The Delivery of Orthodontic Care in New Zealand: The use of Spatial Information Systems in a National Study

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ABSTRACT

A two part study was undertaken to determine the supply of orthodontic services in New Zealand by orthodontists and dentists. Spatial information systems (SIS) were used in evaluating spatial aspects of the study. Buffer zones were established around every orthodontic practice in New Zealand and the accessibility of 10-14-year-olds was measured. Over half were within 5 kilometres of an orthodontist, and nearly three-quarters were within 10 kilometres. The supply of specialist services was measured via the effective orthodontist to 12-year-old ratio at national and regional council level, and via proximal polygons of those urban areas with an orthodontist. There were wide disparities in the supply of specialist orthodontist services in New Zealand at a regional level. Also, the polygons of major urban areas (population >29,999) had more than three times the supply of services compared with those of secondary and minor urban areas. It was surmised that patients in areas of low specialist services, or where there was an absence of an orthodontist, either (i) missed out or did not wish to have treatment, (ii) travelled to major urban areas for treatment, or (iii) were treated by dentists. The study of dentists confirmed that a low supply of specialist services at a regional level, distance to the nearest orthodontist, and, to a limited extent being based in a secondary or minor urban area were factors in determining dentists who carried out more complex and/or had a higher orthodontic patient load. The presence or absence of an orthodontist in an urban area had little or no effect.

Keywords and phrases: *orthodontics, supply, services, spatial, SIS, orthodontists, dentists*

1.0 INTRODUCTION

This study arose from the lack of information on the supply of orthodontic services in New Zealand. Previously, there was little information on the amount, variety or location of services, or the supply of care with regard to those who may require treatment. This information is of importance in identifying areas or

groups in New Zealand which may be under-provided with orthodontic services and could be targeted for improvement, and it may help in identifying workforce and training issues in orthodontics. It is also intended to provide a baseline for future research.

1.1 Orthodontics in New Zealand

Orthodontic care in the New Zealand environment is almost unique in the developed world in that there is invariably no third party (defined as a formal paying organisation other than the family (Gift, 1997)) involved in the choices made for treatment or payment. Government assistance for children has never extended past basic dental health into orthodontic care. State involvement in funding orthodontic treatment is limited to individuals with birth deformities, such as cleft lip and palate. Orthodontic care is not restricted to orthodontists (who are dentists that have carried out specialist training normally consisting of a full-time postgraduate course of three years duration). Any dentist may carry out orthodontic treatment, but they are not permitted to identify themselves as orthodontists. The delivery of orthodontic treatment by a dentist may be influenced by the availability of an orthodontist, and conversely, the lack of a specialist may occur because a dentist is carrying out orthodontic treatment. The only requirements are registration as a dentist, investment in facilities and, arguably, education.

This free market approach to orthodontic treatment means there are no controls on the supply, fees charged or the severity of malocclusion treated by dentists or orthodontists. It also means that the volume of services is not controlled by any third party. With this approach New Zealand lies mid table in the international orthodontic "league tables" (Table 1). Presumably the supply of orthodontic services will coincide with the demand for services. Because there is generally no financial assistance, those who cannot afford, or do not wish to receive treatment are likely to miss out or get limited treatment from a dentist, presumably at a lower cost to themselves. Other factors such as cultural, socioeconomic or gender variables may act as barriers to the utilisation of orthodontic care even if there is no monetary or spatial barriers to care (Joseph and Phillips, 1984).

Norway	1 : 325	Italy	1 : 787
USA	1 : 352	New Zealand	1 :838 (1996)
Denmark	1 : 383	Greece	1 : 870
Sweden	1 : 416	Hungary	1 : 1542
Germany	1 : 427	Spain	1 : 1798
Finland	1 : 550	UK	1 : 2389
Australia	1 : 614		

Table 1. Ratio of orthodontists to 12-year-olds: International comparisons. After Shaw (1997) with permission.

