate appraisals of the local orthodontic service market, rather than more detailed econometric analyses.

An appraisal of the local economic changes over the 1974-1997 period was therefore abstracted from the following data:-

1. Unemployment rates for Manitoba, from 1976 – 1996 (The Labour Force-Catalogue no. 71-001-XPB).
2. Consumer price index for Manitoba and Canada (Consumer Prices and Price Indexes cat. no. 62-010-XPB, and Natural Resources Canada, CANSIM Label #E305030)
3. Gross domestic product—personal disposable income for Canada, in 1981 Constant Dollars (Energy-Mines-Resources Canada).
4. Gross domestic product at market prices for Manitoba (Canadian economic observer. Statistics Canada cat. No. 11-210-XPB)
5. Personal expenditures on consumer goods and services for Manitoba (S.D.D.S. 1902 STC (12-213), CANSIM Label D31853).
6. Births in Manitoba (S.D.D.S 3201 3601 STC (91 – 002), CANSIM Label D151).
7. Population of 7 – 19 year-olds for Manitoba (S.D.D.S. 3604 Demographic Division, CANSIM Labels C894521, C894524, C894527, C894548, C894566).

8. Population of 12-year-olds for Manitoba (S.D.D.S. 3604 Demographic Division, CANSIM Label C894536).

9. Number of Dentists and Orthodontic Specialists for Manitoba (Manitoba Dental Association, 1998).

The derived economic data then comprised the following:-

a. Dentist to population ratios for Manitoba

b. Orthodontist to population ratios for Manitoba

c. Orthodontist to population of 7 – 19 year-olds ratios for Manitoba. The age range was chosen to represent the patients most likely to be referred for orthodontic treatment. Waldman (1998) defined the "orthodontic age" to be 5 – 19 years. However, the age of 7 was used as the lower end of the range in accordance to the American Association of Orthodontists guidelines for when patients should be screened orthodontically.

d. Predicted number of 12-year-olds until the year 2009.

e. Economic indicators in constant dollars, converting the published data using the consumer price index, in order to account for inflation.

3.4 Statistical analysis

Initially the component DAI parameters were entered onto an Excel spread sheet. They were checked for their validity by analysis of scatter plots of the DAI case-scores for each year over the 1974-97 period, where any extraneous score was re-evaluated as a further safeguard. Subsequently, these data were subjected to univariate statistical appraisals, although the multivariate technique of Factor analysis was subsequently used to evaluate the DAI components that provided the most significant contribution to the changes in case-referrals identified from these data. The biostatistician indicated that this required orthogonal data transformation, and that Varimax and Promax rotation was the

most appropriate technique for this analysis, which was executed through the SAS statistical package interfaced with the Excel spreadsheet. By contrast, simple graphical representation was considered sufficient for the econometric analyses of the local market.

Correlation analyses between the "year" and "DAI score" and "Modified DAI score" were carried out, and Pearson correlation coefficients for the mean, median, upper and lower 25th percentiles, and upper and lower 10th percentiles were generated. Correlation analysis between the "year" and the "proportion with impacted canines", "proportion with serial extraction" and the "proportion of no need or elective treatment need" were also carried out and Pearson Correlation Coefficients were generated.

4.0 Results

This section is divided into two components. The first describes the changes in the sample DAI scores over the 1974 – 1997 period, in addition to other variables in the referral base of the orthodontic specialist, whereas the second section contains an overview of the changes in demographics and economics during this time interval.

The results of this investigation are unique, since no other longitudinal evaluation of changes to the referral base of orthodontists have been reported in the literature. In order to provide the most appropriate perspective to evaluate these data, the results from the DAI assays are first considered, prior to consideration of the associated regional and demographic and fiscal changes. The principal interactions between these parameters are presented in the Discussion section of this dissertation.

4.1 Changes in the overall referral base for the 1974 – 97 period

As shown in Figure 4.1, there were marked changes in the annual referral case numbers of this orthodontist over the 1974 – 1997 period. The initial 260 percent increase between the first and second year was the typical expansion expected for a new orthodontist in the 1970's, whereas the analogous rate of decline over the 1996 – 1997 primarily reflected temporary changes in the professional commitments of the orthodontist, to the practice at the time, rather than an actual referral decline to the practice (i.e. patients referred to the orthodontist, were temporarily treated by other partners in the practice). As summarized in Table 4.1, the random 25 percent annual samples resulted in 22 cases being evaluated in 1974 and 1997 respectively, whereas the annual samples for the intermediate period ranged from 77 (1980) to 35 (1988). Due to the method used for their random sampling (Materials and Methods (Section 3.1), the annual samples were considered representative of the referral base as a whole.

Figure 4.1: Annual Referral Case Numbers from 1974 – 1997

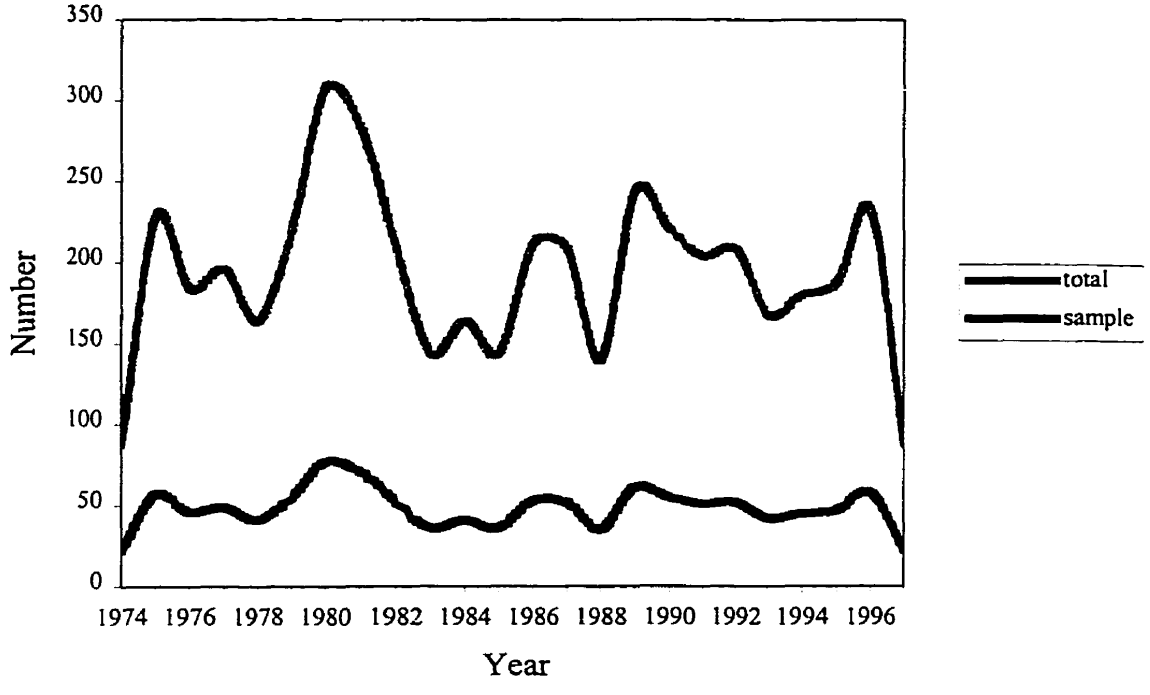


Table 4.1: Summary of the Annual Referral Base Numbers

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Cases	88	228	184	196	164	220	308	284	208	144	164	144
Case Sample	22	57	46	49	41	55	77	71	52	36	41	36

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Total Cases	212	208	140	244	220	204	208	168	180	188	232	88
Case Sample	53	52	35	61	55	51	52	42	45	47	58	22

4.2 Changes to the referral base assayed by the "standard" DAI

As summarized in Table 4.2, the mean annual DAI scores were remarkably constant over the 24 – year (1974 – 97) period. As these data contrasted with the annual sample estimates provided by their standard deviations and coefficient of variations (Figure 4.2), they underscored the need for further investigation of changes in the referral base composition. For instance, Figure 4.3 underscored marked variations in the annual samples, with a decrease in DAI scores over time. These trends proved statistically significant at all levels but the 10^{th} percentile (Table 4.3), and suggested that the cases referred over the time period studied were progressively reduced in severity. These changes were more evident from the DAI component parameters.

Table 4.2: Summary of Mean Standard DAI Scores from 1974 - 1997

Year	Mean	S.D.	S.E.	Coefficient of Variation	Index Relative to 1974
1974	39.00	10.245	2.184	26.27	100.00
1975	38.39	7.345	0.973	19.14	98.43
1976	40.13	11.525	1.664	28.72	102.90
1977	38.71	10.650	1.491	27.51	99.27
1978	40.12	7.308	1.141	18.21	102.88
1979	40.40	8.096	1.092	20.04	103.59
1980	39.73	9.205	1.049	23.17	101.86
1981	41.59	9.250	1.098	22.24	106.64
1982	39.38	8.610	1.194	21.86	100.99
1983	39.00	9.754	1.626	25.01	100.00
1984	36.41	8.643	1.350	23.73	93.37
1985	40.44	9.278	1.546	22.94	103.70
1986	36.85	9.086	1.248	24.66	94.48
1987	37.04	9.191	1.275	24.81	94.97
1988	37.83	9.189	1.553	24.29	97.00
1989	37.15	9.318	1.193	25.08	95.25
1990	38.96	8.988	1.212	23.07	99.91
1991	36.61	7.416	1.039	20.26	93.87
1992	37.60	7.922	1.099	21.07	96.40
1993	37.74	8.563	1.321	22.69	96.76
1994	36.80	8.943	1.304	24.30	94.36
1995	35.85	8.799	1.257	24.54	91.93
1996	36.72	9.407	1.214	25.61	94.16
1997	36.73	9.108	1.859	24.80	94.17

Figure 4.2: Summary of Mean DAI Scores, Standard Deviation and Coefficient of Variation

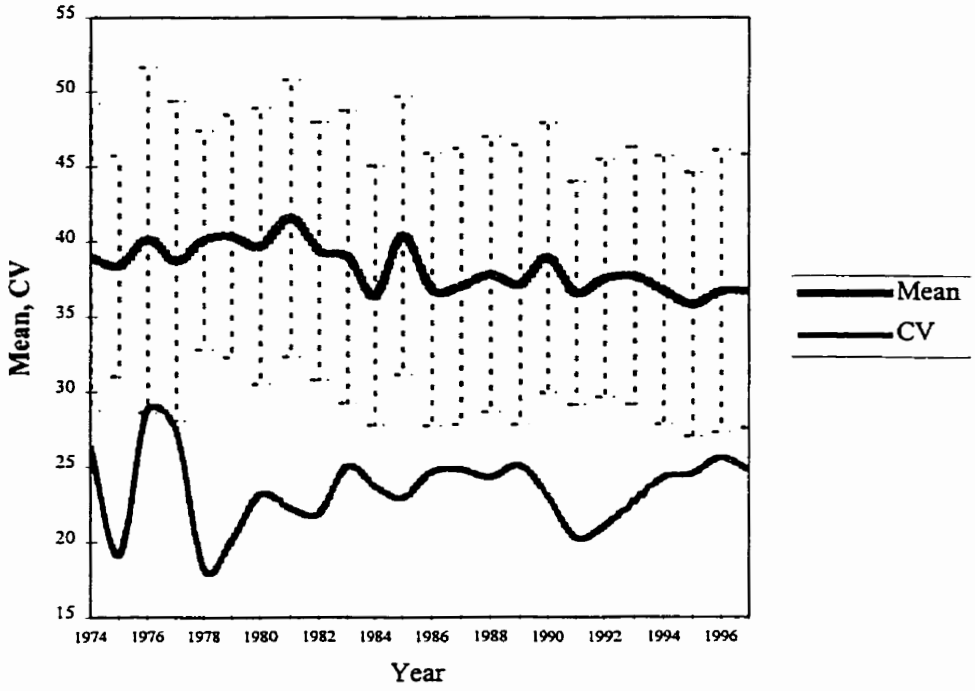
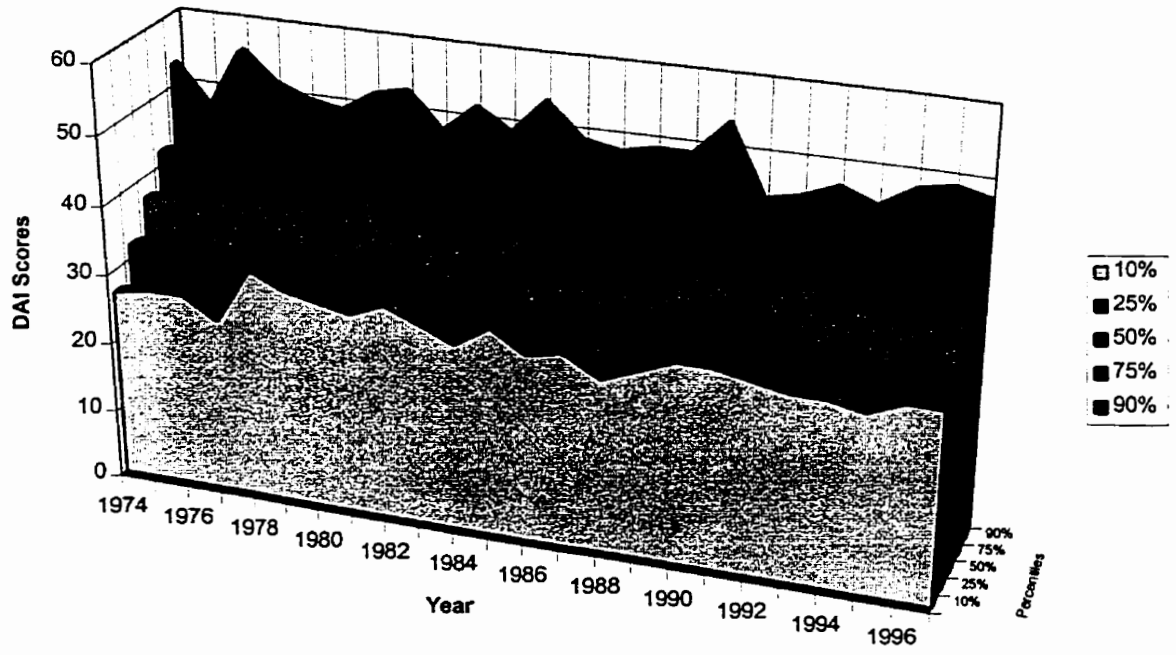


Figure 4.3: Standard DAI Scores from 1974-1997



Note: The figure is slanted to accommodate the 3-dimensional effect. The DAI scores are presented according to the various percentiles. That is, the 10th percentile represents the lowest 10 percent of the scores, while the 90th percentiles encompasses all DAI scores except those in the top ten percent. The median DAI scores are represented by the 50th percentile.

Table 4.3: Correlation Analysis of Standard DAI Scores with Time

	Mean DAI	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Pearson Correlation Coefficient (r)	-0.69*	-0.27,*NS*	-0.60**	-0.570**	-0.55***	-0.53***

p<0.001, **p<0.005, ***p<0.05, NS = Non-significant

4.2.1 Changes in the component DAI parameters

Since the standard DAI comprises the addition of 10 differentially weighted component parameters, plus a constant, their changes over time have provided unique insights into the subtle referral base variations with time. A summary of the correlation of each component with time is presented in Table 4.4.

Table 4.4: Correlation Coefficients of Individual DAI Components with Time

	Missing	Crowding	Spacing	Diastema	Maxillary Irregularity
Pearson's Correlation Coefficient (r)	+0.18 *NS*	-0.52*	+0.51*	+0.18*NS*	-0.14*NS*

	Mandibular Irregularity	Maxillary Overjet	Mandibular Overjet	Overbite	Molar Relationship
Pearson's Correlation Coefficient (r)	+0.39*NS*	-0.77***	-0.03*NS*	-0.43*NS*	-0.60**

p<0.05, **p<0.005, ***p<0.001, NS=Non-significant

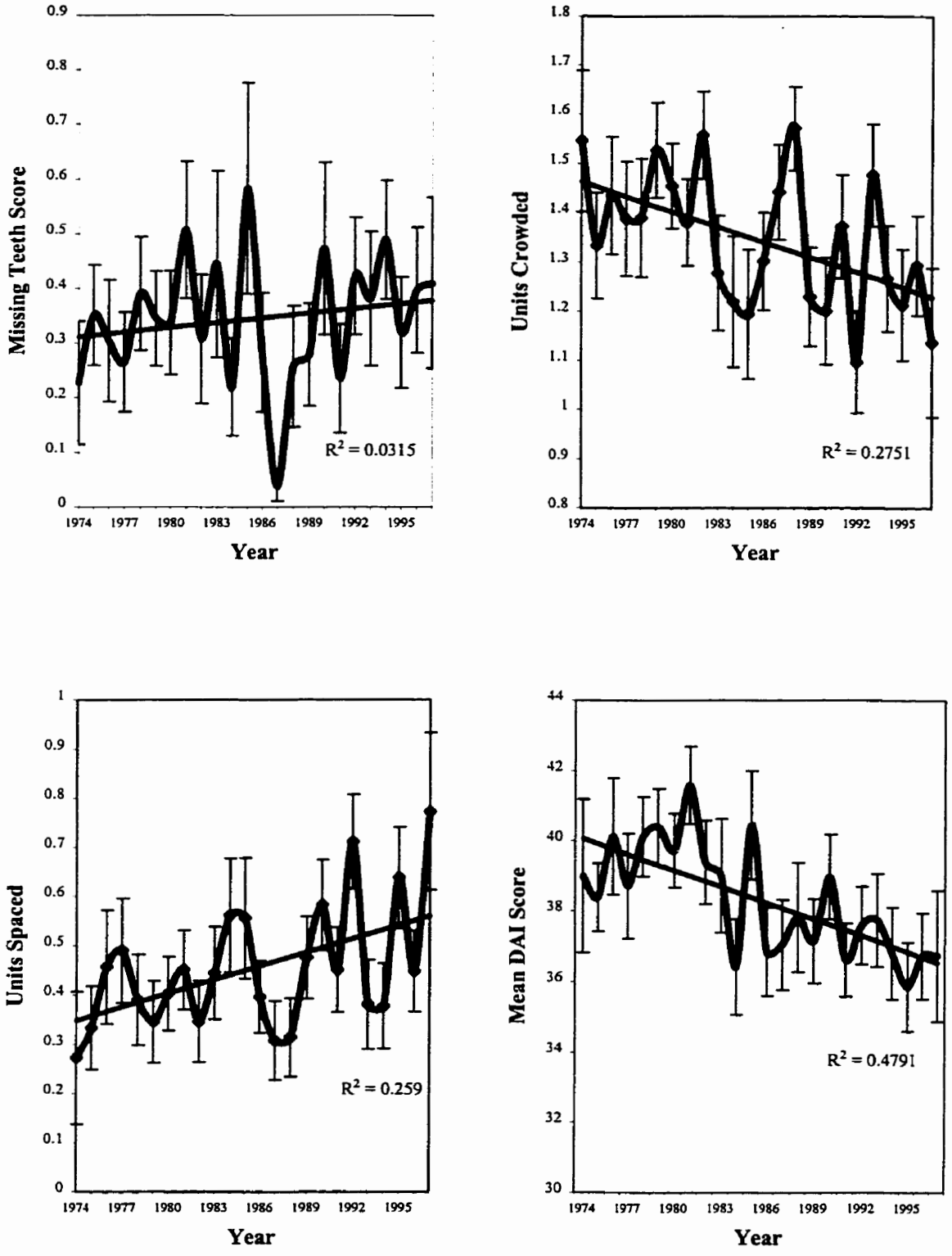
4.2.1.1 Missing teeth, dental crowding and spacing

As summarized in Table 4.5a and Figure 4.4a, the component scores for "missing teeth" demonstrated very high variations over time, with no apparent trend (see Table 4.4). Statistically significant trends were, however, demonstrated in the component scores for "crowding" (r = -0.52) and "spacing" (r = 0.51). The pattern of change for "crowding" was in the same direction as the overall DAI scores (i.e. a decrease in the amount of crowding with time). "Spacing" demonstrated an opposite trend, with a significant increase in the amount of spacing in the anterior segments with time, although these data were highly variable. These data therefore suggest that the orthodontist was referred cases with a lower degree of crowding as time progressed, which may reflect the decline in caries rates culminating in the reduced incidence of premature space loss during permanent dentition development.

