High acuity GIS comparison of dentist and doctor surgery locations in Auckland, New Zealand

E. Kruger[1], R. Whyman[2] and M.Tennant[1]

[1]*The Centre for Rural and Remote Oral Health, University of Western Australia, Nedlands, Australia;* [2]*Dental Service, Hutt Valley District Health Board, Lower Hutt, New Zealand*

Objectives: New Zealanders are one of the healthiest populations in the world, but significant inequalities in health and oral health remain. New Zealand suffers a possible shortage of medical and dental practitioners and an agreed mal-distribution of both. This study examines the distribution of dental and medical practices in New Zealand's largest city Auckland, using modern Geographic Information System tools. The aim of the study is to determine if medical and dental practices are similarly distributed across the city. ***Design and methods***: The address for each dental and medical practice in Auckland was obtained and mapped over the census population data. A total of 442 medical and 256 dental practices were geo-coded in the study area. These practices overlaid the Auckland region, with a total population of 0.8 million, and an adult population (>9 years old) of 0.69 million. Auckland city was deemed, for this study, to be a region included in a 15km radius circle from a central reference point that was the General Post Office (GPO). ***Results***: The medical practice to total population ratio ranged from 1:1,500 for people 12½-15km from the GPO, to 1:1,200 for those within 2½km. Dental practice to population ratio ranged from 1:2,700 for people living 12½-15km from the GPO to 1:1,300 for those within 2½km. Medical practices were relatively evenly distributed, regardless of distance from the GPO, but the fairly dense distribution of dental practices in the city's inner 2½km circle rapidly decreased in density as distance from the GPO increased. ***Conclusion***: These results refute the hypothesis of this study in that there is a similar distribution of primary health practices (medical and dental) across the Auckland region.

Key words: *GIS, health services, city planning, population density mapping, distribution*

Introduction

New Zealand (NZ) is a country of relatively small population (4 million people) distributed unevenly over a relatively high land area (268,000 km squared). As a community with close links to its local Pacific Island neighbours and historical links to England and Europe, it has a mixture of societal and ethnic groups. Maori people (the indigenous Polynesian population of NZ), make up approximately 15% of the population (Statistics New Zealand, 2001). New Zealanders are one of the healthiest populations in the world, but significant inequalities in health and oral health still exist (Jamieson and Thomson, 2006; Ministry of Health, 2008; 2010; Thomson *et al.*, 2002; 2004). Access to primary health services is a key issue for NZ and successive governments have focussed on improved access to primary health care services (Ministry of Health, 2001; 2009). New Zealand, like many countries, suffers a possible shortage of medical and dental practitioners and an agreed mal-distribution of both (Broadbent, 2008; Ministry of Health, 2006; New Zealand Dental Association 2006). Dental services for preschool and primary school children are provided through a government-funded and -operated community oral health programme with clinical facilities primarily located in schools. In contrast, dental services for adults are almost exclusively provided through user pays (fee-for-service) private practices, while dental services for

adolescents are primarily government-funded but provided through private dental practices. Access levels to child dental health services are high. The 2009 New Zealand Oral Health Survey reported that over 80% of children aged 2-17 years had visited a dental professional in the previous 12 months. In contrast, only 47% of people aged 18 years and over had visited a dental professional in the previous 12 months (Ministry of Health, 2010). Previous research using Geographic Information System (GIS) mapping has shown that there is an uneven distribution of dental practices and concentration of dental practices in areas of least social deprivation in NZ (Kruger *et al.*, 2012).

In contrast, primary medical practices are operated through primary health organisations to which the population are enrolled. Primary medical practices provide services for children, adolescents and adults. Primary health organisations are capitation funded by government, through district health boards, although copayment charges also apply to doctors visits by adults and for some visits by children (Ministry of Health, 2012). The 2006/07 New Zealand Health Survey reported that 79% of children and 81% of adults had seen a general practitioner in the previous 12 months (Ministry of Health, 2008).