1.2 Study Aims

In order to explore some of these issues in the supply and demand for orthodontic care, a census of orthodontists and dentists was undertaken. The census aimed to establish the distribution of orthodontists and their spatial relationship to those of treatment age. It also sought to evaluate the practising characteristics of orthodontists. This study was undertaken to find the amount and variety of treatment performed by orthodontists and dentists, and to investigate a number of related hypotheses concerning the relationship between the availability of specialist orthodontics and the supply of orthodontic services by dentists. Studies in the United States have failed to show an association between the decision, by dentists, to provide orthodontic treatment and the distance to the closest orthodontic surgery, or to the number of orthodontists within a 10-mile radius (Wolsky and McNamara, 1996). However, Lawrence *et al* (1995) reported that dentists who worked in central Melbourne performed less orthodontic procedures than those dentists in the suburbs, and country areas.

2.0 MATERIALS AND METHODS

A self-completion questionnaire was distributed to all orthodontists asking for information on the location and days worked per month for the calendar year of 1996, and orthodontic services provided in the year July 1, 1998 to June 30, 1999. The questionnaire sought information on the average number of half days per 28 days of direct patient care that an orthodontist performed at a named main practice and the average number of half days per month that were performed at named branch practices. Information was also sought for the amount and type of orthodontic treatment carried out by individual orthodontists, irrespective of where the orthodontist practiced. For geographic analysis, non responders main practice addresses were assumed to be those registered on the New Zealand Dental Council register for 1999 and branch practices, if any, were assumed to be those listed in the membership list of the New Zealand Association of Orthodontists (NZAO). For non-responders who were not a member of the NZAO, the practice address was assumed to be that in the Dental Council Register. The number of half days at each branch practice for non-responders was set arbitrarily at five per 28 days. The number of half days at the main practice being the remainder, after branch practices, of 38 half days per 28 days, this being the equivalent to the mean number of hours per week worked as reported by the Education and Research Development Group (ERDG) of the NZAO in 1997 (Dallimore *et al.* 1997).

Dentist information was collected by questionnaire, an information sheet and informed consent form. This study involved all those registered as dentists at November 29, 1999. Information on practice address, age, sex, and registration date was obtained from the Dental Council of New Zealand. Data was evaluated to determine (i) the amount and variety of orthodontic services provided by dentists and (ii) Dentists' attitudes and characteristics with respect to orthodontics. Differences between differing practitioner characteristics, procedures carried out, appliance use and active orthodontic patient load were compared using univariate, bivariate and multivariate analysis using Statistical Programme for Social Sciences (SPSS), Version 10.0 (*SPSS Inc., USA*).

All demographic data was obtained directly from Statistics New Zealand and the 1996 census data. All population information was based on the *de facto* "population present" at the place of enumeration on census night (midnight of March 5, 1996). Demographic information for the 10-14 year-old population was attached to individual area units in ArcView GIS software. Each area is a single geographic entity with a maximum total population of 5,000. Where only a portion of an area unit is included in analysis, the population is assumed to be spread evenly over the unit, the population being proportionate to the area included in the unit. The number of 12 year-olds in each area unit was assumed to be 19.9% of the 10-14 year-olds, this being the national percentage. This was considered to be a more accurate measure than that from census data as figures for those area units with low numbers of 12 year-olds are perturbated by Statistics New Zealand for the purposes of confidentiality. The ratio of orthodontists to 12-year-old has a large number of international comparisons, and is appropriate as the age is a good approximation of when children are liable to have lost their deciduous teeth and become eligible for comprehensive treatment via "full fixed braces". The age range of 10-14 years was selected for accessibility to orthodontists as this

encompasses the age range where a child is most likely to need an orthodontic consultation and/or interceptive orthodontics. A small number of children may have completed definitive orthodontic treatment

Practice locations were geocoded and mapped with the half days per month associated with each practice entered. Buffer zones were created at 5 kilometres, 10 kilometres, 15 kilometres, 25 kilometres and 50 kilometres from each orthodontic practice location and used to determine the number of patients (10-14 year-olds) within each zone for each practice. Proximal (Thiessan) polygons were created around each practice and the polygons for each practice within an urban area were joined to form a single polygon for every urban area containing at least one orthodontist (Figure 1). This formed catchments for all urban areas containing orthodontists. Any 12-year-old is closest to the nearest orthodontist in the catchment. The ratio of orthodontist to 12 year-olds was then determined within each catchment and compared between major urban areas (population >29,999) and secondary and minor urban areas combined. The spatial patterns associated with the type and amount of treatment carried out by dentists in the year July 1, 1998 to June 30, 1999 was also examined using univariate, bivariate and multivariate analysis to establish differences in type and amount of services supplied by practitioners.