Table 4.5a: Summary of Component DAI Parameters (Missing Teeth, Crowding and Spacing)

Year	Missing Teeth			Crowding			Spacing		
	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)
1974	0.23	0.528	232.5	1.55	0.671	43.4	0.27	0.631	231.4
1975	0.35	0.694	197.8	1.33	0.809	60.7	0.33	0.636	190.9
1976	0.30	0.756	248.5	1.43	0.807	56.2	0.46	0.780	171.0
1977	0.27	0.638	240.6	1.39	0.812	58.5	0.49	0.739	151.0
1978	0.39	0.666	170.7	1.39	0.771	55.4	0.39	0.586	150.3
1979	0.35	0.645	186.6	1.53	0.716	46.9	0.35	0.615	178.1
1980	0.34	0.837	247.8	1.45	0.753	51.8	0.40	0.654	162.5
1981	0.51	1.054	207.8	1.38	0.744	53.9	0.45	0.672	149.0
1982	0.31	0.853	277.1	1.56	0.639	41.0	0.35	0.590	170.5
1983	0.44	1.027	231.0	1.28	0.701	54.9	0.44	0.558	125.5
1984	0.22	0.571	260.0	1.22	0.852	69.8	0.56	0.743	132.5
1985	0.58	1.156	198.1	1.19	0.786	65.8	0.56	0.735	132.2
1986	0.28	0.794	280.4	1.30	0.723	55.5	0.40	0.531	134.1
1987	0.04	0.194	504.9	1.44	0.698	48.4	0.31	0.579	188.1
1988	0.26	0.657	255.6	1.57	0.502	32.0	0.31	0.471	149.9
1989	0.28	0.733	263.1	1.23	0.783	63.7	0.48	0.648	136.4
1990	0.47	1.168	247.1	1.20	0.803	66.9	0.58	0.686	117.8
1991	0.24	0.710	301.6	1.37	0.747	54.4	0.45	0.610	135.3
1992	0.42	0.776	183.4	1.10	0.748	68.2	0.71	0.696	97.8
1993	0.38	0.795	208.7	1.48	0.671	45.5	0.38	0.582	152.9
1994	0.49	0.727	148.7	1.27	0.720	56.8	0.38	0.576	152.4
1995	0.32	0.695	217.7	1.21	0.778	64.2	0.64	0.705	110.4
1996	0.40	0.877	221.3	1.29	0.773	59.7	0.45	0.626	139.7
1997	0.41	0.734	179.5	1.14	0.710	62.5	0.77	0.752	97.3

Figure 4.4a Summary of Component DAI Parameters (Missing Teeth, Crowding, Spacing)



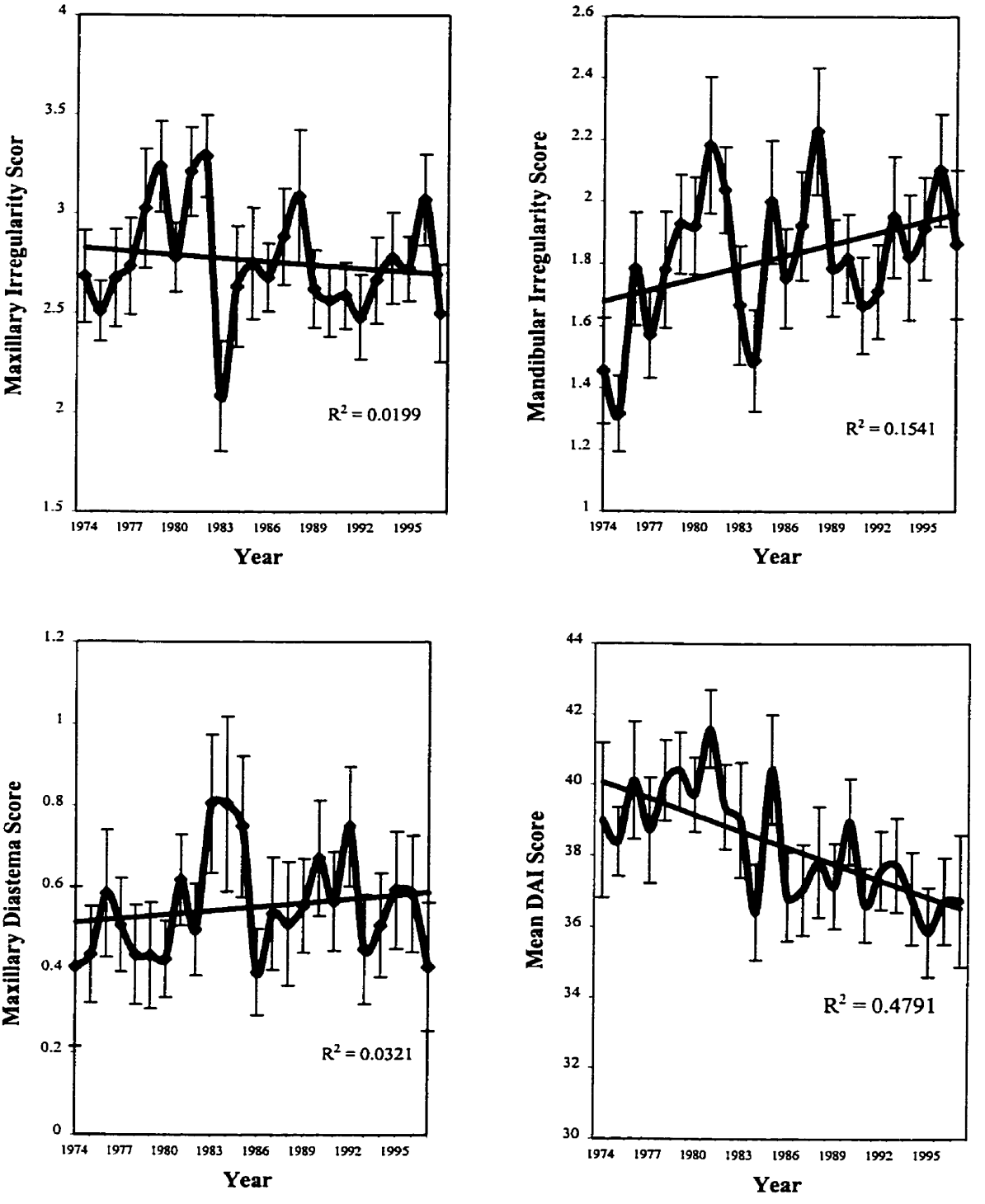
4.2.1.2 Diastema, maxillary and mandibular irregularities

As summarized in Table 4.5b and Figure 4.4b, these three parameters exhibited quite dissimilar patterns of change relative to the DAI. For instance, while the DAI scores have decreased, the scores for "diastema", which depict great variation (up to 2219.8%) demonstrated no change in trend over time. Similarly, the scores for "maxillary" and "mandibular irregularities" showed no observable trends with time. These data therefore suggest that the three parameters did not contribute significantly to the changes observed in the DAI scores, and the degrees of anterior tooth irregularity in the referral base have not changed over the time period for this investigation.

Table 4.5b: Summary of Component DAI Parameters (Maxillary and Mandibular Irregularities, Diastema)

Year	Diastema			Maxillary Anterior Irregularity			Mandibular Anterior Irregularity		
	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)
1974	0.04	0.91	2219.8	2.68	1.09	40.5	1.45	0.80	55.0
1975	0.44	0.89	202.2	2.51	1.14	45.3	1.32	0.93	70.6
1976	0.59	1.05	178.1	2.67	1.65	61.6	1.78	1.23	68.9
1977	0.51	0.79	155.6	2.73	1.69	61.9	1.57	0.98	62.3
1978	0.44	0.78	176.8	3.02	1.92	63.4	1.78	1.19	67.1
1979	0.44	0.96	219.5	3.24	1.70	52.5	1.93	1.18	61.4
1980	0.43	0.82	190.9	2.78	1.51	54.3	1.92	1.37	71.5
1981	0.62	0.93	150.3	3.21	1.89	58.8	2.18	1.86	85.3
1982	0.50	0.80	160.9	3.29	1.49	45.2	2.04	1.01	49.5
1983	0.81	1.01	125.3	2.08	1.66	79.8	1.67	1.15	68.8
1984	0.80	1.36	169.5	2.63	1.93	73.4	1.49	1.05	70.7
1985	0.75	1.02	136.6	2.75	1.68	61.1	2.00	1.20	59.8
1986	0.40	0.77	193.9	2.68	1.24	46.2	1.75	1.16	66.0
1987	0.54	0.98	181.9	2.88	1.75	60.5	1.92	1.27	65.8
1988	0.51	0.89	172.4	3.09	1.99	64.5	2.23	1.21	54.5
1989	0.56	0.89	158.9	2.62	1.51	57.5	1.79	1.21	67.9
1990	0.67	1.04	154.2	2.56	1.33	51.9	1.82	1.06	58.1
1991	0.57	0.85	150.3	2.59	1.19	45.8	1.67	1.11	66.5
1992	0.75	1.05	139.4	2.48	1.53	61.6	1.71	1.09	63.7
1993	0.45	0.86	190.4	2.67	1.39	52.2	1.95	1.27	64.9
1994	0.51	0.84	164.9	2.78	1.54	55.3	1.82	1.35	74.3
1995	0.60	0.97	162.9	2.72	1.10	40.3	1.91	1.14	59.5
1996	0.59	1.08	183.7	3.07	1.75	56.9	2.10	1.39	65.9
1997	0.41	0.73	179.5	2.50	1.14	45.8	1.86	1.13	60.4

Figure 4.4b: Summary of Component DAI Parameters (Maxillary and Mandibular Anterior Irregularities, Diastema)



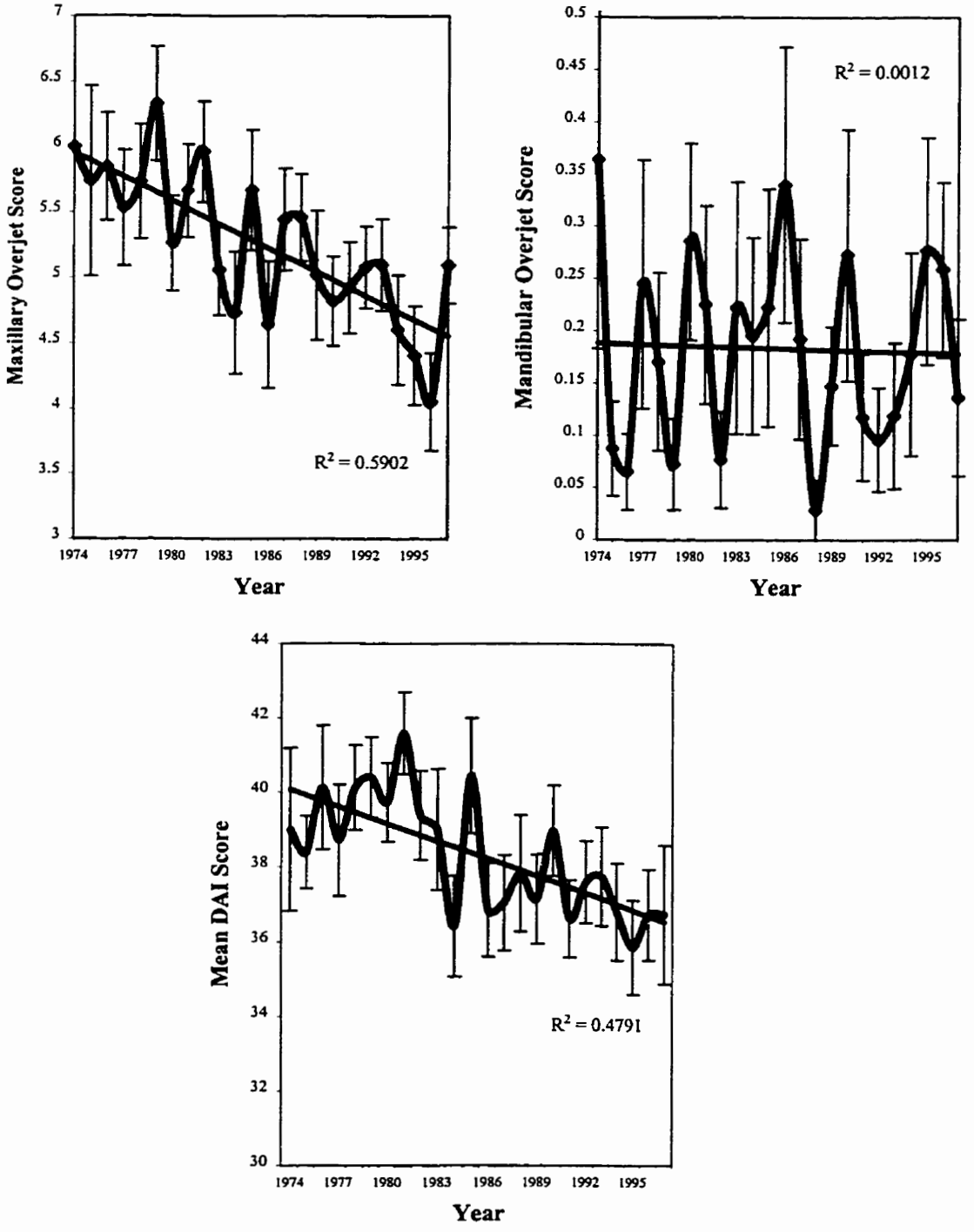
4.2.1.3 Maxillary and mandibular overjet

As summarized in Table 4.5c and Figure 4.4c, the patterns of change for these two parameters were quite dissimilar. For instance, as the overall DAI score decreased, so did the amount of maxillary overjet. This suggests that as time progressed, the cases referred generally presented with relatively less severe maxillary protrusion (dental and/or skeletal). The mandibular overjet component scores demonstrated great variation, without an apparent trend. This suggests that the mandibular overjet component did not contribute to the trend observed in the overall DAI score.

Table 4.5c: Summary of Component DAI Parameters (Maxillary and Mandibular Overjet)

Year	Maxillary Overjet			Mandibular Overjet		
	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)
1974	6.00	3.42	57.04	0.36	0.84	233.12
1975	5.74	3.12	54.48	0.09	0.34	390.22
1976	5.85	3.01	51.61	0.07	0.25	382.77
1977	5.53	3.07	55.62	0.24	0.83	338.88
1978	5.73	2.79	48.73	0.17	0.54	318.19
1979	6.33	2.70	42.80	0.07	0.32	447.08
1980	5.26	3.13	59.67	0.29	0.82	288.71
1981	5.66	3.25	57.42	0.23	0.79	353.38
1982	5.96	2.45	41.21	0.08	0.33	434.31
1983	5.06	2.79	55.33	0.22	0.72	324.69
1984	4.73	2.95	62.52	0.20	0.60	307.91
1985	5.67	2.88	50.97	0.22	0.68	306.36
1986	4.64	2.84	61.38	0.34	0.96	282.55
1987	5.44	2.42	44.47	0.19	0.68	357.28
1988	5.46	2.91	53.39	0.03	0.16	591.60
1989	5.02	2.66	53.05	0.15	0.44	298.94
1990	4.82	2.58	53.60	0.27	0.89	326.85
1991	4.92	2.23	45.40	0.12	0.43	366.47
1992	5.08	2.52	49.77	0.10	0.35	371.83
1993	5.10	2.70	53.05	0.12	0.45	380.32
1994	4.60	2.51	54.72	0.18	0.65	365.50
1995	4.40	2.55	58.11	0.28	0.74	268.67
1996	4.05	2.22	54.78	0.26	0.63	246.26
1997	5.09	2.94	57.79	0.14	0.35	257.58

Figure 4.4c: Summary of Component DAI Parameters (Maxillary and Mandibular Overjet



4.2.1.4 Vertical openbite and antero-posterior molar relationship

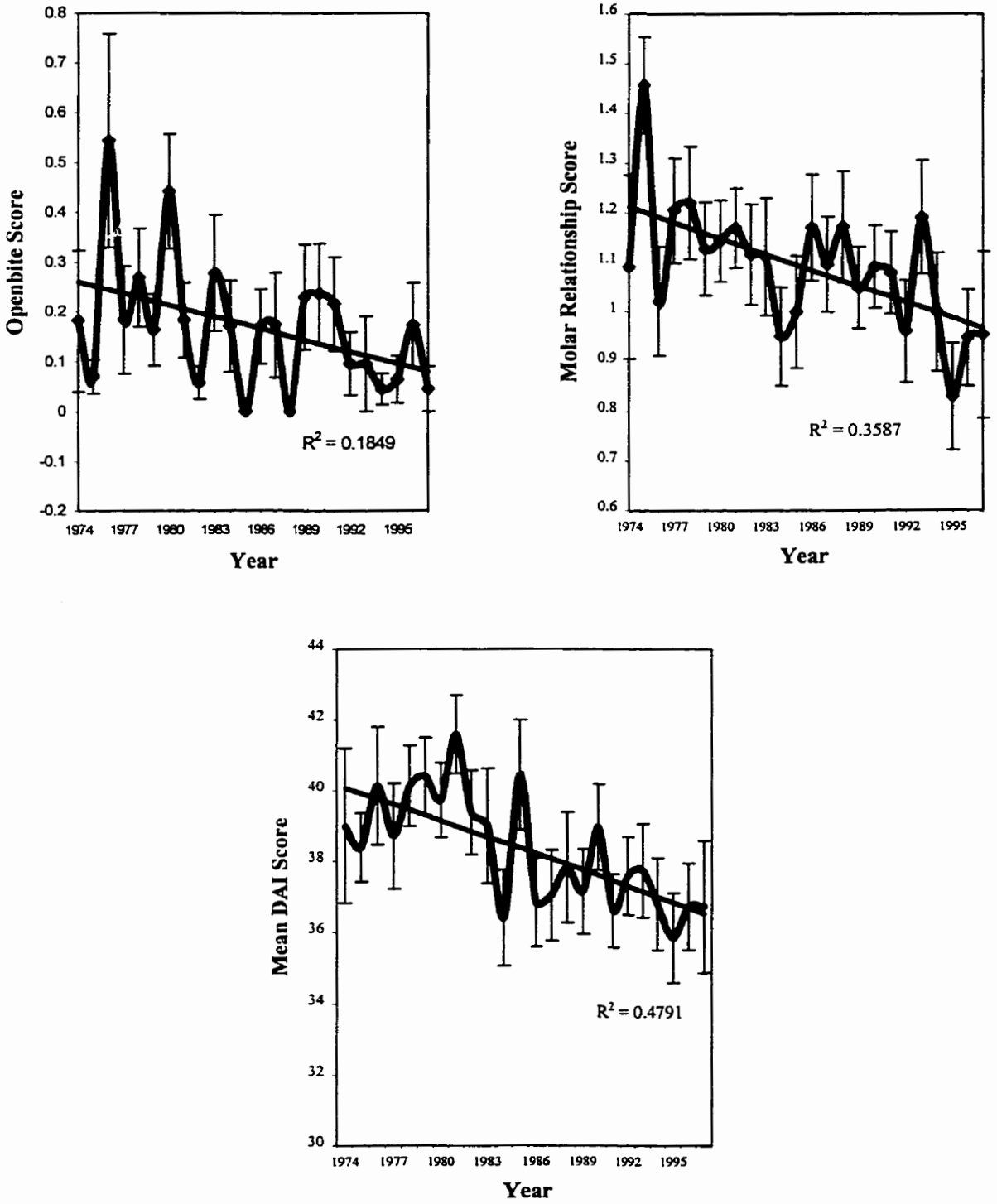
As summarized in Table 4.5d and in Figure 4.4d, the patterns of change for molar relationships were similar to the DAI scores. The significant decrease in the molar relationship scores with time suggests an increase in the proportion of patients with molar relationships closer to normal. However, the degree of vertical openbite was extremely variable, without an observable trend. This implies that the openbite score did not contribute significantly to the observed trend in DAI scores.

Table 4.5d Summary of Component DAI Parameters (Vertical Openbite and Antero-posterior Molar Relationship)

Year	Vertical Openbite			A-P Molar Relationship		
	Mean	S.D.	CV(%)	Mean	S.D.	CV(%)
1974	0.18	0.66	365.47	1.09	0.86	79.55
1975	0.07	0.25	367.24	1.46	0.73	50.38
1976	0.54	1.45	267.92	1.02	0.74	72.91
1977	0.18	0.75	410.94	1.20	0.73	61.07
1978	0.27	0.63	236.09	1.22	0.72	59.44
1979	0.16	0.53	327.69	1.13	0.69	61.68
1980	0.44	1.00	227.93	1.14	0.72	63.02
1981	0.18	0.63	349.22	1.17	0.67	57.81
1982	0.06	0.23	408.08	1.12	0.73	65.60
1983	0.28	0.70	252.53	1.11	0.70	63.74
1984	0.17	0.58	344.09	0.95	0.63	66.28
1985	0.00	0.00	-	1.00	0.67	67.61
1986	0.17	0.54	321.21	1.17	0.77	66.50
1987	0.17	0.76	438.99	1.10	0.69	63.25
1988	0.00	0.00	-	1.17	0.66	56.64
1989	0.23	0.82	359.24	1.05	0.64	61.34
1990	0.24	0.74	314.96	1.09	0.61	56.54
1991	0.22	0.67	311.89	1.08	0.59	55.14
1992	0.10	0.45	472.32	0.96	0.74	76.95
1993	0.10	0.61	648.07	1.19	0.74	62.19
1994	0.04	0.20	468.92	1.00	0.79	79.77
1995	0.06	0.32	506.52	0.83	0.73	88.19
1996	0.17	0.65	378.51	0.95	0.73	77.57
1997	0.05	0.21	469.04	0.95	0.78	82.28

Note: "0.00" values in the table are indicative of samples presenting with no cases of vertical openbite.

Figure 4.4d: Summary of Component DAI Parameters (Vertical Openbite and Antero-posterior Molar Relationship



4.2.1.5 Synopsis

Significant changes were evident in the following component parameters over the 1974 – 97 period: Crowding, spacing, maxillary overjet, and molar relationship (see Table 4.4). While crowding, maxillary overjet, and molar relationship demonstrated a decrease with time, spacing demonstrated an increase. These data show that the average referred case demonstrated less severe crowding, a molar relationship closer to Class I, and a more ideal overjet relationship from 1974 until 1997. In fact the malocclusions would have been progressively more difficult to resolve than gross dental arch discrepancies with severe overcrowding.