Similar patterns of preventive and maintenance attendance were evident with doctors and dentists in the 2009 New Zealand Oral Health Survey and the 2006/07 New Zealand Health Survey. Of adults who had attended a dentist, 48% reported they had visited for

Correspondence to: Professor Estie Kruger, The Centre for Rural and Remote Oral Health, The University of Western Australia, 35 Stirling Highway, Crawley, 6009, Australia. Email: estie.kruger@uwa.edu.au

a check up, while of adults who had attended a doctor 27% of respondents attended for a routine check up or advice, and a further 21% for management of a long term illness. However, substantial differences were reported in perceived unmet need with 55% of adults reporting they didn't see a dentist often enough while only 6% of adults reported an unmet need for seeing their doctor (Ministry of Health, 2008; 2010).

Although the macro-scale difference in practitioner distribution across NZ is known, very little detailed analysis of distribution has been undertaken. This study develops the work reported in Kruger *et al.*, (2012), which focussed only on dental practice distribution across all of NZ, by examining in detail the distribution of dental and medical practices, specifically in NZ's largest city Auckland, using GIS tools. The aim of the study is to test the hypothesis that medical and dental practices are similarly distributed across the city.

Materials and Methods

All data were collected from open access sources and as such no ethics approval were required. Auckland city was deemed, for this study, to be bounded by a 15km radius circle from a central reference point that was the General Post Office (GPO).

The address for each practice in Auckland, NZ, was obtained from the Yellow Pages (phone directory) as at January (Dentist) and July (Doctor) 2011. Duplicates were removed, all addresses were entered into a database and the longitude and latitude of each practice address obtained through a free access geo-coding website (Google Maps). A randomly selected sample of 5% of all geo-coded practices were tested against personal knowledge and other web-based information, to test the integrity of the data (the confirmatory sample was found to be concordant). It is estimated that the study frameset was a sample in excess of 95% of all practices in the wider Auckland region. The study is a geographic examination of practice location and did not examine work practices at individual practices, or the number of practitioners at each practice.

All population data were obtained from the most recently available New Zealand Census (2006). Population data was divided by area unit (AU) and the geographic boundaries of each AU were obtained from the Statistics New Zealand (2001) website. Additional geographic and population data (including boundary files) for district health boards were obtained from the NZ Ministry of Health website (Ministry of Health, 2012).

Population data were also adjusted to represent only people over the age of nine years. This adjustment was to account for the effect created by almost all child dental health services being provided through government health board facilities, which would distort the study results for dental practices. Throughout this manuscript, this adjusted population is referred to as the 'adult' population. All data were downloaded in January 2011.

The Index of Deprivation (NZDep2006) aggregated to AU level formed the basis of the measure of socio-economic disadvantage. The NZDep2006 is a composite measure derived from multiple weighted socio-economic variables collected in the 2006 NZ Census (Salmon and

Crampton, 2001) This index includes nine variables that either reflect or measure material and social disadvantage. NZDep2006 values were ranked into deciles ranging from one (highest deprivation) to ten (lowest deprivation).

Geographic boundary data for each AU, the population data and socio-economic data was geo-coded using ArcGIS (v9, ESRI, Redlands, CA, US). Analysis of geographic measures was completed using the ArcGIS software and minor results tallying was competed using Microsoft Excel.

Results

A total of 442 medical and 256 dental practices were geo-coded in the study area (Table 1). These practices overlaid the Auckland region with a total population of 0.8 million, and an adult population (age >9 years) of 0.69 million (Figure 1).

The medical practice to total population ratio ranged from 1:1,500 for people 12½-15km from the GPO, to 1:1,200 for those within 2½km. Dental practice to population ratio ranged from 1:2,700 for people living 12½-15km from the GPO, to 1:1300 for those within 2½km (Figure 2). Medical practices were very evenly distributed, regardless of distance from the GPO, but the fairly dense distribution of dental practices in the central city (inner 2½km circle) rapidly decreased in density as distance from the GPO increased.