3.0 RESULTS

3.1 Orthodontists

Overall, 56 of 71 (78.9%) questionnaires were returned.

3.1.1 Practising characteristics. The average number of half days of direct patient care per 28 days was 32.1. Nearly two thirds (62.5%) of respondents worked at a practice other than their main practice in 1996. The mean number of half days spent at each branch practice, for those who had branch practices was 4.19 (sd 3.92). The number of half days spent at each branch practice varied between one and sixteen. There were no significant differences ($p<0.05$) between the mean half days worked by those who worked at branch practices (34.8) and those who did not (28.8).

3.1.2 Spatial relationship to treatment groups. Over half of 10-14 year olds live within a 5 kilometre radius of an orthodontic practice. Nearly three-quarters live within a 10 kilometre radius (Table 2).

Distance to orthodontist	10 to 14-year-olds	Percentage
5km	146,630	55.5
10km	192,755	73.0
15km	207,529	78.6
25km	228,566	86.5
50km	253,071	95.8
Total	264,138	100

Table 2. Proximity of 10–14–year-olds to the nearest orthodontic practice: 1996.

There were marked differences in the regional distribution of orthodontists to 12 year olds (Table 3) assuming that one orthodontist worked to the national average of 32.1 half days of direct patient care per 28 day period.

Northland	1:2884	Wellington	1:875
Auckland	1:935	Tasman*	0
Waikato	1:1113	Nelson*	1:295
Bay of Plenty	1:743	Marlborough	1:2268
Gisborne	1:950	West Coast	1:2124
Hawkes Bay	1:964	Canterbury	1:659
Taranaki	1:1680	Otago	1:539
Manawatu – Wanganui	1: 764	Southland	1:743

Table 3. Ratio of orthodontists to 12-year-olds by Regional Council areas: 1996.
**If Nelson and Tasman are combined, this gives a ratio of 1:597.*

The ratio of orthodontists to 12 year olds for New Zealand 1:838 in 1996. The South Island had a higher equivalent orthodontist to 12-year-old ratio of 1:661 compared to the North Island with 1:855. There were wide variations in the effective orthodontist to 12 year-old ratio for polygons around urban areas (Figure 1). The average orthodontist to 12 year-old ratio was 1:682 for polygons surrounding major urban areas, and 1:2101 for polygons surrounding minor and secondary urban areas.

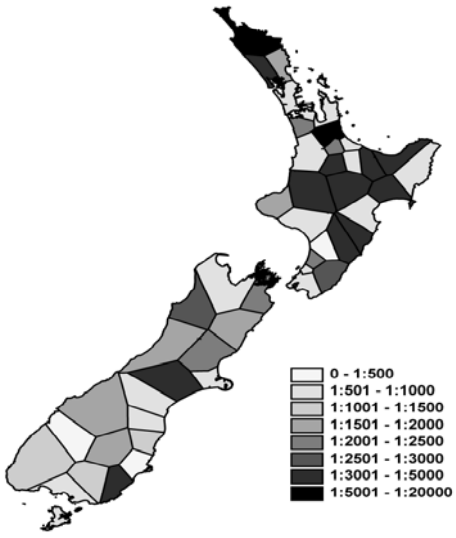

Figure 1. Orthodontist to 12-year-old ratio of proximal polygons for urban areas with an orthodontist present: 1996.

3.1.3 Urban areas. New Zealand is a highly urbanized country with 85% of the population living in areas defined as urban (greater than 1,000 population) at the 1996 Census. Of the total population 69% live in the "major urban areas" (greater than 30,000 population); (New Zealand yearbook, 1998). In 1996, all sixteen major urban areas, thirteen of the fifteen secondary urban areas (10,000-29,999 population) and twenty of the ninety-eight minor urban areas (1,000-9,999) had practising orthodontists.

3.2 Dentists

Overall, 1,015 of 1,254 (80.9%) questionnaires were returned.