4.2.2 Additional changes detected in the referral base over the 1974-97 period

Marked changes in the referral base were also delineated in parameters excluded from the DAI. In particular:

4.2.2.1 Impacted canines (Figure 4.5)

In this investigation, impacted teeth were counted as missing teeth in concordance with the strict definition of "missing" in the DAI scoring guidelines (Appendix B). In order to determine the effect of this assumption on the DAI scores, they were recalculated, excluding impacted teeth from the "missing" component. When subjected to the same battery of statistical analyses, the trends showed a decrease of higher significance relative to the inclusion of impacted teeth into this parameter. The results are presented in Table 4.6.

Table 4.6: Correlation Coefficients of DAI Scores with Time (Impacted Teeth Not Counted as Missing)

	10^{th} Percentile	25^{th} Percentile	50^{th} Percentile	75^{th} Percentile	90^{th} Percentile
Pearson Correlation Coefficient (r)	-0.40*NS*	-0.70*	-0.70*	-0.61*	-0.58*

**p<0.005, NS=Non-significant*

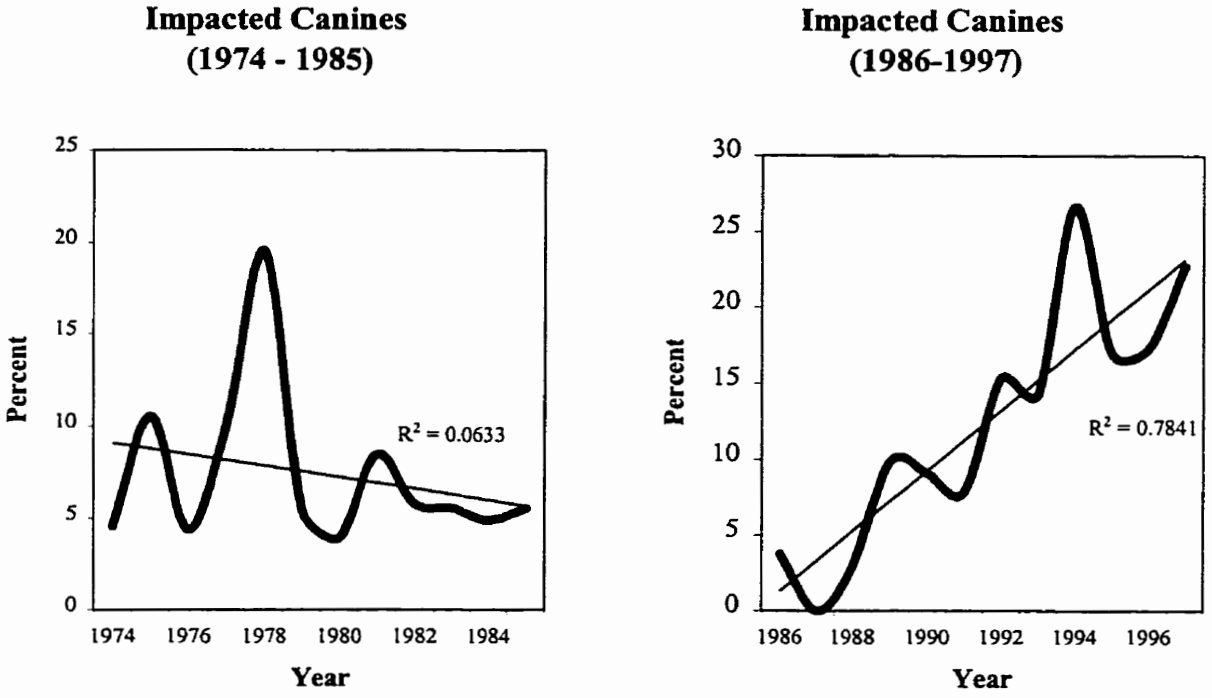
These changes were expected, as the proportion of cases with impacted canine teeth also increased with time ($r = 0.53$, $p < 0.01$), especially in the latter half of the time period studied (19.0%), thus contributing to a greater reduction in the later scores (i.e. impactions not counted as missing contribute "zero" to the DAI score, whereas "missing teeth" are multiplied by a weighting of 6). More specifically, there was no statistically significant trend in the proportion of cases with impacted canines in the first half of the time period studied ($r=-0.25$, $p>0.05$), whereas a statistically significant increase in the last half of the time period studied ($r=0.88$, $p<0.005$) was observed. The results shown in Table 4.7 and Figure 4.5 may be suggestive of a shift in the preventive guidance of eruption philosophies of general dentists.

Table 4.7: Pearson Correlation Coefficients of Specific Variables

	Impacted Canines	Missing Teeth	Serial Extraction
Year (1974-97)	0.53*	-0.32, *NS*	-0.34, *NS*
Year (1974-85)	-0.25, *NS*	0.86**	0.73*
Year (1986-97)	0.89**	-0.71*	-0.62*

**p<0.05, p<0.0005, NS=Non-significant*

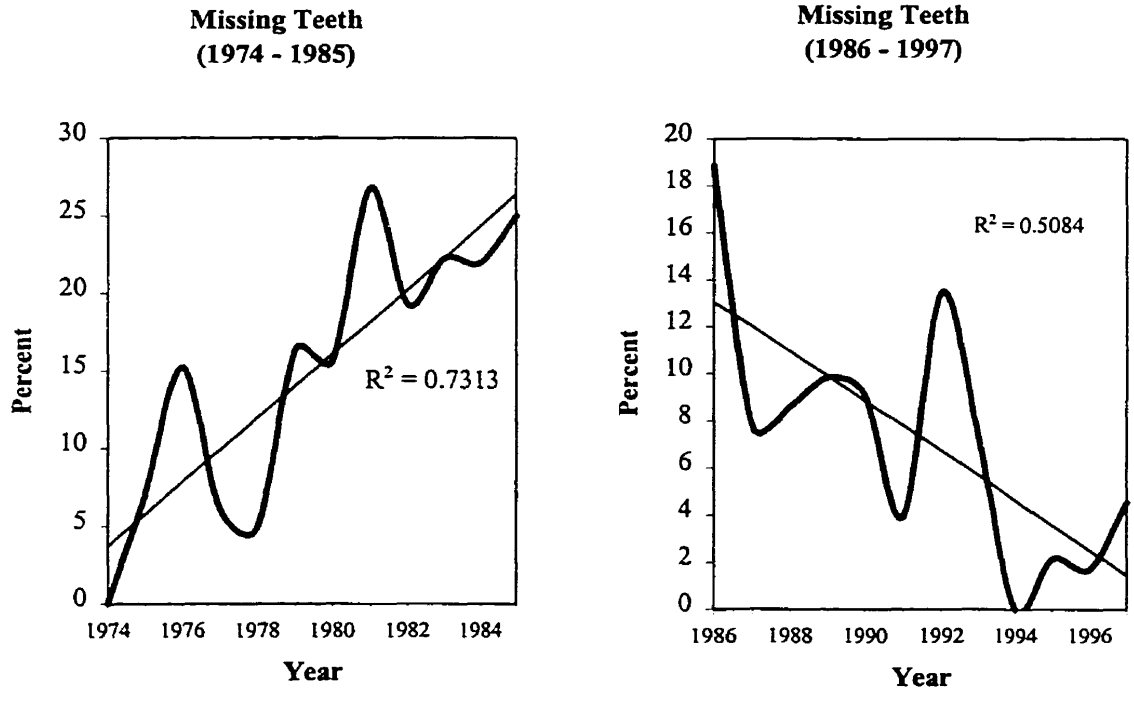
Figure 4.5: Changes in Referred Cases with Impacted Canines Over Time



4.2.2.2 Missing teeth (Figure 4.6)

When considering the proportion of cases referred with missing teeth (including congenitally missing teeth, and serial extraction cases), no significant linear trend was apparent ($r = -0.32$, $p>0.1$). However, significant trends were evident when the two halves of the time period were studied separately. For instance, from the period of 1974 until 1985, the percentage of missing teeth showed a statistically significant increase ($r=0.86$, $p<0.001$), while a statistically significant decrease was evident in the period from 1985 until 1997 ($r=-0.71$, $p<0.01$). The results (Figure 4.6) suggest a change in the treatment philosophies for crowding in the developing dentition by the referring dentists i.e. interceptive treatment with lingual arches to maintain leeway space.

Figure 4.6: Changes in Referred Cases with Missing Teeth Over Time



4.2.2.3 Serial extractions (Figure 4.7)

The percentage of previous "serial extraction" cases referred for treatment were similarly calculated, based on the assumption that pre-treatment study models with at least two missing first bicuspids were the result of a previous attempt at some kind of guidance for permanent tooth eruption. These data revealed that the trend with time was not linear, as seen in figure 4.7. However, when the time series was divided into two equal halves, there was a statistically significant decrease in the proportion of serial extraction cases referred for orthodontic treatment in the period from 1986 to 1997 ($r=-0.6202$, $p < 0.05$) relative to a statistically significant increase in the period from 1974 to 1985 ($r=-0.7296$, $p < 0.01$). Results of these data (Figures 4.7 and 4.8) suggest a shift in treatment philosophy with respect to serial extraction therapy, or extraction as a whole by the referring dentists.

Figure 4.7: Changes in Referred Cases with Serial Extractions Over Time

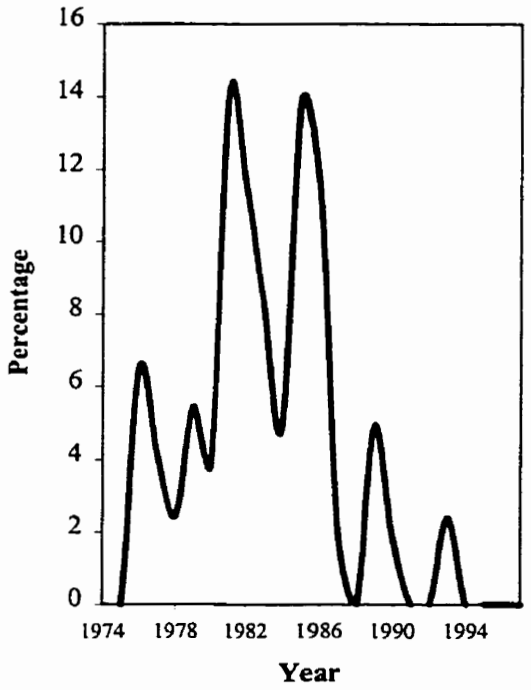
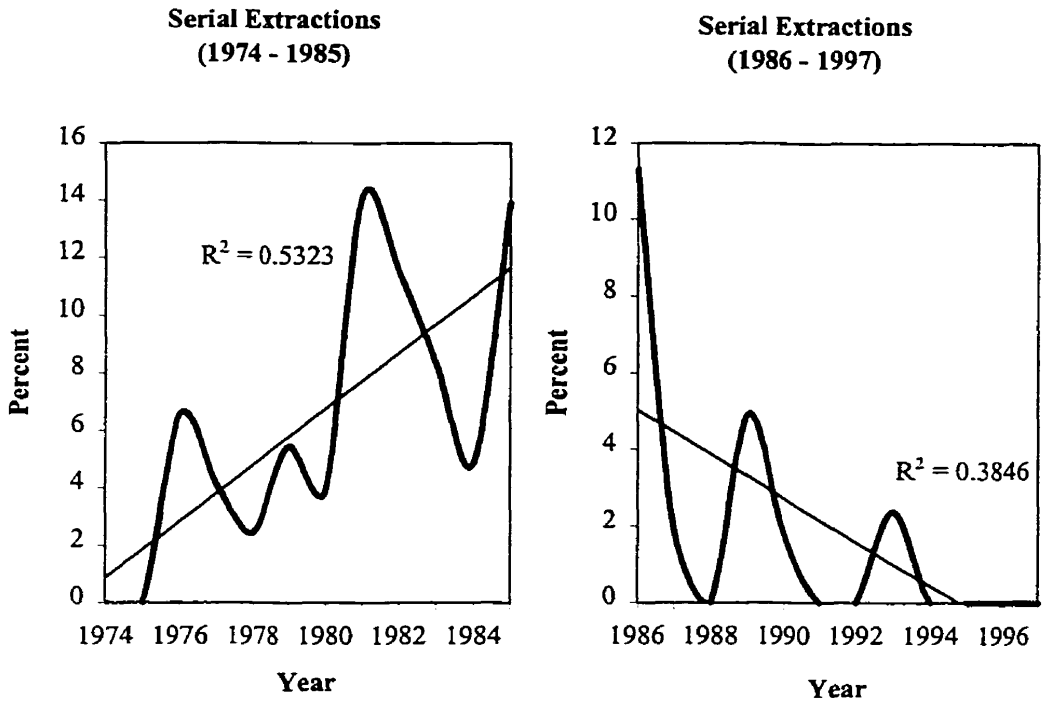


Figure 4.8: Changes in Referred Cases with Serial Extractions Over Time



4.2.2.4 Malocclusion severity

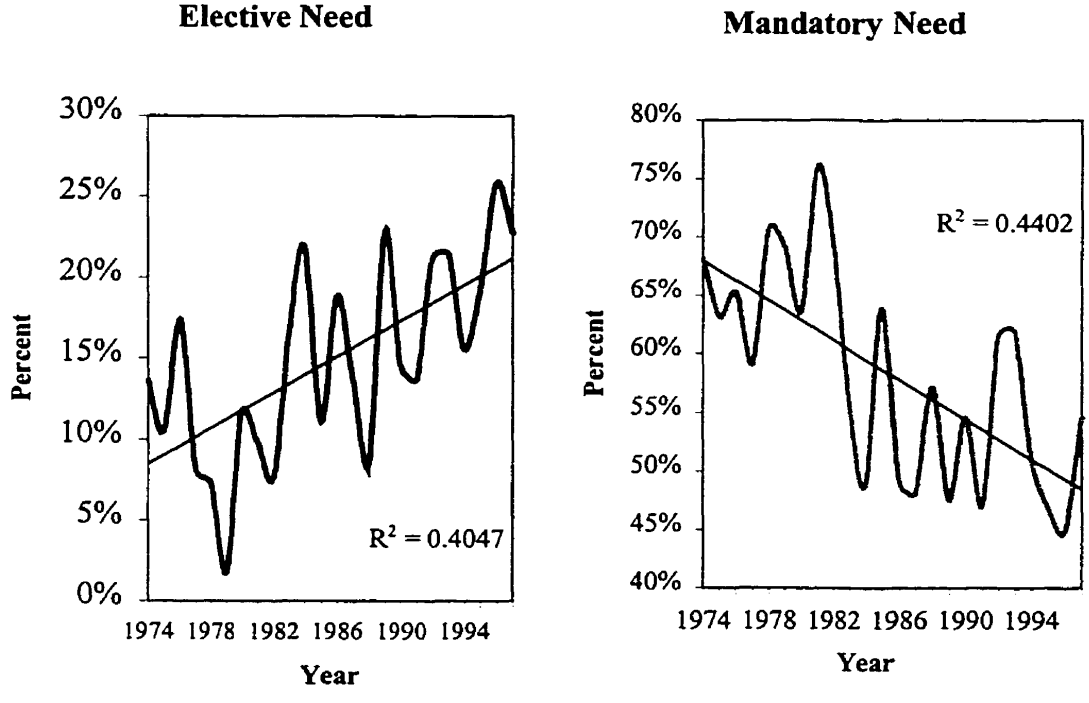
The correlation of the different malocclusion severity levels with time (see section 3.2.1) are presented in Table 4.8 and shown in Figure 4.9. The percentage of cases that were considered to have elective need for treatment significantly increased over time ($r=0.65$, $p < 0.001$), an indication of an increased proportion of referred cases with less severe malocclusions. Furthermore, the percentage of cases with very severe treatment needs (handicapping malocclusion, score > 35) was found to decrease significantly with time (0.66, $p=0.001$). These results suggest an increased demand for treatment of more minor malocclusions in the latter years. However, the possible reasons for the increased demand cannot be delineated from these data as mentioned in the Discussion section of this thesis.

Table 4.8: Correlation of Malocclusion Severity Levels With Time

Severity Level (Score)	Interpretation Treatment Need	Pearson's Correlation Coefficient
≤ 25	**No or Slight Need**	**0.09 *NS***
26 – 30	**Elective Need**	**0.64 ***
31 – 35	**Highly Desirable Need**	**0.30 *NS***
≥ 36	**Mandatory**	**-0.66 ***

p<*0.001, NS=Non-significant

Figure 4.9: Changes in the Referred Cases with Elective or Mandatory Need for Treatment

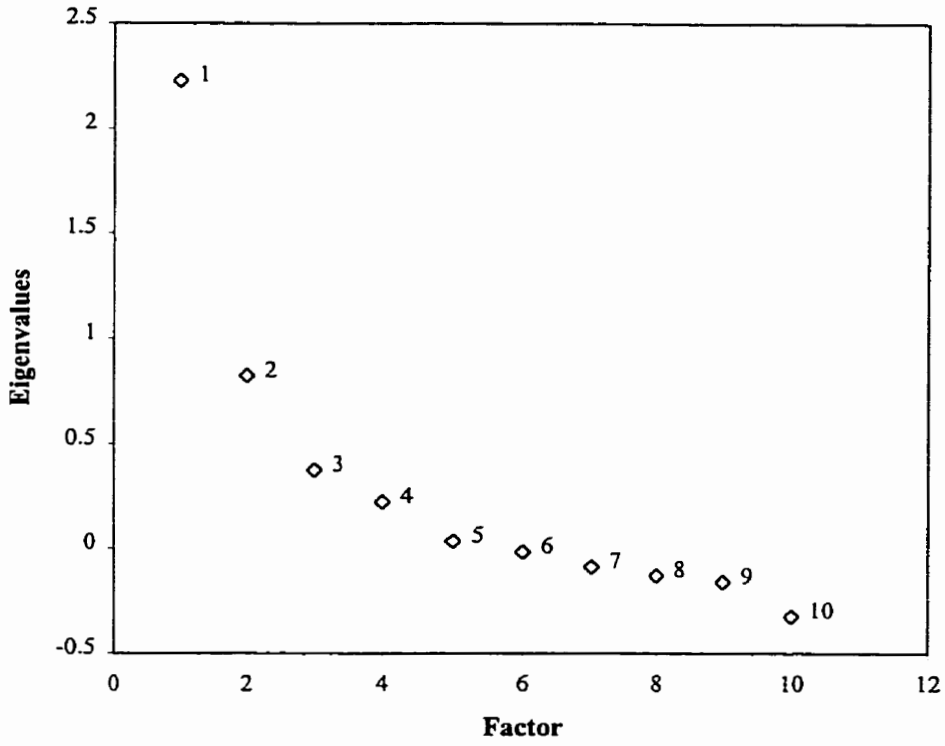


4.2.3 Factor Analysis

Factor analysis is a statistical method whose purpose is to group variables (i.e. the 10 DAI component parameters. Correlations among the component parameters were calculated in order to determine which could be grouped logically. Linear combinations of the parameters which are highly correlated were created and these are known as factors. These factors are numbered, according to the amount of sample variation that they explain, with the first factor accounting for most of the variation. With factor analysis, the end result is a smaller number of parameters required in order to explain the majority of the variation of the sample, and possible the elimination of some of the redundant parameters.

This multivariate analysis of the data in this dissertation was primarily undertaken to determine the combination of DAI parameters primarily accounting for the changes in DAI scores over the 1974-97 period (Figure 4.10, Table 4.9). Figure 4.10 indicates the factors identified in the sample on the "X" axis and the variance explained by each factor (Eigenvalue) on the "Y" axis. On the advice of the biostatistician (M Cheang, personal communication), only the first three factors were considered to be important, as the others (Factors 4 – 10) did not explain much of the sample variance. Furthermore, the data were subjected to complex statistical rotation methods by the biostatistician and the factors identified as statistically significant were identified and shown (Table 4.9).

Figure 4.10: Factor Analysis of DAI Components



Factor 1 comprised "spacing" , "diastema" and "crowding". "Crowding" was negatively correlated with "Diastema" and "Spacing". Factor 2 comprised "molar relationship", " mandibular overjet", and "maxillary overjet", where "mandibular overjet" was negatively correlated with both "maxillary overjet" and "molar relationship". Factor 3 comprised "spacing", "crowding" and "maxillary irregularity". "Spacing" was negatively correlated with both "Crowding" and "Maxillary irregularity".

Table 4.9: Factor Structure (Correlation)—Rotation Method: Promax

	Factor 1	Factor 2	Factor 3
Spacing	88 *	8	-42 *
Diastema	66 *	-1	-17
Crowding	-84 *	-3	58 *
Mx overjet	4	66 *	10
Molar relation	0	39 *	6
Openbite	3	8	-2
Missing	19	-19	-19
Md overjet	-2	-42 *	22
Mx irreg	-27	5	56 *
Md irreg	-34	-6	34

NOTE: The correlation coefficients have been multiplied by 100 and rounded to the nearest integer. Values flagged by an '*' denote statistical significance.

The factor analysis suggests that the most significant changes in the DAI scores were explained by the changes in the combination of spacing, crowding and diastema. As three other components (openbite, missing teeth and mandibular irregularity) did not contribute significantly to the variation in scores over time, they could have been deleted from the calculations of the total DAI scores.

4.3 Changes in the referral base assayed by the modified DAI

As shown in Figure 4.11 and Table 4.10, the modified DAI assay revealed very different patterns of change in the referral base over the 1974 – 97 period. To a certain extent these contrasts were to be expected, since not only does the modified DAI comprise only 4 parameters of the "standard" DAI (maxillary and mandibular overjet, vertical openbite, and antero-posterior molar relationship), but they are also differentially weighed, i.e. Modified DAI score = 9.07(Md Overjet) + 1.62(Mx Overjet) + 10.16(Vertical Openbite) + 1.86(A-P Molar Relationship). The variation in the scores measured by the modified DAI were much higher than the standard DAI, which is a reflection of the great variation in two of the components used in this equation (i.e. openbite and mandibular overjet).