Although children were statistically removed from the population data as NZ has a universal coverage (free) school dental service that would distort the distribution, analysis against full population data checked for any variation and no significant differences were evident.

Contour lines of iso-density to examine the difference in distribution of dental and medical practices, was applied (Figure 3). Results indicated little difference in the localisation of the highest density region between medical and dental practices. However the rapid change in density of dental practices moving away from the core was evident in the closeness of the iso-density lines for dental practices.

The proportion of the population in each socio-economic decile that were of Maori or Pacific Island ethnicity was higher between 5½ and 15km from the GPO, and this was most significant for the highest four

Table 1. The number (and proportion) of medical and dental practices for increasing 2½km zones out from the Auckland GPO of NZ and for the wealthiest and poorest 30% of population (collected by area units and 0-15km from the GPO)

	Medical		Dental	
0-2½ km	50	(11%)	46	(18%)
0-5 km	145	(33%)	87	(34%)
0-7½ km	242	(55%)	151	(59%)
0-10 km	321	(73%)	183	(71%)
0-12½ km	375	(85%)	216	(84%)
0-15 km	442	(100%)	256	(100%)
SoD 8,9,10 [a]	87	(20%)	70	(27%)
SoD 1,2,3 [a]	164	(37%)	93	(36%)

[a] Socioeconomic Deprivation decile for NZ: 8,9,10 are the most deprived 30%, while 1,2,3 are the least deprived 30%.
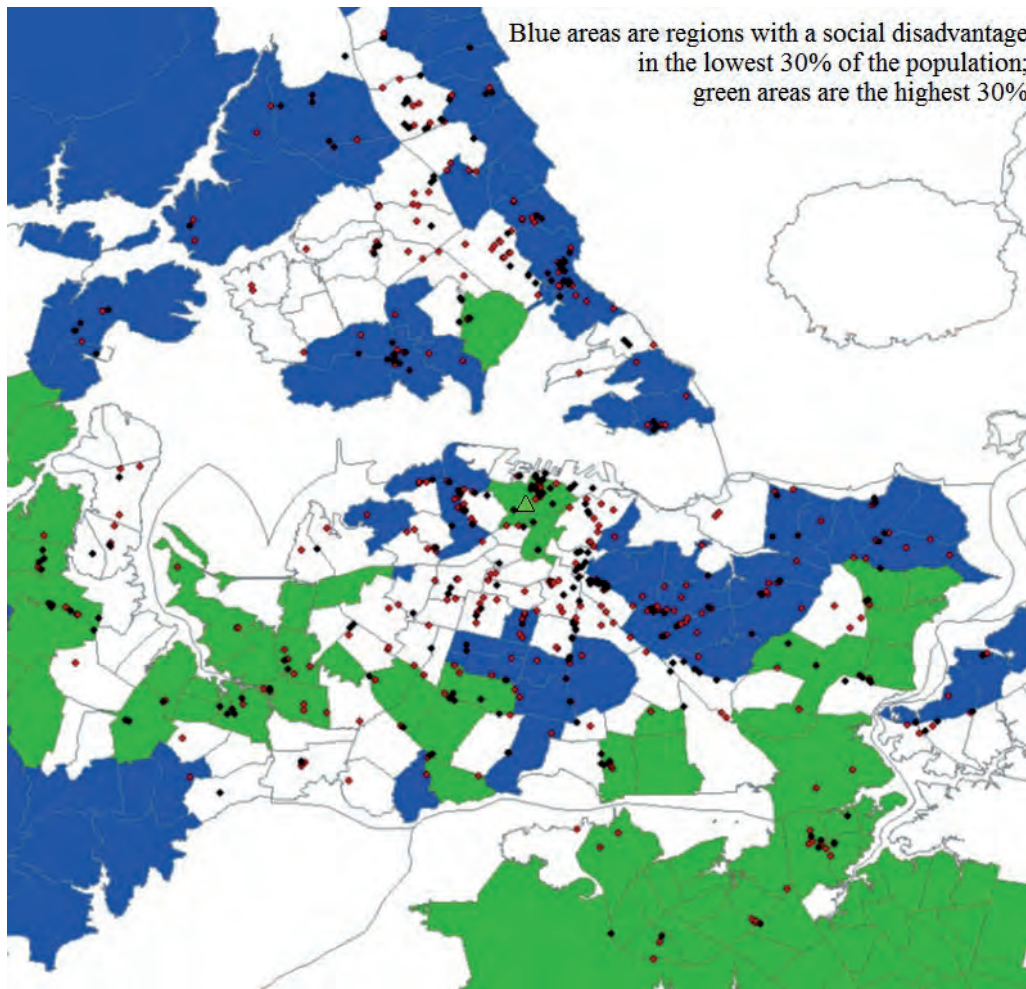
Note: *The image depicts the density of dentist and doctor practices across Auckland in relation to the differential socio-economic structure of the city. An increasing density of practices can be seen towards the centre of the city and and increased number of practices (of either type) can be seen overlaying blue (wealthy) areas but in particular dental practices (black dots).*