3.2.1 Spatial relationship to orthodontists. Nearly three quarters (73.7%) of dentists practised within 5km of an orthodontist, 84.9% within 10 km, 88% within 15 km and 90.3% within 20 km.

3.2.1 Procedures. There was wide variation in the types of orthodontic procedures carried out by dentists. On the whole there was a higher incidence of differing orthodontic procedures carried out by (i) those in minor and secondary urban areas, (ii) those who were in regions with a low supply of specialist orthodontic services, (iii) those who were more than 5 kilometres from an orthodontist.
Complex procedures. 28.1% of dentists carried out one or more procedures viewed as complex (including placing fixed braces). Males had more than 2 times the odds of carrying out complex procedures. Dentists in secondary and minor urban areas had 1.7 times the odds of carrying out complex procedures.
All procedures. 73.1% of dentists carried out at least one orthodontic procedure. Those from a secondary or minor urban area had 2.5 times the odds of carrying out at least one type of procedure.

3.2.2 Appliances. Appliances denote the method of orthodontic "hardware" used to move teeth into the desired position whether it be a plate, nightbrace or full fixed braces. Over half of dentists used removable appliances (simple plates that move teeth, usually via springs). There was a higher incidence of the use of most appliances by those in secondary and minor urban areas, those in areas with a low supply of specialist orthodontist services and those more than 5km from an orthodontist.
38.2% of dentists used no appliances. There was a higher incidence of those using no appliances by (i) those in major urban areas, (ii) those in urban areas where an orthodontist was present.

3.2.2 Active orthodontic patient load. The average active orthodontic patient load of dentists ranged from 0 to 700 with 12.5% of dentists having 10 or more orthodontic patients at any one time and 3.1% 50 or more. The wide difference between the mean active load (7.0) and median active load (1.0) is an indication that a few dentists have a significant number of patients under treatment at any one time.
There were higher ratios of mean active patient loads by dentists in regions which had a low supply of specialist orthodontic services and those greater than 5 kilometres from an orthodontic practice.

3.3 Total treatment.
If the mean active patient loads of orthodontists and dentists respectively are multiplied by the number in each group, 35,132 (26,339- 43,925 95% CI) patients are receiving orthodontic care in New Zealand at any one time with 8,790 (6,174- 11,405 95% CI), or 25% (22.2%- 27.8% 95% CI), of these patients being seen by dentists. This is significantly lower than the United Kingdom and the United States where over half of all malocclusions, irrespective of complexity, are treated by dentists (Moyers, 1990; Richmond *et al*, 1992). Of the 11,398 (8,647-14,149 95%CI) full braces placed, dentists placed 18.9% (16.5%-21.2% 95%CI).

4.0 DISCUSSION

This study faced several problems in dealing with spatial issues relating to the delivery of orthodontic care in New Zealand. When analysing the location and supply of specialist orthodontic services, the spatial relationship of orthodontists to the target population (10-14 year-olds) was important for reasons of accessibility, and quantifying supply.

The use of SIS allowed us to analyse large amounts of census information, and to gain valuable baseline information regarding the assessment of orthodontic care. The establishment of buffer zones around the orthodontic practices helped to quantify the number of 10-14-year-olds within a certain distance of an orthodontist. The main limitation of the mapping system, as used in this study, is that it tabulates distances to practices "as the crow flies", taking no account of geographic barriers to accessibility, the most efficient transport routes, or the availability of public transport. Despite this, "aerial distance remains a crude, but objective measure of accessibility to health care facilities" (Kohli *et al*, 1995); in this case, orthodontic care. Also, by using a small age range, it meant that it was difficult to use census units below area unit size because the information at meshblock level is perturbated for reasons of confidentiality.
Quantifying the supply of orthodontic services was also a theoretical and philosophical problem. By measuring the effective orthodontist to 12-year-old ratio at national, regional council level, and via proximal polygons, we were able to gain insights into the supply of specialist orthodontic services. The evaluation of proximal polygons assumes that a 12-year-old will attend the nearest specialist orthodontic service in the nearest urban area. This may not be true, especially where polygons are closer together, although a study on the West Coast, a region with no major urban areas, found that 82.1% of respondents visited the closest dentist (Dixon *et al*, 1999). Also, there remains no other effective way to quantify the catchment of orthodontic practices below a regional analysis.