Figure 4.11: Contrasts Between DAI and Modified DAI Scores

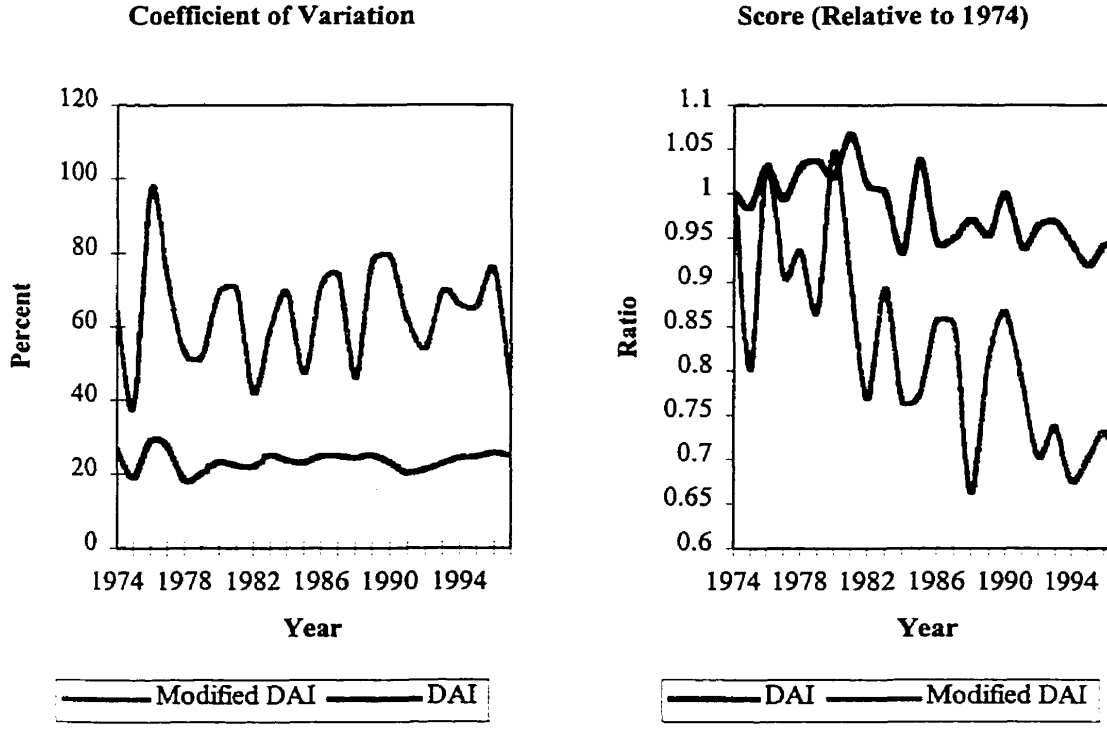
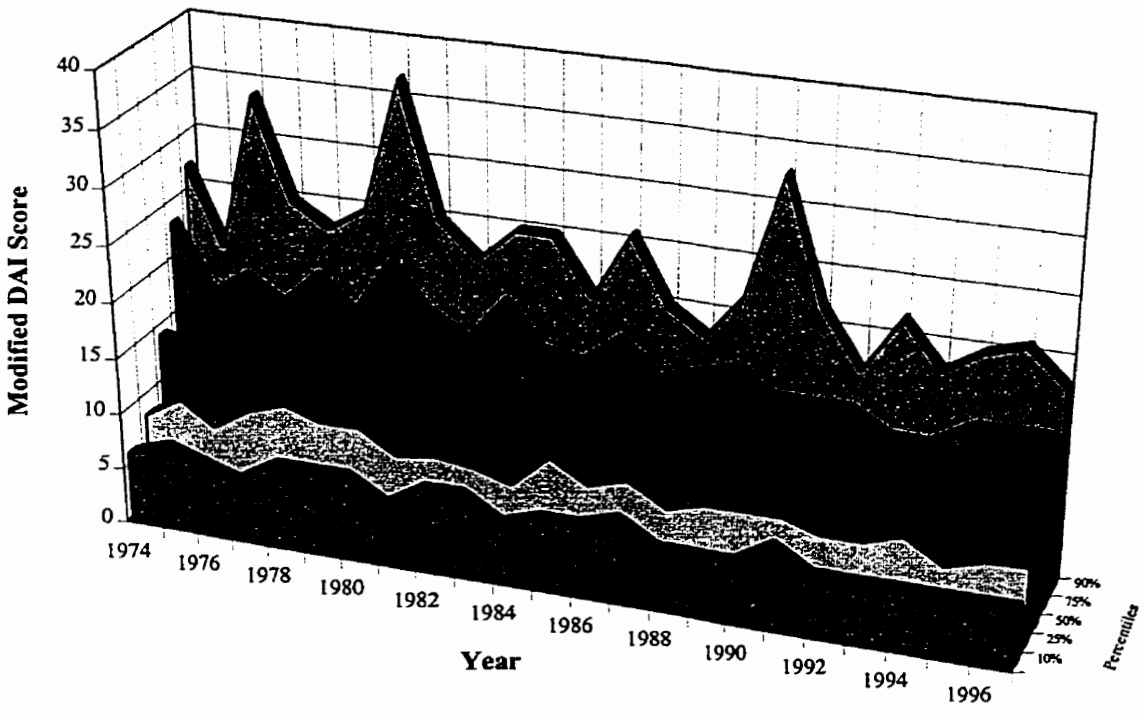


Table 4.10 Summary of Mean Modified DAI Scores from 1974 - 1997

Year	Mean	S.D.	S.E.	CV(%)	Index Relative to 1974
1974	16.91	10.776	2.298	63.73	1
1975	13.56	5.197	0.688	38.32	0.802
1976	17.41	16.832	2.482	96.66	1.03
1977	15.33	11.193	1.599	73.03	0.906
1978	15.80	8.343	1.303	52.79	0.935
1979	14.67	7.588	1.023	51.72	0.868
1980	17.70	12.268	1.398	69.30	1.047
1981	15.25	10.683	1.268	70.03	0.902
1982	13.00	5.478	0.760	42.14	0.769
1983	15.08	8.876	1.479	58.85	0.892
1984	12.95	8.973	1.401	69.28	0.766
1985	13.06	6.200	1.033	47.49	0.772
1986	14.47	10.317	1.417	71.29	0.856
1987	14.38	10.627	1.474	73.88	0.851
1988	11.20	5.165	0.873	46.12	0.662
1989	13.75	10.673	1.367	77.60	0.813
1990	14.64	11.561	1.559	78.99	0.866
1991	13.27	8.178	1.145	61.61	0.785
1992	11.88	6.437	0.893	54.16	0.703
1993	12.45	8.636	1.333	69.35	0.736
1994	11.42	7.529	1.122	65.92	0.676
1995	11.83	7.751	1.131	65.52	0.7
1996	12.34	9.277	1.218	75.15	0.73
1997	11.68	5.030	1.072	43.06	0.691

When the modified DAI scores were considered, their correlations with the year showed higher agreement than the standard DAI scores. A statistically significant decrease was observed at all percentiles ($p < 0.05$) (Figure 4.12, Table 4.11).

Figure 4.12: Modified DAI Scores from 1974 – 1997



Note: the figure is slanted to demonstrate the three dimensional effect.

Table 4.11: Correlation Analysis of Modified DAI Scores with Time

	Mean MDAI	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Pearson Correlation Coefficient (r)	-0.77**	-0.53*	-0.67**	-0.63**	-0.75**	-0.4937*

*$p<0.05$, **$p<0.005$

4.4 Synopsis of changes to the referral base depicted by DAI and other assays

- Standard DAI scores decreased significantly with time at all but the 10th percentile ($p < 0.05$)
- Component parameters that showed a statistically significant trend over time included the following:
    - Crowding decreased, ($p < 0.05$)
    - Spacing increased, ($p < 0.05$)
    - Maxillary overjet decreased, ($p < 0.001$)
    - Molar relationship decreased, ($p < 0.005$)
- The proportion of cases with impacted canines increased significantly, especially from 1986 – 1997.
- The proportion of cases with missing teeth and serial extractions showed non-linear trends, increasing in the first half and decreasing in the second half of the time period studied.
- The malocclusion severity of the referred cases was found to decrease with time.
- Factor analysis revealed that the most significant changes in DAI scores could be explained by changes in the combination of "spacing", "crowding" and "diastema".
- Factor analysis indicated that "openbite", "missing teeth" and "mandibular irregularity" did not contribute significantly to the change in DAI scores with time.
- Modified DAI scores showed a greater statistically significant decreasing trend ($r=-0.77$, $p < 0.005$) than the standard DAI scores ($r=-0.69$, $p <0.001$).
- Modified DAI scores showed greater variation than the standard DAI scores.

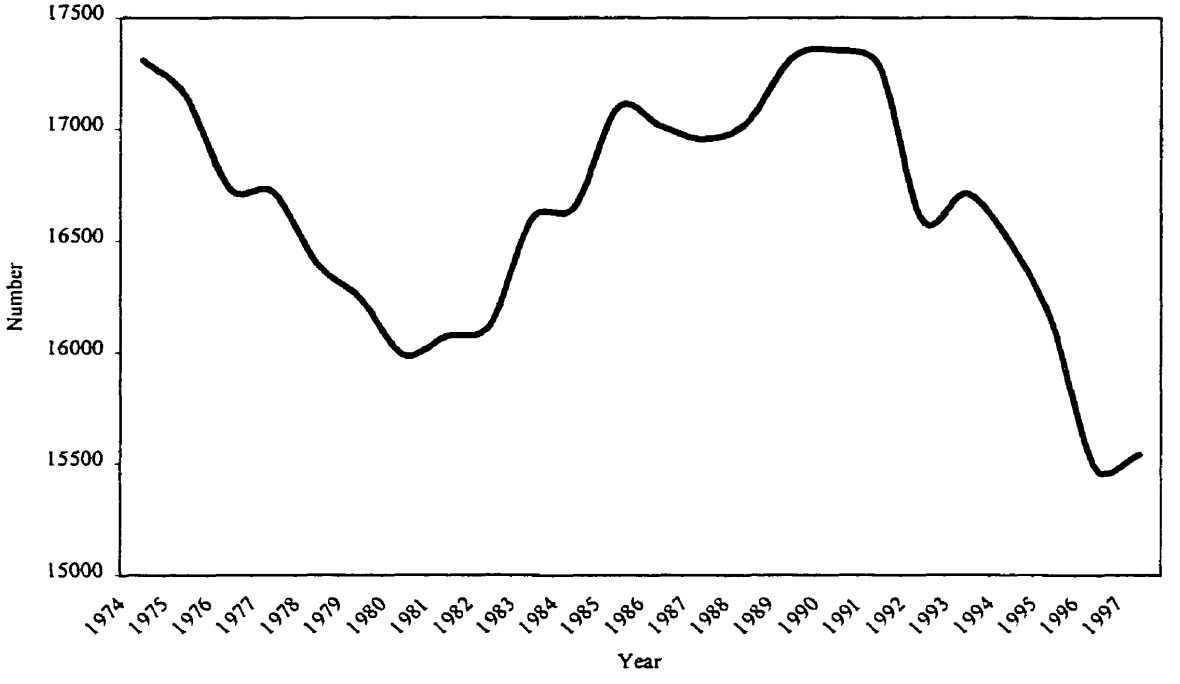
4.5 Demographic changes to the population of the referral base

Due to the complexity of the demographic changes in Manitoba over the 1974 – 97 period, only those most pertinent to the referral base are presented in this section.

4.5.1 Changes in Manitoba birth rates over the 1974 – 97 period

As seen graphically from data extracted from the Canadian Socioeconomic Information and Management (CANSIM) database (Figure 4.13), declining birthrates were evident in the past decade. The number of births in Manitoba for the time period studied peaked in 1974 (17,311) and in 1990 (17,352). Rates were observed to decline from 1974 to 1980 (7.6%) and from 1990 to 1996 (10.8%). The lowest number of births occurred in 1996, and it appears that the number is beginning to increase in 1997. These data suggest that a real decrease had occurred in the potential patient base over the time period studied.

Figure 4.13: Number of Births in Manitoba from 1974 – 1997

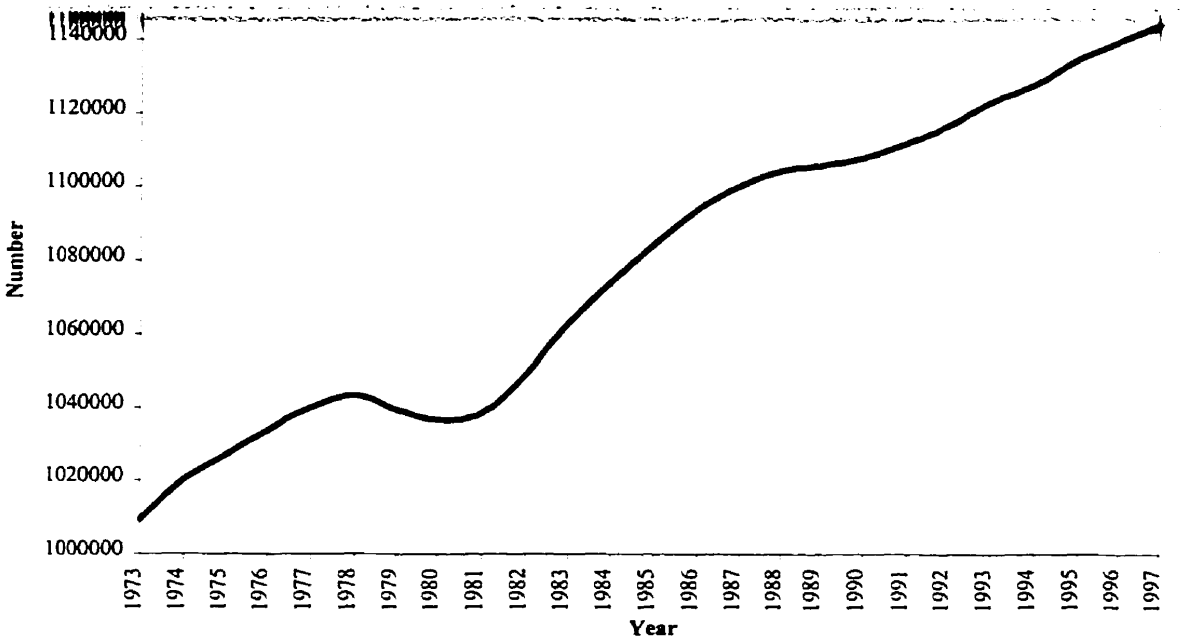


Source: S.D.D.S. 3201, 3601, STC (91 – 002); CANSIM Label D151

4.5.2 Changes in the overall population for Manitoba over the 1974 – 97 period

The overall population of Manitoba continually increased with the exception of a slight decrease from the 1978 – 1981 period. From the slope of the curve in Figure 4.14, it is clear that the greatest growth rate occurred from 1981 until 1987. The overall rate of growth of the population for Manitoba for the entire time period studied was 12.3 %.

Figure 4.14: Population of Manitoba (All Ages) from 1974 – 1997

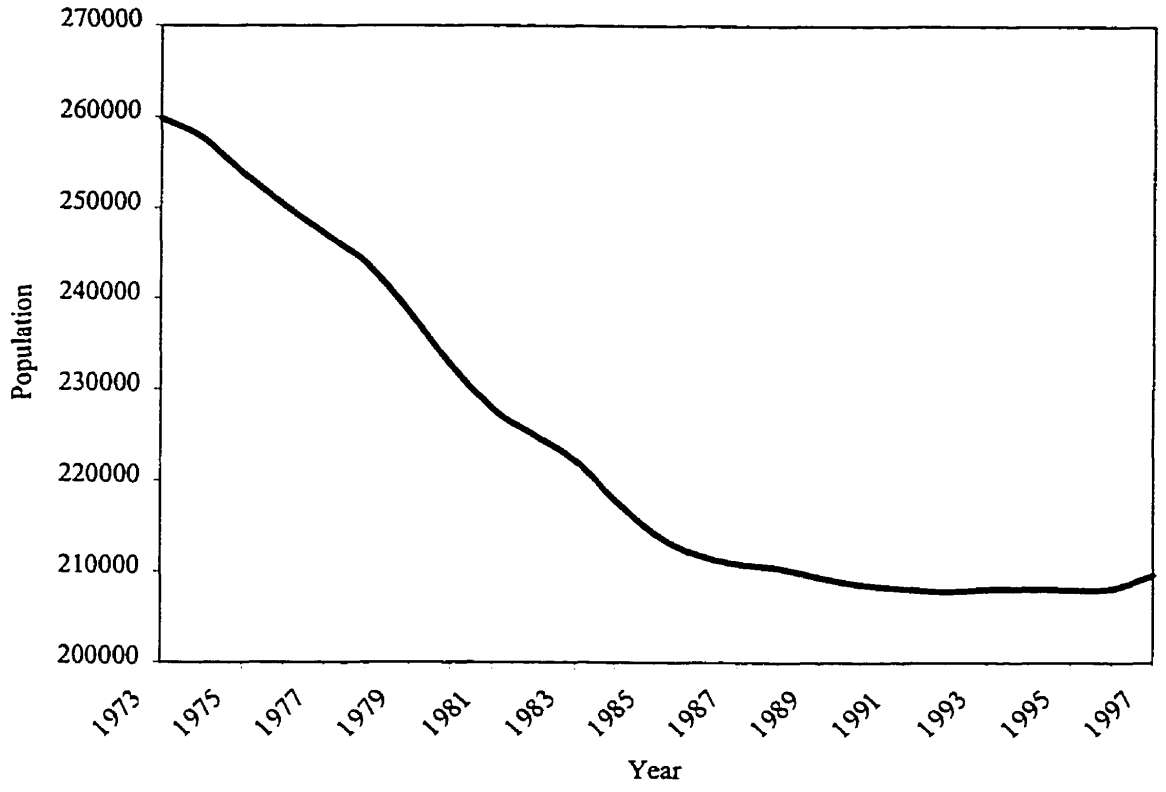


Source: S.D.D.S. 3604 Demography Division, CANSIM Label C894494

4.5.3 Changes in the orthodontic population age groups over the 1974 – 97 period

The population data were subdivided into specific age groups in order to identify the trends which contributed to the overall observed changes. Figure 4.15 indicates that the population of those 7 – 19 years of age had been on a steady decline from 1974 (257,744) until 1986 (211,946, 17.8%), and remained fairly constant from 1987 until 1997, changing only a further 1%. In the 1981 – 91 period there was an overall increase in the birthrate and a steady population growth, however, there was a decline in the population of 7 – 19 year olds. Although only speculative, this may have been a reflection of the egress of young people out of the province.

Figure 4.15: Population of Manitoba (Ages 7 – 19) from 1974 – 1997

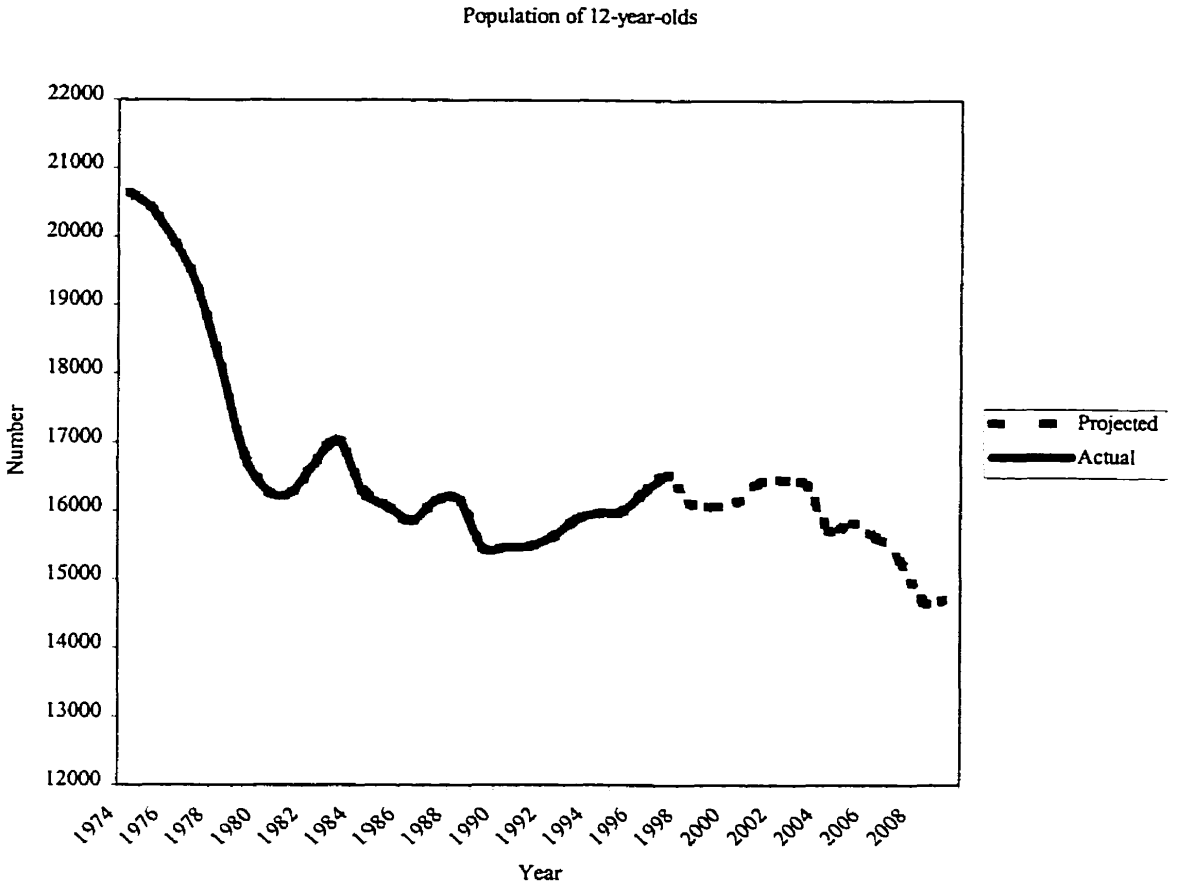


Source: S.D.D.S. 3604 Demographic Division; CANSIM Labels C894521, C894524, C894527, C894548,C894566

Currently available data suggest that the number of 12 – year olds in the province also declined by just under 20% in the time period studied (Figure 4.17). However, the growth rate of the population of 12-year-olds exhibited many fluctuations with time, i.e., the population declined by 21.2% from 1974 until 1981, increased slightly until 1983, and resumed its decline until 1989. From 1990 until 1997, positive population growth had occurred (6.85%). Based on calculations derived using the birth rate data from the time period 1986 until 1997, the number of 12 year-olds was projected to drop a further 9.1% from 1997 until the year 2009. This figure was based on the assumption that there

would be no net change in the number of 12-year-olds relocating into and out of the province. The data are summarized in figure 4.16.