Figure 1. *The Auckland region of NZ with private dental practices (black dots) and medical practices (red) geocoded*
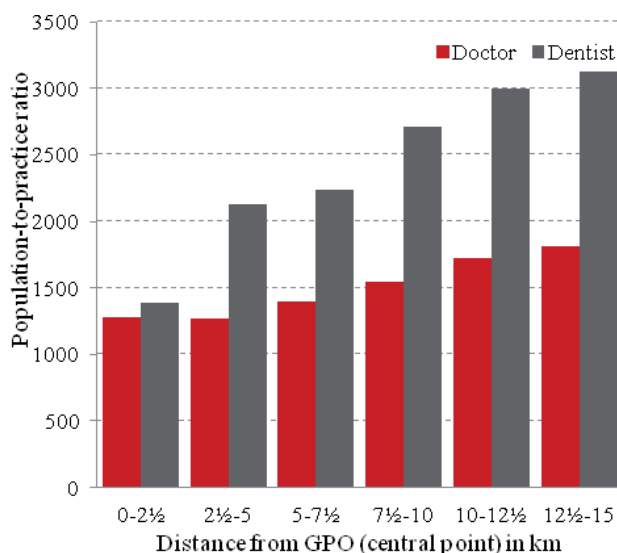

Figure 2. *The population-to-practice ratio for medical practices and dental practices at different distances out from the Auckland GPO for people aged over 9 years*

socio-economic deciles (Figure 4). These data need to be viewed in comparison to the diminishing density of dental practices moving further from the core of the city.