This study found that there were wide disparities in the supply of specialist orthodontist services in New Zealand (measured as the effective orthodontist to 12-year-old ratio) at a regional level. Also, the catchment areas of major urban areas (urban area population >29,999) had an average orthodontist to 12-year-old ratio of 1:682 while the catchment areas of secondary and minor urban areas had a ratio of 1:2,101. Because there are no regulatory barriers to dentists performing orthodontic treatment, it was surmised that patients in areas of low specialist services, or where there was an absence of an orthodontist, either (i) missed out or did not wish to have treatment, (ii) travelled to major urban areas for treatment, or (iii) were treated by dentists. The dentist may be performing minor and comprehensive treatment, or limited treatment, irrespective of the severity of the malocclusion.

By "tagging" dentists by what urban area they were from, it was possible to test the theory that dentists were carrying out complex or more treatment where orthodontists were not present or not in adequate supply. This was measured by the presence or absence of an orthodontist in the dentist's urban area, by the distance a dentist practised from an orthodontic clinic, and by the size of the urban area in which the dentist was based in.

Dentists orthodontic characteristics were evaluated using three main measures; the use of various orthodontic procedures, the use of orthodontic appliances and the average active orthodontic patient load. The results of the dentist's study seem to indicate a pattern that may seem surprising.
The absence of an orthodontist in an urban area seems to have little effect on those dentists carrying out complex procedures, nor did dentists have a higher mean active orthodontic patient load; yet supply of specialist orthodontic services, distance to the nearest orthodontist, and, to a limited extent, being based in a secondary or minor urban area did have an effect. This may indicate that in secondary or minor urban areas, less people get their malocclusions treated by an orthodontist or dentist, they get limited treatment for both major and minor malocclusions with procedures that do not involve comprehensive fixed appliances, or they travel to major urban areas for comprehensive treatment.

In this national study SIS were used as a tool to complement other methods of analysis. One of the aims of this study was to provide a baseline for future research. We now know that there are inequalities in the supply of specialist orthodontic services at a regional level, and between major urban area catchments and minor and secondary urban area catchments combined. We also know that dentists are partially "filling the gap" (to use a pun). With this knowledge, future research can be undertaken to identify groups or areas that could be targeted for improvements in orthodontic services, whether by dentists or orthodontists.

While this study was based on the supply of orthodontic services it raised some interesting spatial questions from a demand perspective that could be investigated in the future: Will those with more severe malocclusions be prepared to travel further for treatment than those with minor malocclusions? Are there

areas in major cities where children are disadvantaged because accessibility to orthodontists is difficult? Is time off school a limiting factor for those who have to travel to a distant location for treatment? If a person or family attends one centre for a service, do they receive orthodontic care when visiting, even if they have access to a branch practice that is closer to their residence?

5.0 CONCLUSIONS

1) Branch practices are an important component in the supply of specialist orthodontic services. Nearly three quarters of orthodontists who replied to the survey worked at a practice other than their main practice.

2) Over half of all 10-14 year-olds were within a 5 kilometre radius of an orthodontist. Nearly three-quarters are within 10 kilometres.

3) There are disparities in the supply of specialist orthodontic services in New Zealand. The catchment area of secondary and minor urban areas (population less than 30,000) have an orthodontist to 12-year-old ratio of 1:2101 compared with 1:682 for major urban areas. Dentists in secondary and minor urban areas did not have a higher orthodontic patient load but did carry out more complex procedures. This could be because patients in secondary and minor areas travel to major urban areas for treatment, miss out altogether, or get limited treatment from their dentist.

4) Dentists in regions with a low supply of orthodontic services had a higher mean active orthodontic patient load, and a higher incidence of using full fixed braces. This may indicate that the dentists are carrying out more complex treatment in the absence of an adequate supply of specialist orthodontic services and a greater amount of treatment, or conversely, orthodontists are not supplying services because of competition from dentists.

5) Overall, dentists treat a quarter of New Zealand's active orthodontic patient load. However, the question remains as to whether dentists are effectively fulfilling the unmet needs and demands of patients in areas of low specialist supply or where distance to an orthodontist is a factor. Further research on patient behaviour may resolve some of these issues.

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