Figure 4.16: Population of Manitoba (Age 12) from 1974 – 2009



Source: S.D.D.S. 3604 Demographic Division. CANSIM Label C894536

4.5.4 Synopsis of relevant demographic changes in Manitoba over the 1974 – 97 period

- Birth rates in Manitoba had decreased by 10.2% over the 1974-97 period.
- The overall population in Manitoba had increased by 12.3% over the 1974 – 97 period.

- The orthodontic population age groups had decreased by 18.6% over the 1974 – 97 period
- The average number of 12-year-olds had decreased by 19.9% over the 1974 – 97 period, and was projected to drop an additional 9.1% until the year 2009.

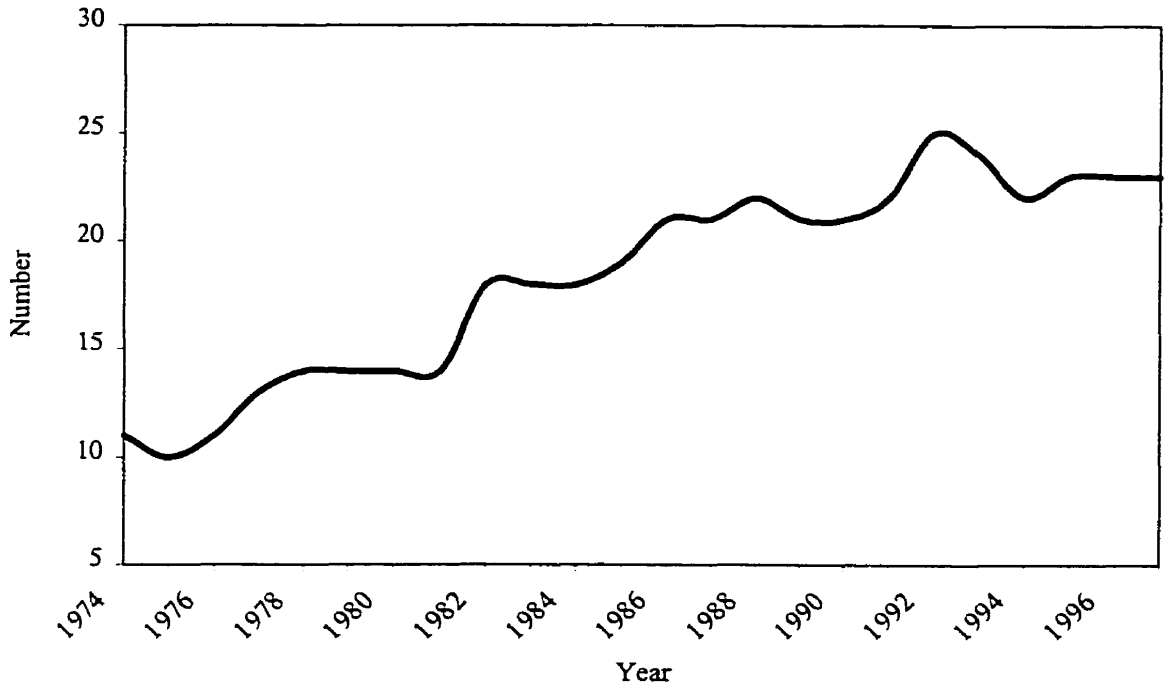
4.6 Changes to the supply of Manitoba orthodontic services over the 1974 – 97 period

Due to insufficient data on the demand for orthodontic services and their supplies from non-orthodontists, the information regarding changes in their supplies is necessarily limited. However, changes in the number of generalists, orthodontists and population to professional rations will be considered in the sections that follow.

4.6.1 Changes in the number of orthodontists

According to the data published by the Manitoba Dental Association (MDA), the number of licensed orthodontists registered in the province of Manitoba has increased by 109% over the 1974 – 97 period, from 11 to 24. The numbers had remained constant from 1978 until 1981, and from 1996 – 97. The data are presented in Figure 4.17, which shows that the overall number of orthodontists increased fairly steadily from 1982 until 1997.

Figure 4.17: Changes in the Number of Orthodontists in Manitoba (1974-97)

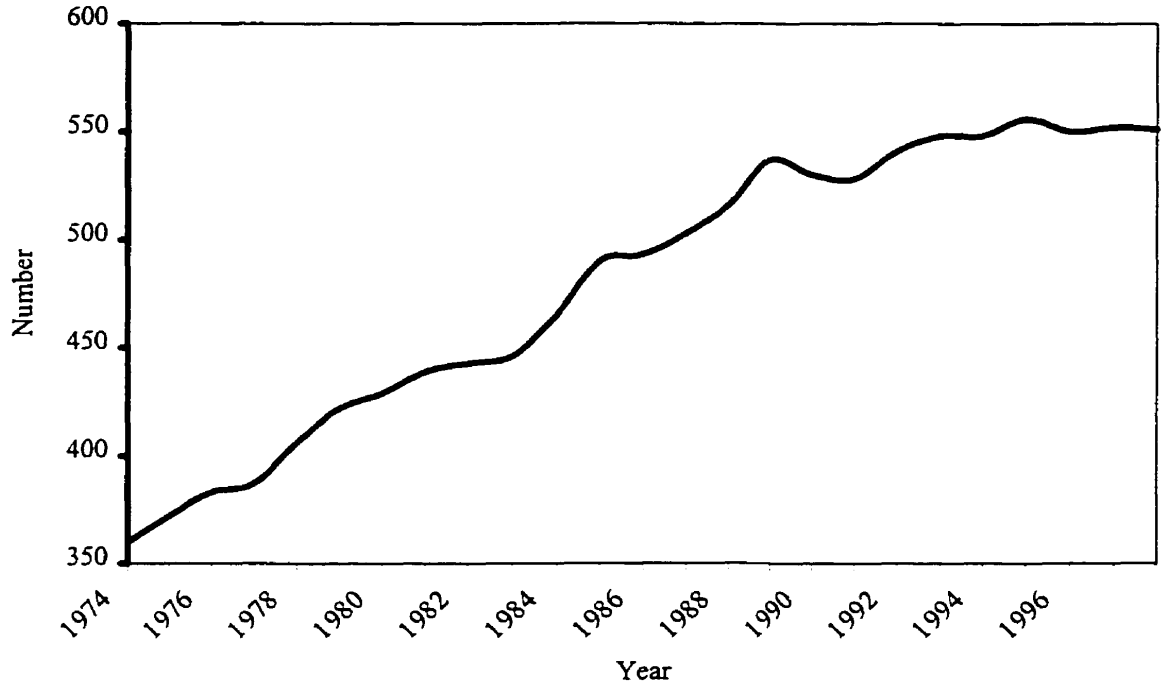


Source: The Manitoba Dental Association

4.6.2 Changes in the number of dentists

The number of all MDA members registered in the province of Manitoba had increased 56% from 1974 until 1997. The data are presented in Figure 4.18. It is evident that the rate of increase had slowed substantially beyond 1989 since the average annual increase in MDA members from 1974 until 1989 was 12.6 members, and the average number had increased by only 1.75 per year from 1989 until 1997.

Figure 4.18: Changes in the Number of MDA Members (1974 – 97)

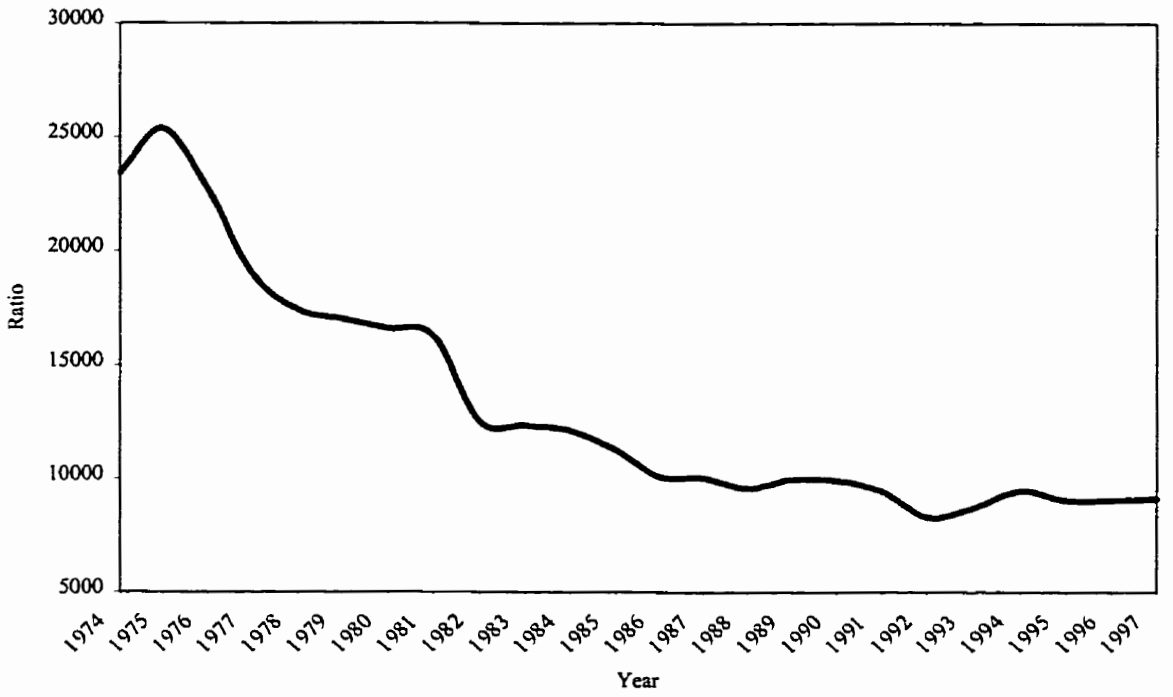


Source: The Manitoba Dental Association

4.6.3 Changes in the population to dental professionals ratio

The above data indicates that the growth of the number of registered orthodontic specialists (109.1%) and generalists (56.0%) had exceeded the overall population growth (12.3%). This was evident when considering the population to orthodontist and general dentist ratios for the province of Manitoba. As seen in figure 4.19, the ratio of the population of 7 – 19 year-olds to the number of orthodontists registered in the province had declined by 61.1% from 1974 until 1997. The ratio had decreased by an average of 1389.6 per year from 1974 until 1986, and seemed to have remained fairly constant in the second half of the time period studied (a change in the ratio of only 88.73 per year).

Figure 4.19: Ratio of the Orthodontic Age Population to the Number of Orthodontists from 1974 until 1997



The change in the population to MDA members ratio was not as drastic, since the overall the number of MDA members had increased by only 56% compared to the 109% increase in the orthodontists. There was a 26.6% decrease in the ratio of the total population to the MDA members from 1974 until 1988. However, the ratio seems to have leveled off with only a 1% change from 1992 until 1997. The data are summarized in figure 4.20 and 4.21.

Figure 4.20: Ratio of the Total Population of Manitoba to MDA Members

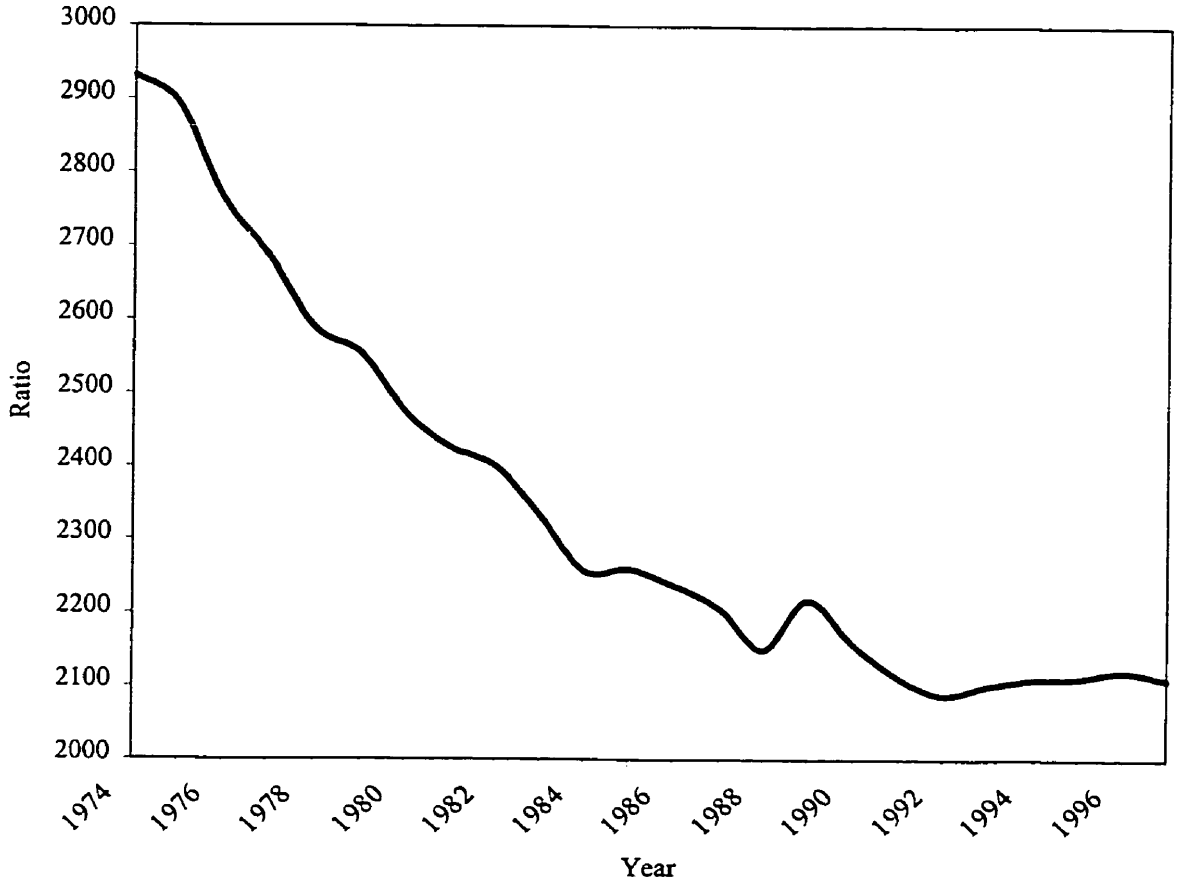
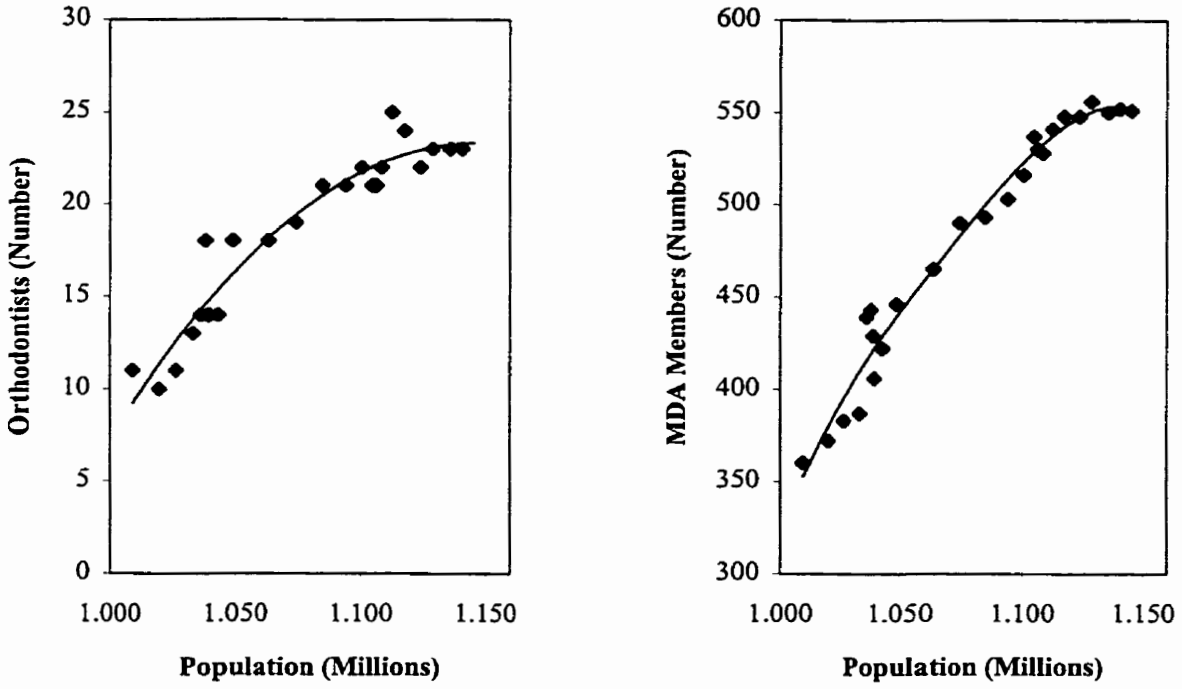


Figure 4.21: Changes in the Number of Orthodontists and All MDA Members to the Total Population of Manitoba



4.6.4 Synopsis

- The number of orthodontists had increased by 109% from 1974 until 1997.
- The number of MDA members had increased by 56% from 1974 until 1997.
- The orthodontic aged population to orthodontist ratio had decreased by 61.1% from 1974 until 1997.
- The population to MDA member ratio had decreased 28.0% from 1974 until 1997

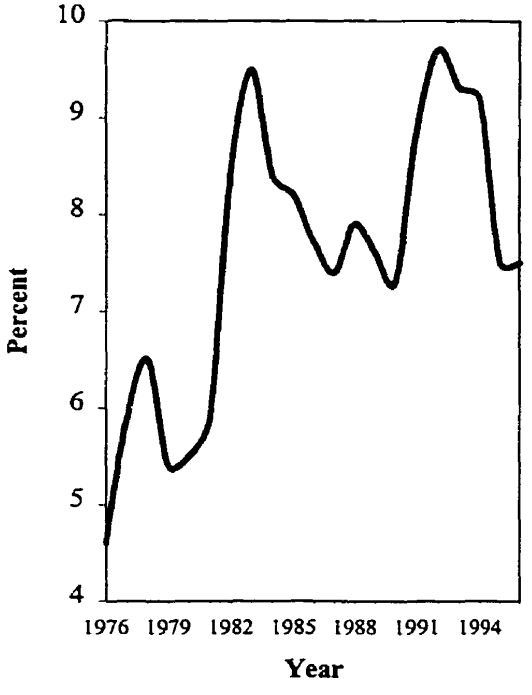
4.7 Economic changes

The various indicators selected to describe the economy of Manitoba are reported in the sections below.

4.7.1 Changes in the unemployment rate

The unemployment data obtained from Statistics Canada were reported for the time interval from 1976 until 1996. In figure 4.22, it is apparent that the trend in unemployment had not been linear. The unemployment rates had peaked above 9% in 1983, dropped from 1984 until 1987, and peaked again in 1992. The lowest rates were reported for 1976 and 1979. In the 1980s, a strong economy was evident with rates dropping in 1987 and 1989. However, the unemployment rates had never recovered to the low values reported for 1976.

Figure 4.22: Unemployment Rates for Manitoba



Source: The Labour Force-Catalogue no. 71-001-XPB

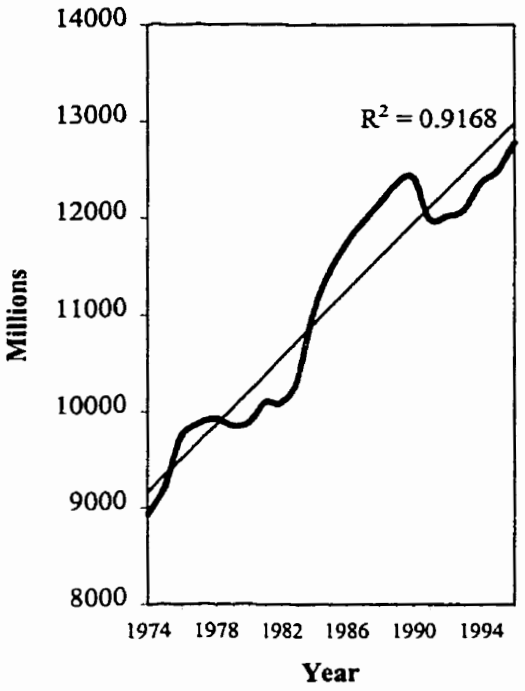
4.7.2 Changes in the Consumer Price Index

Published data on the Consumer Price Index (CPI) for Canada and Manitoba revealed that the CPI for Manitoba was similar to the Canadian average ($t=1.05$, N.S.). The values were utilized to calculate inflation rates and to remove the effects of inflation from economic data that were reported in current market dollars. Since the Manitoba CPI was reported only as far back as 1979, the Canadian averages were used in the calculations for the time period from 1974 – 1978.

4.7.3 Changes in personal expenditures on consumer goods and services

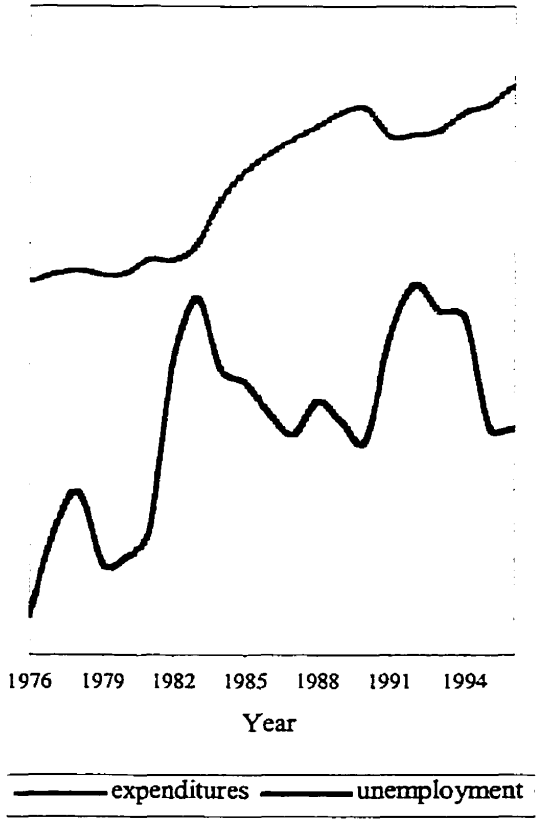
"Personal expenditures" was chosen as an economic indicator for the population in the province of Manitoba based on the premise that orthodontic treatment is a service that the public chooses to purchase. As seen in Figure 4.23, there had been a steady increase in the amount of revenue spent on goods and services over the past three decades. Even when the figures were adjusted for the overall inflation rate, a general increase in spending was observed in the time period of this investigation (r^2=0.92). However, the spending pattern was fairly constant from 1976 until 1983, when it began an increase of 20.3% until 1990. The amount of spending had again decreased for a short period of time, from 1990 until 1991, (3.5 %), and resumed its increase until the termination of the data in 1996. As expected, expenditures dipped when the unemployment rates were at their highest and had decreased when at their lowest.(Figure 4.24).

Figure 4.23: Personal Expenditures on Consumer Goods and Services for Manitoba, Adjusted for Inflation (1986)



Source: S.D.D.S. 1902 STC (12-213), CANSIM Label D31853

Figure 4.24: Relationship Between Expenditures and Unemployment Rates

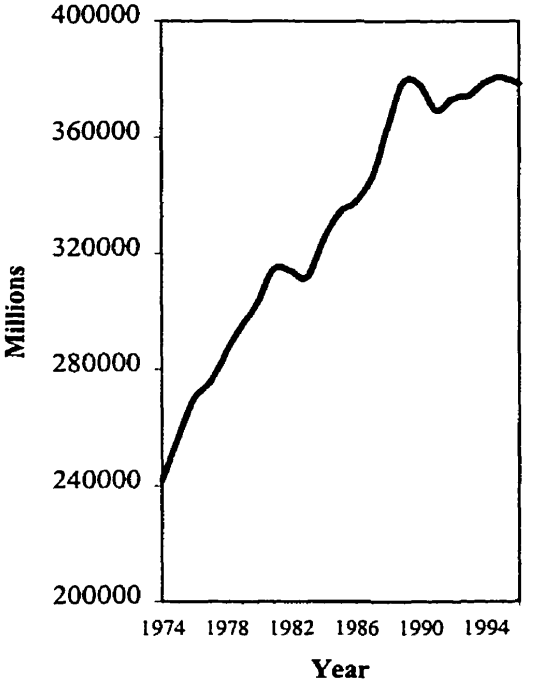


4.7.4 Changes in personal disposable income

Data on the personal disposable income for the population of Manitoba were available from 1926 until 1990 from statistics Canada, in current market dollars. Since the data was terminated in 1990, and correlation analysis revealed that the personal disposable income for Manitobans was not significantly different from the Canadian average, the personal disposable income for all of Canada until 1996 was considered as an economic indicator for this study period. The data was reported in millions of dollars, adjusted for the value of the dollar in 1981, and presented in Figure 4.25. The personal disposable income for Canadians rose steadily until 1981, dropped in 1982 and 1983, and rose again, peaking in 1989 (378,955,000). The income fell again until 1991,

and seemed to have leveled off until 1996. Overall, a 56.6% increase in disposable income had occurred over the time period studied.

Figure 4.25: Personal Disposable Income for Canada (Adjusted for Inflation)

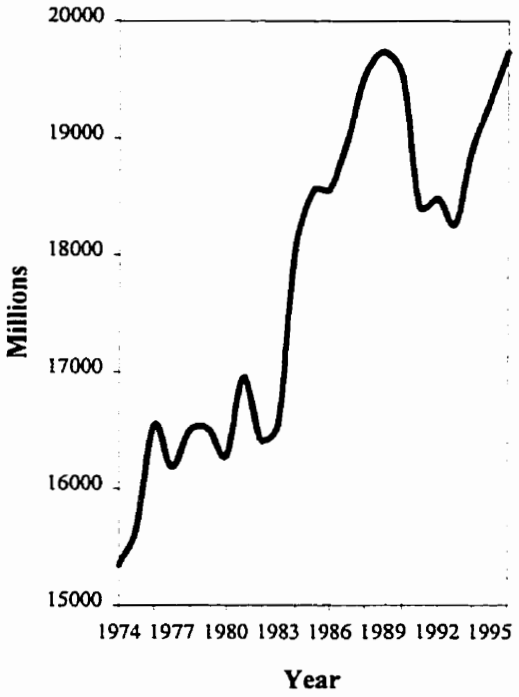


Source: Energy-Mines-Resources Canada

4.7.5 Changes in the Gross Domestic Product for Manitoba

The Gross Domestic Product (GDP) data for Manitoba are reported at current market prices, and were converted into constant dollars by adjusting for the annual inflation rates as determined by the Consumer Price Index. The GDP exhibited only slight fluctuations between 1976 until 1983 (maximum 4.7% change). However, the GDP grew by 20.3% from 1983 until it peaked in 1989. Following this accelerated growth, the GDP declined by 6.7% until 1991, and remained relatively "sluggish" until 1993. The GDP had increased again until 1996 to a level similar to that of 1989. The data are presented in Figure 4.26.

Figure 4.26: Gross Domestic Product for Manitoba (Adjusted for Inflation)



Source: Statistics Canada cat. No. 11-210-XPB

4.7.6 Synopsis

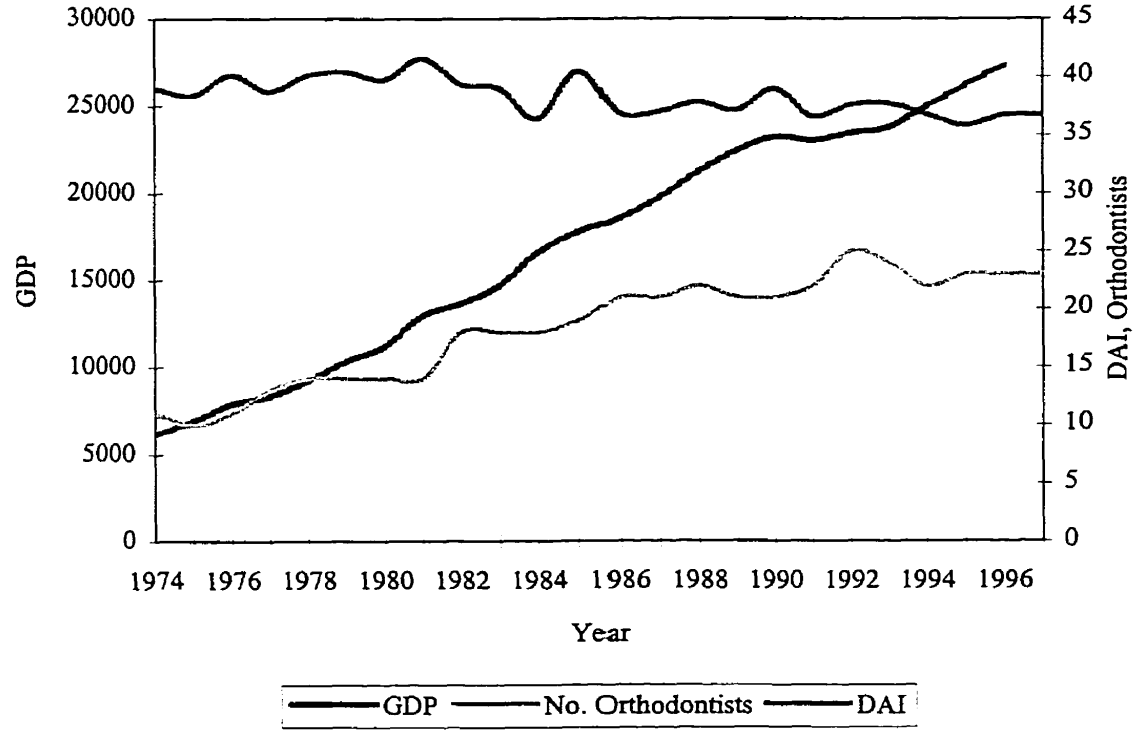
- Unemployment rates fluctuated from below 5% in 1976, to above 9% in 1983, partially recovered to around 7% in 1987 and 1989, and peaked again above 9% from 1992 until 1994.
- Personal expenditures on consumer goods and services for Manitoba have increased by 43.1% over the 1974 to 1996 period.
- Personal expenditures appeared to change in the opposite direction to unemployment rates.
- Personal disposable income has increased by 56.6% over the time period studied, but seemed to have leveled off from 1991 until 1996.

- Changes in the GDP for Manitoba demonstrated large economic growth from 1983 until 1989, a relatively sluggish economy from 1991 until 1993, and a rebound period until 1996.

4.8 Summary

Clearly the interaction between demographic and economic changes for Manitoba relative to the referral base of an orthodontist is very complex, as summarized in Figure 4.27.

Figure 4.27: Changes in the Economic and Demographic Profile for Manitoba Relative to the Changes in the Referral Base



5.0 Discussion

The principal finding from this investigation was the progressive reduction in malocclusion severity exhibited by the cases referred to the specialist over the 1974 – 97 period (Table 4.8). This trend was underscored by the 4.5% increase in annual DAI case-scores below 31, together with a 5.9% reduction in the mean annual DAI case-scores, over the 1974 – 97 period. Since DAI scores comprised functions of malocclusion severity (Cons et al, 1986), their overall decline over the 24-year test period indicated that specialist referrals exhibited progressively less severe malocclusions over time. This trend was confirmed by the changes exhibited by some of the DAI components, which principally included the following:

- A 15.2% reduction in the severity of maxillary overjet, 12.8% for anteroposterior molar relationships and 26.4% for crowding;
- A 64.9% increase in the severity of tooth spacing.

These latter changes underscored the difficulties associated with the interpretation of changes exhibited by an index (DAI) derived from multiple parameters, especially when they were variably inter-correlated and differentially weighted. For instance, overjet is most likely correlated with molar relationship (McNamara, 1981) and the DAI parameter defining missing teeth may be correlated with that for the diastema. Such variable correlations between these parameters were, however, accommodated when the data were subjected to Factor analysis. For instance, the results indicated that three factors (i.e. spacing/diastema/crowding; molar relationship/mandibular overjet; spacing/crowding/maxillary irregularity) were primarily responsible for the progressive reduction in the DAI scores (Figure 4.10).

Although a trend for lower DAI scores (less complex occlusions) was the principal finding of this investigation, further information on the referral bases of other orthodontists or the case-loads of non-orthodontists in the same region will be required to elucidate the aetiologic factors. Eight potential scenarios may be speculated to account for these changes:

1. If non-orthodontists had progressively provided services to resolve simple malocclusions, then their referral of complex cases to the orthodontist would have been associated with an increase in annual DAI scores, i.e. a higher proportion of case DAI scores above 31 would have been expected.
2. If non-orthodontists had provided an expanded service range to include serial extractions to resolve the potential for overcrowding, then a trend for lower DAI scores would have been anticipated over the 1974-97 period.
3. A similar trend would also have been anticipated if the non-orthodontists had provided increasing numbers of interceptive services to reduce the malocclusion severity (e.g. headgear, lingual or Nance-holding arches, etc. to reduce overjet and optimize molar relationships) prior to their referral to the orthodontist (Joondeph, 1993).
4. Progressive increases in the provision of orthodontic services by non-orthodontists may have increased potential patients' interest in the potential benefits of such services, inducing their demands to seek services for relatively minor malocclusions.

5. With the influx of more orthodontists in the region (Figure 4.17), conceivably the number of cases with complex malocclusions would have been dissipated between other orthodontists, thereby allowing the single orthodontist in the study to compensate his referral base by accepting cases with less complex malocclusions.
6. If the declines in caries prevalence for the region were similar to those reported for North America (Brunelle and Carlos, 1987) and if the referred cases accurately reflected the malocclusion patterns prevalent in the population as a whole, then a decrease in the prevalence of overcrowding would have been anticipated. This is due to the associated avoidance of premature deciduous tooth loss, drifting of permanent teeth and therefore reduced dental arch lengths (Kunzel, 1987).
7. Other orthodontists in the region may have preferentially developed a reputation for the provision of services for more complex malocclusions, thereby depriving the orthodontist of a broader referral base.
8. If the referral base of this specialist had remained stable over the 1974-97 period, then similar malocclusion referral patterns would have been anticipated, with no overall changes in their annual DAI sample scores.

In the absence of further data relative to the referral bases of other orthodontists in the region and the types of orthodontic services provided by non-orthodontists, the principal reasons(s) for the changes in DAI scores identified in this investigation will remain uncertain. Further evaluations of these data were also constrained by limitations of the DAI to evaluate changes in the referral bases.

5.1 Limitations of the Dental Aesthetic Index

Although the Dental Aesthetic Index is the most suitable index of treatment need for the present investigation, considering the importance of aesthetics, it is not without limitations.

1. The DAI was devised to evaluate cases in the permanent dentition. However, the revision of the index in 1996 (Cons et al, 1996) set out rules for dealing with mixed dentition cases: "When scoring a case in the mixed dentition, the space from a recently exfoliated primary tooth should not be scored as missing if it appears that the permanent replacement will soon erupt". This definition leaves a lot to interpretation and variation of the application of the index, and takes away from its objectivity (e.g. when the canines are missing). A problem is quickly identified when the canines are missing. Deciduous cuspids are quite often exfoliated early in cases of hereditary tooth size-arch size discrepancy (Graber, 1994). In the evaluation of study models in such a case, the definition of missing teeth applied to the canines will then depend upon the expected eruption time of the permanent teeth. Furthermore, in cases of impacted canines, unless a radiograph is available, the examiner is left to guess whether or not the tooth will erupt, and therefore whether or not to count it as missing. In this study, if the canines were unerupted with less than 4 mm space available for their alignment in the arch, they were considered impacted

and counted as missing. This is in accordance with the scoring of impacted teeth by the PAR index (Richmond et al, 1992a). An assumption of the normal exfoliation pattern was also made, counting teeth as "not missing" if there was a space present within 2 years of the expected eruption date of the succedaneous tooth.

2. If a tooth is missing, yet the space for it had completely closed, then according to the DAI, the tooth is not scored as "missing". In the case of one missing maxillary canine, the midline may have shifted substantially to the side of the missing canine, causing an obvious aesthetic deviation from the norm. Yet, the patient could potentially be identified as having a low DAI score, or no treatment need, i.e. the DAI is not necessarily sensitive to the needs of all patients.

3. The DAI does not record buccal cross bite or lateral open bite (Otuyemi and Noear, 1996), which may be considered an aesthetic and functional impairment and therefore a social handicap if severe.

4. The DAI does not differentiate between teeth that are missing with very small, easily manageable spaces, and those that are missing with large residual spaces. Obviously the extent of the space will contribute to the severity of the malocclusion, yet is ignored by the DAI scores.

5. The severity levels of malocclusion defined by the DAI scores are functions of the general perceptions of malocclusion and aesthetics. Therefore, for more precision, the DAI may need to be revised in the future to include other parameters, or to change their differential weights.

6. The psychosocial importance of aesthetics may fluctuate with time. The present weightings of the DAI components, which are based on the public's perception of aesthetics, may therefore not be applicable to all populations.

Clearly, further research is required to develop a more appropriate index to provide more precise descriptions of malocclusions prior to extending this study to other (orthodontist and non-orthodontist) providers.

5.2 The S(Strengths), W(Weaknesses), O(Opportunities) and T(Threats) analysis

Since the SWOT analysis was applied to the general orthodontic specialty market in the Introduction, this can now be refined to identify the possible reasons for the DAI score declines identified in this investigation (Table 5.1 and 5.2).

The internal strengths of the orthodontic specialty include factors such as patient satisfaction, the ability to maintain a stable referral source, and public desire and recognition for specialty services. The orthodontist in this investigation has a good reputation for being competent and personable and reports a stable referral source over the years in practice. Since patient satisfaction is measured by the perceived quality of care, which is in turn measured by total patient experience in the office (Gronroos and Massalin, 1990) as well as treatment outcome, then it is likely that this factor is a definite strength of the particular practice. Furthermore, as discussed in the **Introduction**, there are potential advantages to the services derived from an orthodontist who has graduated from an accredited university-based full-time graduate orthodontic specialty training programme. It is expected that the public will respect the value of treatment by such a

specialist due to the extensive education involved. Patients so informed, will hopefully continue to seek treatment by orthodontists, even though a greater proportion of non-orthodontists provide the services.

In contrast to the strengths, internal weaknesses of the orthodontic profession are also apparent. These include an increase in the supply of specialist manpower, as well as a shift in the practice infrastructure (i.e. large group practices and Management Service Organizations (MSOs). Management Service Organizations, which have entered the market in North America, threaten the traditional orthodontic practice by introducing a new source of low-fee competition. Although this is presently not a factor in Manitoba, their popularity and potential introduction into the province poses a threat to the local orthodontic market. A large group practice set-up may also possess an internal weakness by minimizing the familiarity and positive experience of the patient when the inevitable interaction with other specialists of the practice may result in patient dissatisfaction. The internal strengths and weaknesses are summarized in Table 5.1.

Table 5.1: Summary of the SWOT Analysis for the Specific Practice of the Specialist—Internal Parameters

Parameter	Type	Example
Internal Strengths	Specialist Recognition	Long established reputation (Teaches in the Graduate Orthodontic Programme
	Stable Referral Source	Limited referral base that continues to refer patients (personal communication)
	Patient Satisfaction	Personality and competency of the specialist that continues to satisfy patients (Hughes et al, 1996) Member of large practice; other specialists available for emergencies
	Adequate Infrastructure	Modern practice, well-trained and competent staff
	Location	1 Downtown (older) and 1 suburban (newer) office
Internal Weaknesses	Increased Specialist Manpower	↑ 109% in orthodontic Specialists from 1974 – 97 (Figure 4.19, 4.20)
	Shift In Local Practice Paradigm	Potential introduction of MSOs in Manitoba with low-fee competition (Oppenhuizen, 1997)
	Group Practice	Patient dissatisfaction with another specialist/manager may decrease patient demands for treatment (Gronroos & Massalin, 1990). Loss of "personal attention" and increased use of auxiliaries.

External threats to the orthodontic specialty market include the provision of orthodontic services by non-orthodontists, the reduced potential patient pool and a fluctuating economy (Table 5.2). Anecdotal evidence suggests that the increase in the orthodontic services provided by an increasing number of non-orthodontists is perhaps one of the most influential factors affecting the referral base of the orthodontic

practitioner and has been the primary concern of orthodontists (Gottlieb et al, 1997c). The existing continuing education courses available to the general dentist encourages both and increase in quantity and scope of orthodontics in their practices (Chate, 1994). This is acceptable, however, provided that correct diagnosis, treatment planning and appropriate case selection is made (White, 1998; Woodside, 1998). Problems however occur when in-treatment difficulties arise which general dentists are not trained to handle nor have the experience to deal with them appropriately.

Birth rates serve as an estimate of the future potential patient pool for the orthodontic specialist. Over the time period of the investigation, birthrates in Manitoba had dropped 11.4%. However, population data attained by birth rates has its limitations, since the population is affected by migration into and out of the province, which precludes accurate future prediction. A continual decline may, however, be considered to be a threat in the future.

The economic picture of the region will also pose external threats (or opportunity) to the specialty market with its fluctuations. Although the general economy for Manitoba has been experiencing growth in recent years, future downward changes could undoubtedly have a negative impact on the demand for specialty orthodontic services.

The external threats to the specialty market have, however, been compensated by external opportunities that promote the demand for orthodontic services, including economic factors, as well as changes in perceptions of malocclusions due to psychosocial aesthetic concerns and shifts in population demographics. The psychosocial benefit derived from an improvement of dental aesthetics appears to be the dominating motivator for orthodontic treatment. If patients currently weigh aesthetics more heavily now than in

the past, this suggests that the perceived benefit of treatment is much higher than previously envisaged. Furthermore, the increased popularity in orthodontic treatment amongst adults (Nattrass and Sandy, 1995) demonstrates a demographic shift in the potential patient pool, representing both new and residual orthodontic treatment need (Proffit et al, 1998; Nattrass and Sandy, 1995). The increased availability of resources through third party benefits and the general economic growth in the province has also made orthodontic treatment more affordable, which encourages patients to seek orthodontic treatment with less reservation. A 43.1% increase over the 1974 – 97 period in the personal expenditures on consumer goods and services indicates a strong economic growth and willingness of the population to direct their discretionary funds on services. Furthermore, a 56.6% increase in personal disposable income is conducive to a greater demand for services. The external components of the SWOT analysis are summarized in Table 5.2.

Table 5.2: Summary of the SWOT Analysis for the Specific Practice of the Specialist—External Parameters

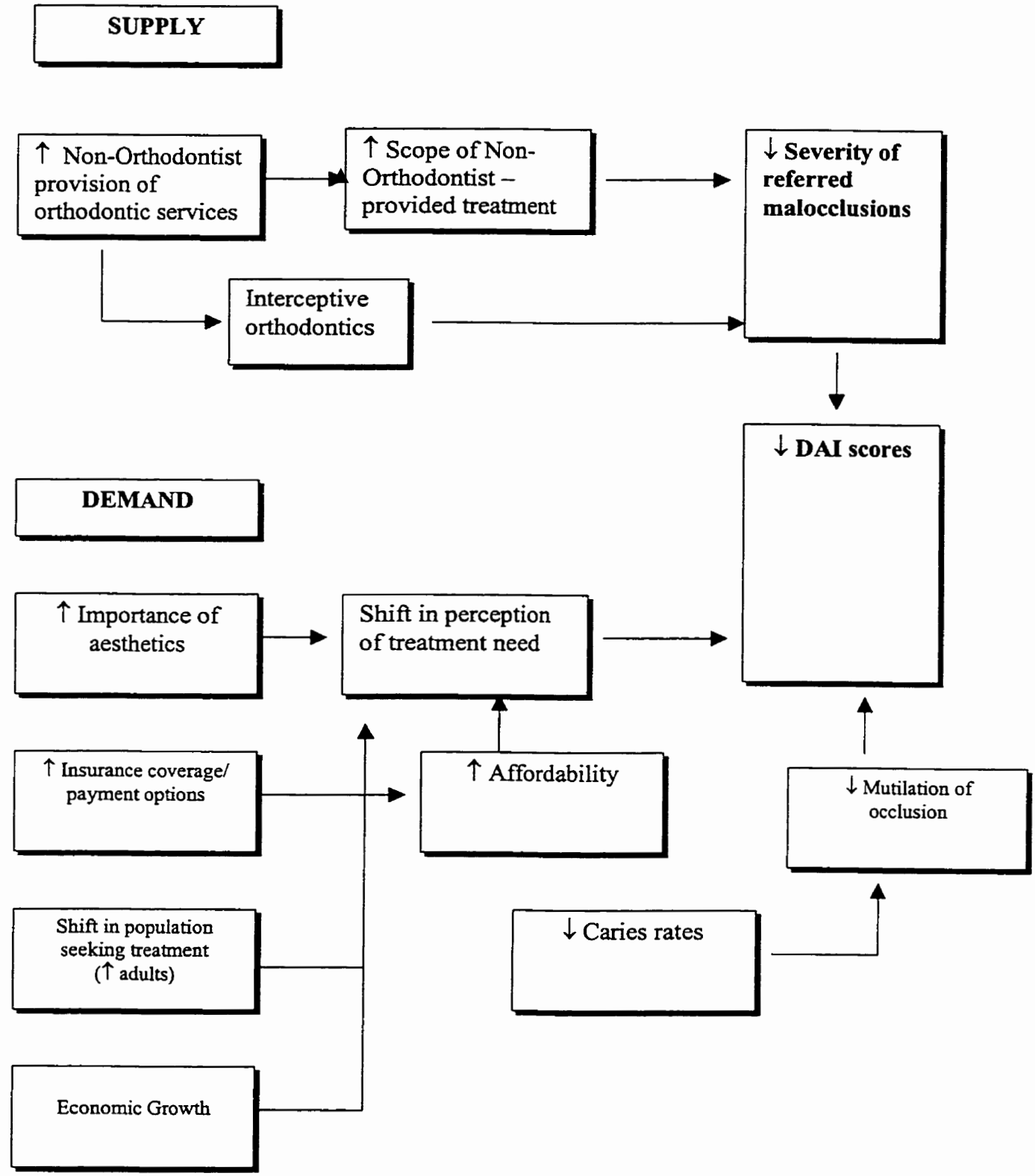
External Opportunities	Psychological Aspects of Malocclusions	Aesthetics becoming increasingly important determinants of orthodontic service demands in Manitoba as evidenced by reduced DAI of patients (Figure 4.3). This trend is common in other regions of North America and Europe (Plunkett, 1997; Sergl & Zentner, 1997)
	Adult Orthodontic Treatment Demands	Increase in age of referral base or↑ proportion of adults in the referral base. This trend reflects and ↑ popularity, residual treatment need (Nattrass & Sandy, 1995) desire for retreatment (Bergstrom and Halling, 1998), physiologic lower incisor crowding (Proffit et al, 1998) and growth in adult years (Behrents, 1986).
	Perceived Service Values	Costs are not a concern (Gronroos & Massalin, 1990)
	Economic Changes in Manitoba	↑ 43.1% in Personal Expenditures on Consumer Goods and Services (Figure 4.23) ↑ 56.6% in Personal Disposable Income (Figure 4.24)
External Threats	Provision of Orthodontic Services by Non-Orthodontists	No data available from Manitoba, but assumed to be analogous to other N. American regions (Gottlieb, 1984; Moorrees, 1984; Koroluk et al, 1988; Jacobs et al, 1991; Wolsky and McNamara, 1996) Interceptive Procedures (Alexander, 1987) 2-phase Orthodontic Treatment Establishing "ownership" (Bowman, 1998)
	Reduced Potential Patient Pool	11.4% decline in birth rates from 1974 – 97 (Figure 4.13)
	Economics	Future downturn in Manitoba economy i.e. economics important determinants of service demand (Douglass & Furino, 1990)

The potential external threats and internal weaknesses which have been identified in the SWOT analysis need to be addressed. For instance, various strategies may be considered to control the increase in specialist manpower (an internal weakness). These may include a reduction in both dental and specialty programme enrollment to reduce the number of entrants into the profession, or at the far extreme, the closure of graduate orthodontic programmes. The potential entrance MSOs into the local market may be addressed in Canada through educating the current providers and users in order to increase their awareness of its ramifications (Oppenhuizen, 1997).

Similarly, the external threats to the specialty market (i.e. non-orthodontist-provided services, reduced potential patient pool and economics) may be minimized by some measures. For example, a change in the dental school curriculum and the creation of accredited continuing education courses provided by the dental schools may reduce the general dentist's reliance on "motel" courses. This may help to maintain clear boundaries between treatment requiring the attention of an orthodontist and treatment that may be rendered by a generalist. The reduction in the potential patient pool may be addressed by enhancing advertising by the orthodontic specialty organizations (i.e. the American and Canadian Associations of Orthodontists) in order to promote the dentist as well as patient awareness of the services available to them. Unfortunately, global and local economics are not well predicted or controlled. However, times of economic hardship may be balanced by strategies to render orthodontic treatment more affordable, such as reasonable payment options. However, further analysis of the orthodontic specialty market, is required to determine the feasibility of the above options.

In summary, the orthodontic specialty market is not defined by a simple supply and demand equation, due to the interactions between the principal determinants. For instance, the decline in birth rates and population of the orthodontic-aged group may have decreased the service demand, although this may have been offset by an increase in treatment demand by the non-traditional patient (i.e. adult). Similarly, whereas the increase in specialists and generalists, as well as the decline in the population to professionals ratios, have contributed to an increase in the supply of services, the demand side of the equation is a function of the general economy, i.e. strong economic growth potentially increases demands, while recession is associated with decreased demands. The provision of orthodontic services by non-orthodontists and the expansion of the scope of these services (i.e. the supply) could potentially decrease the severity of the referred malocclusions, which is reflected in a decrease in DAI scores. Reduction in scores could also reflect a shift in demand for services, which are affected by factors which contribute to the affordability and the shift in perception of treatment mean. The potential contribution of these various factors to the referral base are summarized in Figure 5.1.

Figure 5.1: Potential Contributions of Various Factors Involved in the Referral Base



5.4 Limitations of the Study

This study was designed primarily as a pilot project, so that there were limitations with respect to the formulation of generalized statements concerning the delineation of changes to the orthodontic service market as a whole. This study necessarily focused on only one orthodontic practitioner, over the 24 year period. There is now a definite need for future studies into similar assays of the referral base of other orthodontic practitioners, in the same and other geographic locations in order to attain a more complete overview of the total orthodontic service market. Furthermore, a longitudinal study of the orthodontic patients in general practitioner and paediatric dental specialist offices would also be useful in determining the changes in scope and quantity of orthodontic services provided by non-orthodontists.

Another limitation of the approach of this study stems from the assumption that the referral base of the orthodontist resulted from dentist referrals. However, a closer examination of the longitudinal changes in the referral sources for the dentist would be appropriate in order to detect the proportion of dentist-derived to patient-derived referrals. If there were a shift toward more patient referrals, then the severity of the malocclusions seen by the orthodontists may not have been subjected to the screening of the general dentist indicative of a change in referral criteria.

When considering the demographic and economic components of the study, the data collected were not optimal. For instance, the economic data were limited to that reported by the statistical database which did not cover the entire period for the study in some cases. Furthermore, data collection from the Manitoba Dental Association may not

have been ideal, in that they are primarily related to their members only. These data may therefore have overestimated the actual numbers of licensed dentists practicing in Manitoba, since members may not necessarily remain in the province. Also, the number of hours in private practice, by each member was not recorded. For instance, some of the members (especially specialists) may work part time, and therefore do not equally contribute to the supply of manpower estimated by the numbers of professionals.

5.5 Future Research

This study was limited to the evaluation of changes in the referral base of the private practice of one orthodontic specialist. The observations were further confined to assessments of the pre-treatment malocclusions. However, in order to examine the orthodontic specialty market in greater detail, research into other aspects of the market is necessary.

5.5.1 Examination of the referral base of other orthodontists

An examination of the referral base of several other orthodontic specialists in the same area and also in other geographic locations in Canada is necessary, due to the inability to extrapolate and generalize from the results of only one practitioner. It would be interesting to evaluate the changes in various areas of Canada, which may exhibit differences in their local threats, opportunities, strengths and weaknesses.

5.5.2 Treatment outcomes

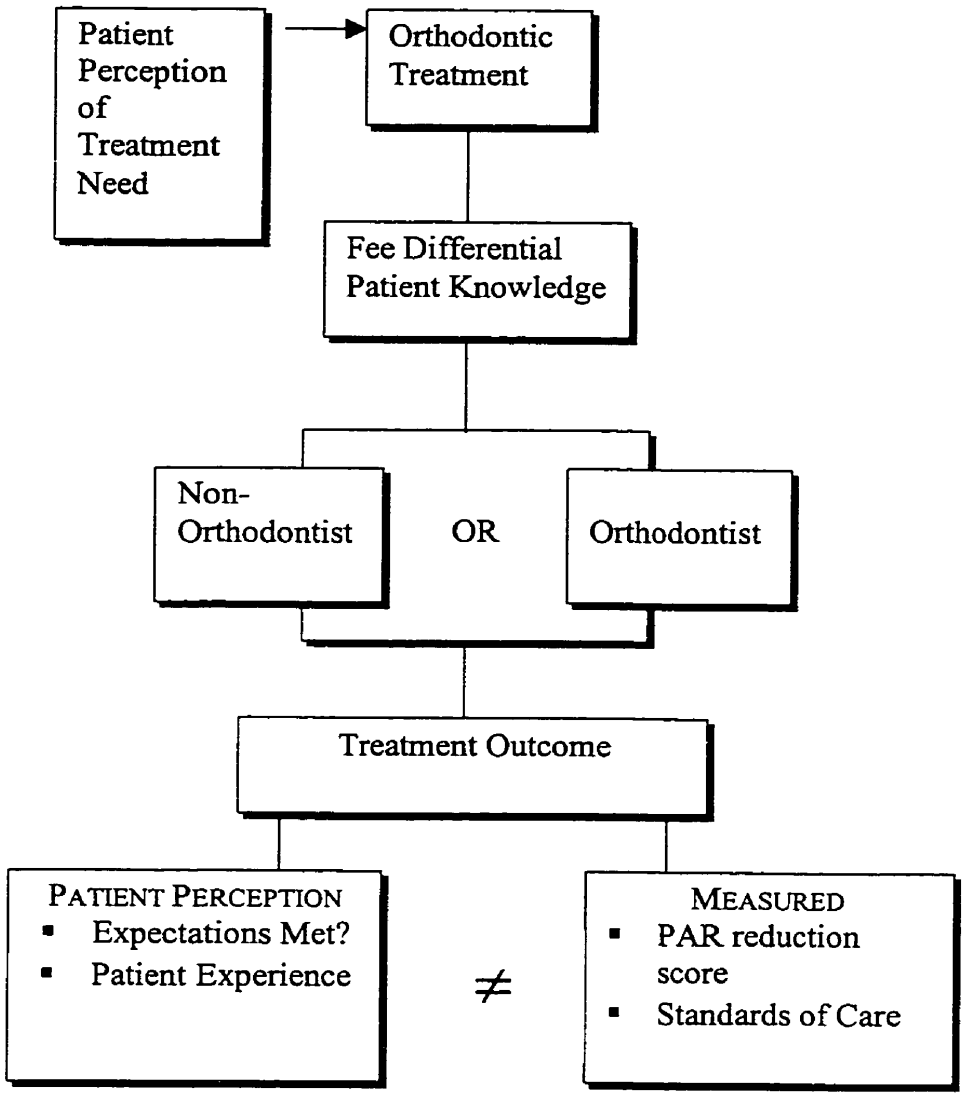
Treatment outcome is influenced by the perceptions of the patients which includes a subjective evaluation as to whether or not their expectations had been met, as well as the overall patient experience (see Figure 5.2). However, the profession needs objective

treatment outcome measures to evaluate the relative competency of specialists and generalists in providing the orthodontic services to resolve malocclusions. For instance, the Peer Assessment Rating (PAR), reviewed in appendix A, has been devised to objectively measure treatment outcome by comparing pre-treatment and post-treatment scores (Richmond et al, 1992; Fox et al, 1997). This PAR index would therefore potentially evaluate service outcomes over time which is important information to evaluate the specialty orthodontic market, (i.e. are outcomes improving with time?). Research would also be useful to devise an absolute measure of the standard of care, which may then be used to compare the specialist orthodontist and the non-orthodontist in their provision of orthodontic services.

5.5.3 Non-orthodontist derived treatment

It is beyond the scope of this research to evaluate or comment on the quality of the treatment provided by the non-orthodontists versus the orthodontic specialist. However, treatment outcome research supports the contention that treatment rendered by orthodontists, on average, exceeds that provided by general dental practitioners with respect to patient satisfaction and quality of results (Bergstrom and Halling, 1998). This may be interpreted to imply that general dentists provide services beyond their capabilities. Therefore, in addition to treatment outcome studies concerning the orthodontic specialists, it is necessary to impose such studies on the non-orthodontists as well. As the quality assurance issue will grow with the increasing numbers of non-orthodontist providers, the need for such a measure cannot be overstated.

Figure 5.2: Patient Perception and Orthodontic Treatment



6.0 Conclusions

Based on the involved statistical analyses of the DAI scores from the 1156 sample cases over the period from 1974 – 97, the principal finding was that the malocclusion severity of the referred cases had decreased. Therefore, the null hypothesis is rejected i.e. there have been changes to the referral base of the orthodontic practitioner over the 1974 – 97 time period. This study also underscored the need for further development of an index to embrace all of the parameters to evaluate a referral base, before extending this study to other orthodontists and non-orthodontists.

Appendix A—Indices of Malocclusion

i. Handicapping Labiolingual Deviation Index (Draker, 1960, 1967)

This index was devised by Draker (1960) for the assessment for orthodontic treatment need. Draker identified 9 components that were of importance and assigned weightings according to their contribution to the overall assessment:

- Cleft palate, given a score of 15 if present
- Traumatic deviations, given a score of 15 if present
- Overjet, in millimetres
- Overbite, in millimetres
- Mandibular protrusion (negative overjet) in millimeters, and multiplied by a weighting of 5
- Anterior openbite, in millimetres, multiplied by a weighting of 4
- Ectopic eruption of anterior teeth, measured in the number of teeth involved, multiplied by a factor of 3
- Anterior crowding, measured as present or absent in the maxilla and the mandible, given a score of 5 each
- Labio-lingual spread, in millimeters (the distance between the most protracted and the most lingually displaced anterior tooth, or the most deviated to the normal arch form)

The weightings assigned to the components were subjective and arbitrary and the reliability for this index was found to be lower than other available indices (Younis et al, 1997).

ii. Treatment Priority Index (TPI)

Grainger's Treatment Priority Index (Grainger, 1967) was based on evaluations of study casts of 375 twelve year old children from the Burlington Orthodontic Research

Centre (Grainger, 1967; Turner, 1990). In addition to the automatic categorization of cases with severe dentofacial defects and cleft palate into the most severe category, the following 10 measurements are involved:

- Overjet
- Reverse overjet
- Overbite
- Anterior openbite
- Congenitally missing incisor teeth
- Distocclusion
- Mesiocclusion
- Posterior buccal crossbite of upper teeth
- Posterior lingual crossbite of upper teeth
- Displacement of individual teeth

The above components are recorded on forms, and the patient is classified as belonging to one of the following seven malocclusion syndromes, depending on the major characteristics of the malocclusion:

- Syndrome I, maxillary expansion syndrome
- Syndrome II, overbite
- Syndrome III, retrognathism
- Syndrome IV, openbite
- Syndrome V, prognathism
- Syndrome VI, maxillary collapse
- Syndrome, VII, congenital incisors.

The total score is considered to reflect the malocclusion severity. Unfortunately, the weighting of each component is arbitrary (Helm et al, 1975) and the validity of the indes was found to be only moderately good (Slakter et al, 1980).

iii. Handicapping Malocclusion Assessment Record (HMAR)

The Handicapping Malocclusion Assessment Record (HMAR) was developed by Salzmann (1968) in order to priorize treatment-need, according to malocclusion severity. The following components are measured:

- Missing teeth
- Crowded teeth
- Rotated anterior teeth
- Rotated posterior teeth
- Open spacing, scored as the number of interdental papilla visible
- Overjet
- Overbite
- Crossbite of incisors and posterior teeth
- Openbite
- Anterior-posterior relationship of the buccal segments

The index is useful only in the permanent dentition and the validity and reliability of the HMAR was found to be lower than other indices (Grewe and Hagan, 1972).

iv. Occlusal Index (OI)

The Occlusal index was devised by Summers (1971), based on the work of Grainger (1967). The following components are measured:

- Dental age
- Molar relation
- Overbite
- Overjet
- Posterior cross-bite
- Posterior open-bite
- Tooth displacement (actual and potential)
- Midline relations
- Missing maxillary incisor teeth

Each component is scored and a weighting is applied. Scores are entered on a code sheet specific for the dental age of the patient and the patient is classified into one of seven syndromes.

The OI scored highest in validity and reproducibility compared to other indices, such as the HMAR, TPI, and HLDI (Grewe and Hagan, 1972), but the complexity of the index makes it far from simple to use.

v. Malocclusion Severity Index (MSI)

The Malocclusion Severity Index (MSI) (Hill, 1992) was developed by applying a series of weighted scores to 9 occlusal measurements:

- Anterior open bite (AOB), defined by an openbite of 3 mm or more, is given a score of 10.
- Traumatic overbite (TOB) is scored as 18 if there is tissue impingement or stripping.
- Anterior crossbite is scored as 14, 16, 18, or 20, depending on whether 1, 2, 3 or 4 teeth are involved.
- Posterior crossbite is scored as 16 when present in one or more teeth
- Upper anterior spacing of 3 mm or more in the anterior segment is given a score of 14.
- Incisal overjet: if 1 – 5 mm, there is no weighting score; if 6 – 9 mm, there is a weighting score of 8, and if 10 mm or more, the weighting score is 24.
- Upper incisor rotations, of 30° or more are weighted according to the number of teeth involved: if one tooth is involved = 10; two teeth =14; three teeth = 16; four teeth = 18.
- Upper and lower posterior crowding is measured when one or more posterior teeth are displaced from the line of the dental arch by more than half the mesio-distal diameter of the crown of the tooth. Unilateral crowding is given a weighted score of eight, and bilateral crowding is given a score of 10. Each arch is measured separately.
- Upper and lower anterior crowding, based on the number of slipped contacts in the anterior of each arch, was multiplied by 4 for the upper teeth and by 3 for the lower.

The weightings assigned to the components are subjective, and the validity was similar, but not as high as other indices, and tested by the same author who developed it (Hill, 1992).

vi. Index of Orthodontic Treatment Need (IOTN)

The IOTN, which was developed at the University of Manchester (Brook and Shaw, 1989), differs from the other indices since it has two independent components: The Dental Health Component (DHC) and the Aesthetic Component (AC). The DHC comprises five categories or grades of malocclusion severity, which translate into a spectrum of no need to very great need for treatment. The categories are based on the measurements of the following occlusal traits, that may have deleterious effect on dental health:

- Overjet
- Missing teeth
- Crossbites
- Contact point displacement
- Overbite

The most severe occlusal trait is identified on a patient, who is then assigned to a category.

The Aesthetic Component is a ten point scale of attractiveness, illustrated by intra-oral photographs, which are based on the Standardized Continuum of Aesthetic Needs index (Evans and Shaw, 1987). The examiners and patients select the photograph which matches their dental attractiveness most closely. The measurements are reported as categorical data, and therefore cannot be subjected to statistical analyses and the severity of the cases within each severity level cannot be rank-ordered according to relative severity. Since only the worst trait determines the category, several minor irregularities of the different occlusal features do not necessarily add up to score high enough to indicate treatment need (McGuinness and Stephens, 1994).

vii. Peer Assessment Rating (PAR)

Although the PAR index was designed to measure the results of orthodontic treatment and is not an index of treatment need, it may be used to assess the severity of the malocclusion. It was based on the opinion of a panel of ten experienced orthodontists in 1987. The following components are involved in the PAR score (McGuinness and Stephens, 1994):

- Anteroposterior relationship of the buccal occlusion
- Transverse relationship of the buccal occlusion
- Vertical relationship of the buccal occlusion
- Centerline discrepancy
- Overbite
- Contact point displacement of the anterior teeth
- Overjet.

The PAR index was validated by 74 British orthodontists and reflects contemporary British orthodontic opinion and further studies are required to evaluate its validity on North American populations, by North American-trained orthodontists.

Appendix B--Recommended Guidelines for the Application of the Dental Aesthetic Index

From: Cons and Jenny, 1986 and Cons and Jenny, 1991.

1. **Missing Visible Teeth**
   - Only incisors, canines and premolars are counted as missing
   - If spaces are closed, the teeth are not counted as missing
   - If a primary tooth is in position and its successor has not yet erupted, then the tooth is not counted as missing

2. **Crowding in the Incisal Segments**
   - 0 = no segments crowded
   - 1= 1 segment crowded
   - 2 = 2 segments crowded
   - when in doubt, assign the lower score
   - do not mark the segment as crowded if the 4 incisors are in proper alignment but 1 or both canines are displaced

3. **Spacing in the Incisal Segments**
   - If 1 or more teeth have proximal surfaces without any interdental contact, then they are counted as spaced
   - 0 = no segments spaced
   - 1 = 1 segment spaced
   - 2 = 2 segments spaced
   - when in doubt, assign the lower score

4. **Diastema**
   - Measure the space between the maxillary central incisors, at any level and record to the nearest whole millimetre

5. **Largest Anterior Irregularity on the Upper Arch**
   - Includes rotations out of or displacements from normal alignment
   - Locate the greatest irregularity between adjacent teeth (4 incisors)
   - Measure the site of greatest irregularity in millimeters, from labial surface to labial surface, to the nearest whole millimetre
   - Include irregularities at the distal of the lateral incisors

6. **Largest Anterior Irregularity on the Lower Arch**
   - Similar as in the upper arch

7. **Anterior Maxillary Overjet**
   - Measure with the teeth in centric occlusion
   - Record only the largest maxillary overjet from the labial of the incisal edge of the most prominent upper incisor, to the labial surface of the corresponding lower incisor, parallel to the occlusal plane

8. **Anterior Mandibular Overjet**
   - When any lower incisor protrudes anteriorly to the opposing upper incisor (in crossbite) then record the largest mandibular overjet of any of the incisors to the nearest whole millimetre
   - Do not mark the tooth as mandibular overjet if a lateral incisor is rotated so that 1 part of the incisal edge is in crossbite but another part is not.

9. **Vertical Anterior Openbite**
   - If there is lack of vertical overlap between any of the opposing pairs of incisors, then record the largest open bite to the nearest whole millimetre

10. **Anterior-posterior Molar Relation**
   - If the upper molars are missing, not fully erupted or miss-shaped because of decay or fillings, then the relations of the permanent canines and premolars are assessed
   - Only the largest deviation from normal molar relation is recorded
   - Look at the lower 1st molar and compare its position with normal relation
   - 0 = normal relation
   - 1 = ½ cusp relation
   - 2 = full cusp off

Special Considerations:

1. **Cases with severe anomalies**
   - Deep overbite that impinges on soft tissue and cleft palate or other congenital anomalies are not part of the numerical score; they are automatically considered to be in treatment need.

2. **Mixed dentition cases**
   - The space from a recently exfoliated primary tooth should **NOT** be scored as missing if it appears that the permanent replacement will **SOON** erupt.

3. **Case severity levels**
   - DAI scores can be rank-ordered on a continuous scale from 13 and higher. This continuous scale makes the DAI sensitive enough to differentiate cases with greater or lesser need for treatment within the various severity levels.

References

Alexander SA. Preventive and interceptive orthodontics: A goal of clinical practice. NYS Dental Journal 1987;53(6):25-27.

Angle EH. Classification of malocclusion. Dent Cosmos 1899;41:248-64.

Baker A. Personal communication, 1998.

Ballard CF, Wayman JB. A report on a survey of the orthodontic requirements of 310 apprentices, Trans Br Soc St Orthod 1964; 86: 81– 6.

Behrents R. JCO/ Interviews Dr. Rolf Behrents on adult craniofacial growth. J Clin Orthod 1986; 20(12):842-7.

Bergstrom K, Halling A. Orthodontic care from the patients' perspective: perceptions of 27-year-olds. Eur J orthod 1998;20(3):319–29.

Bergstrom K, Halling A, Huggare J, Johansson L. Treatment difficulty and treatment outcome in orthodontic care. Eur J orthod 1998;20(2):145-157.

Blake M, Bibby K. Retention and stability: A review of the literature. Am J Orthod Dentofacial Orthop 1998;114:299 – 306.

Bowman SJ. One-stage versus two-stage treatment: Are two really necessary? Am J Orthod Dentofac Orthopedics 1998; 113: 111 – 116.

Brennan DS; Spencer AJ; Szuster FS. Differences in time devoted to practice by male and female dentists. Br Dent J. 1992;172(9): 348-9

Brezniak N, Wasserstein A. Root resorption after orthodontic treatment: Part 1. Literature review. Am J Orthod Dentofacial Orthop 1993a; 103:62 – 66.

Brezniak N, Wasserstein A. Root resorption after orthodontic treatment: Part 2. Literature review. Am J Orthod Dentofacial Orthop 1993b;103:138 – 146.

Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. Eur J Orthod 1989;11:309-320.

Brunelle JA, Carlos JP. Recent trends in dental caries in U.S. children and the effect of water fluoridation. J Dent Research 1990; 69 Spec No: 723 – 7.

Burden DJ; Mitropoulos CM; Shaw WC. Residual orthodontic treatment need in a sample of 15- and 16-year-olds. Br Dent J. 1994;176(6):220-4.

Chate RAC. The burden of proof: A critical review of orthodontic claims made by some general practitioners. Am J Orthod Dentofac Orthop 1994;106:96-105.

Cons NC, Jenny J, Kohout FJ. DAI: The Dental Aesthetic Index, Iowa City: College of Dentistry, University of Iowa 1986.

Cons NC, Jenny J, Kohout FJ. Associations of dental aesthetics (DAI) with dental appearance, smile and desire for orthodontic treatment. J Dent Res 1987;66: abstr. no. 1081.

Cons NC, Jenny J. Guidelines for using the DAI. A supplement to the Dental Aesthetic Index, Iowa City: College of Dentistry, University of Iowa 1988.

Cons NC, Jenny J, Kohout FJ. Addendum to DAI: The Dental Aesthetic Index, Iowa City: College of Dentistry, University of Iowa 1991.

Cons NC, Jenny J. Comparing perceptions of dental aesthetics in the USA with those in eleven ethic groups. Int dent J 1994;44(6):489-94.

Cons NC, Jenny J, Kohout FJ, Jakobsen J, Shi Y, Ying WH, Pakains G. Comparing ethnic group-specific DAI equations with the Standard DAI. Int Dent J 1994;44:153-158.

Cons NC, Jenny J, Kohout FJ, Songpaisan Y, Jotikastira D. Utility of the Dental Aesthetic Index in Industrialized and Developing Countries. J Pub Health Dent 1989;49(3):163-166.

Danyluk, K (1998). The development of an objective orthodontic treatment-need index. Unpublished Master's thesis, University of Manitoba, Manitoba, Canada.

Dawson-Saunders B, Trapp RG. Basic and clinical biostatistics. Connecticut: Appleton and Lange, 1994;227 – 228.

Dickson GC. Long-term effects of malocclusion. Br J Orthod. 1974; 1(3): 63-8

Douglass CW, Furino A. Balancing dental service requirements and supplies: epidemiologic and demographic evidence. J Am Dent Assoc 1990;121:587-592.

Draker HL. Handicapping labio-lingual deviations: A proposed index for public health purposes. Am J orthod (1960);46:295-305.

Dugoni AA, Chambers DW, Roberts WE. The role of orthodontics in the predoctoral education of a dentist. Am J Orthod. 1981;79(5): 564-71

Evans R, Shaw WC. Preliminary evaluation of an illustrated scale for rating dental attractiveness. Eur J Orthod 1987;9(4):314-318.

Foster TD. The public health interest in asessment for orthodontic treatment. J Public Health Dentistry 1979:39(2);137-142.

Freidson E. Doctoring together. Chicago: University of Chicago Press, 1975.

Furino A, Douglass CW. Balancing dental service requirements and supplies: the economic evidence. J Am Dent Assoc 1990;121:685-691.

Ghafari J, Locke SA, Bentley JM. Longitudinal evaluation of the Treatment Priority Index (TPI). Am J Orthod Dentofac Orthop 1989;96:382-9.

Gottlieb EL. Preserving the referral-source: Practice of orthodontics. J Clin Orthod 1984;18:870-6.

Gottlieb EL, Nelson AH, Vogels DS III. 1997 JCO Orthodontic Practice Study Part 3 Practice Growth. J Clin Orthod 1997c;31(12):801 – 810.

Graber TM, Vanarsdall RL. Orthodontics current principles and techniques. St Louis: Mosby, 1994; 311 – 312.

Grainger, R.M. (1967): Orthodontic Treatment Priority Index, Public Health Sevice Publication No. 1000, Series 2, No. 25, Washington, D.C., 1967, U.S. Government Printing Office.

Graves RC, Stamm JW. Oral health status in the United States: Prevalence of dental caries. J Dent Educ 1985; 49(6): 341 –349.

Grembowski DE; Cook K; Patrick DL; Roussel AE. Managed care and physician referral. Med Care Res Rev. 1998; 55(1): 3-31.

Grewe JM; Hagan DV. Malocclusion indices: a comparative evaluation. Am J Orthod. 1972; 61(3): 286-94

Gronroos C, Masalin K. Motivating your patients: marketing dental services. Int Dent J 1990;40:18 – 23.

Hechter, F. Personal Communication 1999.

Helm S, Kreiborg S, Barlebo J, Caspersen I, Eriksen JH, Hansen W, Hanusardottir B, Munck C, Perregaard J, Prydso U, Reumert C, Spedtsberg H. Estimates of orthodontic treatment need in Danish schoolchildren. Community Dent Oral Epidemiol 1975:3;136-142.

Hill PA. The Prevalence and severity of malocclusion and the need for orthodontic treatment in 9-, 12-, and 15-year-old Glasgow Schoolchildren. Br J Orthod 1992;19(2):87-96.

Hughes D, Landay M, Straja S, Tuncay O. Application of a classical model of competitive business strategy to orthodontic practice. Am J Orthod Dentofacial Orthop 1996;110:405-9.

Hurley RF, Bannick RP. Utilization managers in medicare risk contract HMOs: from control to collaboration. QRB Qual Rev Bull 1993;19(4):131 – 7.

Ibikunle SA. The implications of changing patterns in oral health for the general practice of dentistry. Int Dent J 1985; 35:73 – 77.

Iglehart JK. The American health care system. Managed care [see comments]. N Engl J Med. 1992;327(10): 742-7

Jacobs RM, Bishara SE, Jakobsen JR. Profiling providers of orthodontic services in general dental practice. Am J Orthod Dentofacial Orthop 1991;99:269-75.

Jenny J, Cons NC. Guidelines for using the DAI-A supplement to DAI: The Dental Aesthetic Index. Iowa, Iowa City: College of Dentistry, University of Iowa 1988.

Jenny J, Cons NC. Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale. Aust Dent J 1996;41(1):43-6.

Jenny J, Cons NC. Comparing and contrasting two orthodontic indices, the Index of Orthodontic Treatment Need and the Dental Aesthetic Index. Am J Orthod Dentofac Orthop 1996;110:410-6.

Jenny J; Cons NC. Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale. Aust Dent J. 1996; 41(1): 43-6.

Joondeph DR. Early orthodontic treatment. Am J Orthodont Dentofacial Orthopedics 1993;104:199 – 200.

Kassirer JP. Access to specialty care [editorial; comment] [see comments] [published erratum appears in N Engl J Med 1994 Dec 1;331(22):1535] N Engl J Med. 1994; 331(17): 1151-3.

Koroluk LD, Jones JE, Avery DR. Analysis of orthodontic treatment by pediatric dentists and general practitioners in Indiana. J Dent Child 1988;55:97–101.

Kunzel W. the impact of changing patterns in dental diseases on the practice of orthodontics. Int Dent J 1987; 37: 77 – 85.

Leake JL. Expenditures on dental services in Canada, canadian provinces and territories 1960 – 1980. J Can Dent Assoc 1984;50(5):362-368.

Leake JL, Porter J, Lewis DW. A macroeconomic review of dentistry in the 1980s. J Can Dent Assoc 1993;59(3)281-287.

Lewis EA, Albino JE, Cunat JJ, Tedesco LA. Reliability and validity of clinical assessments of malocclusion. Am J Orthod Dentofacial Orthop 1982;81(6):473-7.

Little RM, Wallen T, Riedel R. Stability and relapse of mandibular anterior alignment: first premolar extraction cases treated by traditional edgewise orthodontics. Am J Orthod 1981;80:349 – 65.

Little RM, Riedel RA, Artun J. An evaluation of changes in mandibular anterior alignment from 10 – 29 years post-retention. Am J Orthod 1988;93:423 – 8.

Little RM. Stability and relapse of dental arch alignment: review article. Br J Orthod 1990;17(3);235 – 241.

Lupi JE, Handelaman CS, Sadowsky C. Prevalence and severity of apical root resorption and alveolar bone loss in orthodontically treated adults. Am J Orthod Dentofacial Orthop 1996;109;28 – 37.

McGuinness NJ, Stephens CD. An introduction to indices of malocclusion. Dent Update 1994:May;140 –144.

McNamara JA Jr. Components of class II malocclusion in children 8-10 years of age. Angle Orthod. 1981; 51(3): 177-202.

Miller RH. Healthcare organizational change: implications for access to care and its measurement. Health Serv Res 1998;33:653 – 84.

Miller RH; Luft HS. Estimating health expenditure growth under managed competition. Science, simulations, and scenarios. JAMA. 1995 Feb 22; 273(8): 656-62

Moorrees CF. Orthodontic specialty education [editorial] Am J Orthod. 1984; 86(5): 435-6

Nattrass C, Sandy JR. Adult orthodontics—a review. Br J Orthod. 1995; 22(4): 331 – 7.

Ong MA, Wang HL, Smith FN. Interrelationship between periodontics and adult orthodontics. J Clin Periodontol 1998; 25(4): 271 – 7.

Oppenhuizen G. Management service organizations in orthodontics: A paradigm shift? Am J Orthod Dentofacial Orthop 1997;112:345-349.

Otuyemi OD, Noar JH: Variability in recording and grading the need for orthodontic treatment using the handicapping malocclusion assessment record, occlusal index and dental aesthetic index. Community Dent Oral Epidemiol 1996;24:222-224.

Petersson HG, Bratthall D: The caries decline: a review of reviews. Eur J Oral Sci 1996; 104: 436 – 443.

Plunkett DJ. The provision of orthodontic treatment: some ethical considerations. N Zeal Dent J 1997;93:17-20.

Poulton DR, Aaronson SA. Relationship between occlusion and periodontal status. Am J Orthod 1961;47:690 – 699.

Proffit WR, Fields HW, Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: Estimates from the NHANES III survey. Int J Adult Orthod Orthognath Surg 1998; 13: 97 – 106.

Richmond S, Shaw WC, Roberts CT, Andrews M. The development of the PAR Index (Peer Assessment Rating): Reliability and validity. Eur J Orthod 1992a; 14: 125 – 139.

Richmond S, Shaw WC, Roberts CT, Andrews M. The PAR Index (Peer Assessment Rating): methods to determine outcome of orthodontic treatment in terms of improvement and standards. Eur J Orthod 1992b;14:180-187.

Rudolph DJ, Sinclair PM. Orthodontic graduate education survey 1983-1994. Am J Orthod Dentofacial Orthop 1997;112(4)418-424.

Salama M, Sarne O. Esthetic considerations in adult orthodontic treatment. Curr Opin Cosmet Dent 1993; 67 – 74.

Salzmann JA. Handicapping malocclusion assessment to establish treatment priority. Am J Orthod. 1968; 54(10): 749-65

Scivier GA, Menezes DM, Parker CD. A pilot study to assess the validity of the Orthodontic Treatment Priority Index in English schoolchildren. Community Dent. Oral Epidemiol. 1974;2(5):246-252.

Shaw WC, Addy M, Ray C. Dental and social effects of malocclusion and effectiveness of orthodontic treatment: a review. Community Dent. Oral Epidemiol. 1980;8:36 – 45.

Shaw WC, Richmond S, O'Brien KD, Brook P. Quality control in orthodontics: Indices of treatment need and treatment standards. Br Dent J, 1991;170(3)107- 102.

Sinclair PM; Rudolph DJ. Orthodontic graduate education survey--1983 to 1989. Am J Orthod Dentofacial Orthop. 1991; 100(5): 465-71

Slakter MJ, Abino JE, Green LJ, Lewis EA. Validity of an orthodontic treatment priority index to measure need for treatment. Am J Orthod 1980:78(4);421-425.

Spencer AJ; Allister JH; Brennan DS. Predictors of fixed orthodontic treatment in 15-year-old adolescents in South Australia. Community Dent Oral Epidemiol. 1995; 23(6): 350-5.

Statistics Canada. Canadian Economic Observer. Ottawa: Statistics Canada (1997).

Summers CJ. The occlusal index: A system for identifying and scoring occlusal disorders. Am J Orthod 1971;59(6):552-567.

Tang EL; So LL. Correlation of orthodontic treatment demand with treatment need assessed using two indices. Angle Orthod. 1995; 65(6): 443-50

Turner SAM. Occlusal indices revisited. Brit J Orthod 1990;17:197-203.

Van Kirk LK and Pennell EH. Assessment of malocclusion in population groups, Am J Orthod (1959); 45: 752 – 758.

Wheeler TT, McGorray SP, Yurkiewicz L, Keeling SD, King GJ. Orthodontic treatment demand and need in third and fourth grade school children. Am J Orthod Dentofac Orthop 1994;106:22-33.

Wahner Roedler DL; Knuth P; Juchems RH. The German health-care system. Mayo Clin Proc. 1997;72(11): 1061-8

Wennberg JE; Barry MJ; Fowler FJ; Mulley A. Outcomes research, PORTs, and health care reform. Ann N Y Acad Sci. 1993;703: 52-62

Wolsky SL, McNamara JA Jr. Orthodontic services provided by general dentists. Am J Orthod Dentofacial Orthop 1996;110:211-7.

Woodside DG. Do functional appliances have an orthopedic effect? Am J Orthod Dentofacial Orthop 1998;113:11-14.

Younis JW, Vig KWL, Rinchuse DJ, Weyant RJ. A validation study of three indexes of orthodontic treatment need in the United States. Community Dent Oral Epidemiol 1997; 25: 358 – 62.

Sergl HG; Zentner A. Study of psychosocial aspects of adult orthodontic treatment. Int J Adult Orthodon Orthognath Surg. 1997; 12(1): 17-22

Helm S; Kreiborg S; Solow B. Psychosocial implications of malocclusion: a 15 year follow up study in 30 year old Danes. Am J Orthod. 1985; 87(2): 110-8

Vlaskalic V; Boyd RL; Baumrind S. Etiology and sequelae of root resorption. Semin Orthod. 1998; 4(2): 124-31.

White L Early orthodontic intervention. Am J Orthod Dentofacial Orthop. 1998; 113(1): 24-8

Zammit MP; Hans MG; Broadbent BH; Johnsen DC; Latimer BM; Nelson S Malocclusion in Labrador Inuit youth: a psychosocial, dental and cephalometric evaluation. Arctic Med Res. 1995; 54(1): 32-44