Discussion

These results refute the hypothesis of this study that there is a similar distribution of primary health practices (medical and dental) across the Auckland region. The greatest change in density is for dental practices that see the practice to population ratio shift from 1:2,700 down to 1:1,300 in the inner 2½km of the city. The dentist mal-distribution is consistent with previous findings (Ministry of Health, 2006; Broadbent, 2008; New Zealand Dental Association, 2006) and is not inconsistent with other developed countries (Widstrom and Eaton, 2004). The core mal-distribution across the city of Auckland is not inconsistent with international findings. The periphery of cities are often short of health services and often also have greater populations of lower socioeconomic deciles that suffer greater burdens of disease: another example of the inverse-care-law (Hart, 1971).
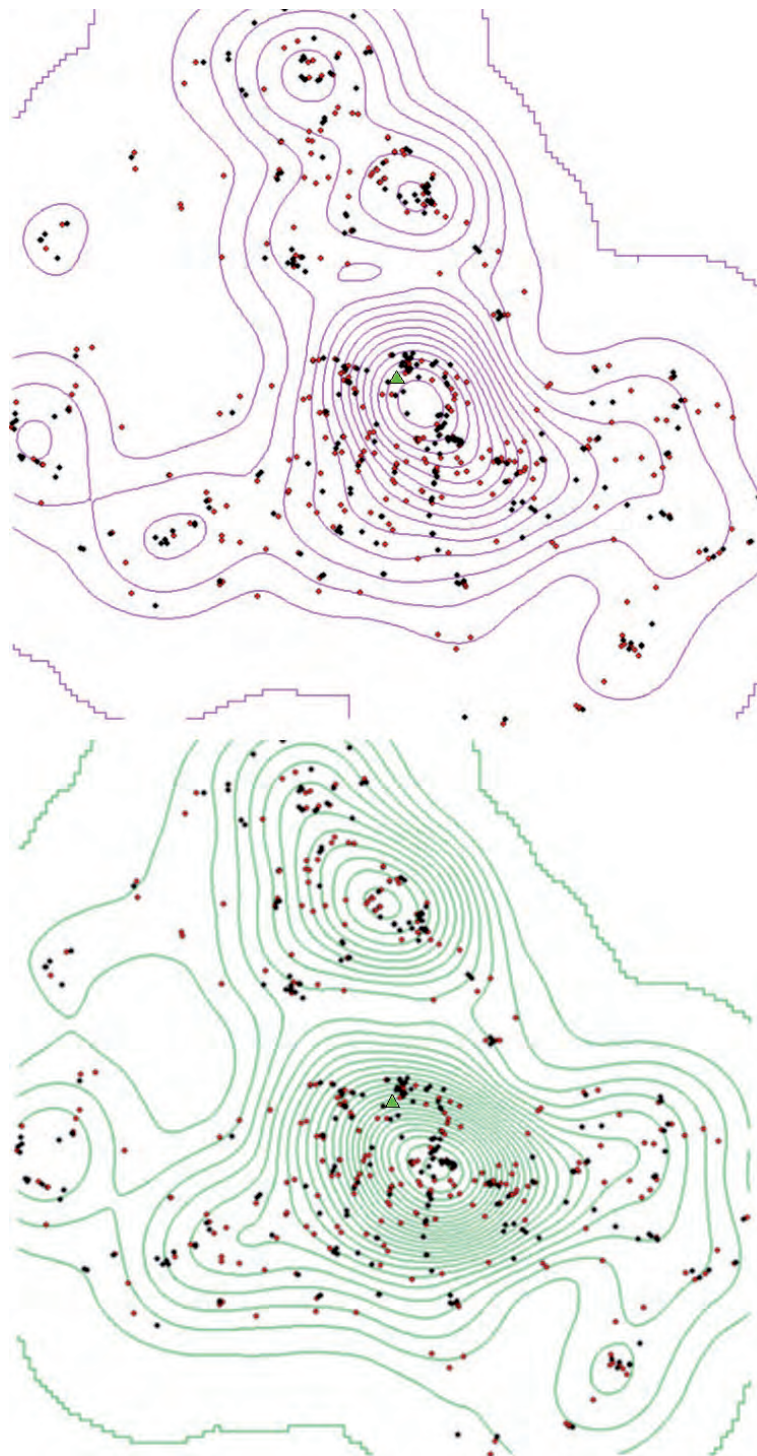
Density contours join points of equal density of practices. The closer together the contours, the greater the change in density.

Figure 3. *Density contours for Medical surgeries (top) and Dental surgeries (bottom) for the Auckland region of NZ*

It is also known that Maori and Pacific Islander people in NZ have poorer health than non-Maori and non-Pacific Islander people, across all ages and multiple health indicators (Jamieson and Thomson, 2006; Ministry of Health, 2008, 2010; Thomson *et al*., 2002, 2004). Health care delivery models driven by disease burden would focus care resources in areas of high need, that is, low socio-economic areas and in NZ, in areas with higher concentrations of Maori and Pacific Islander people. However, in NZ, previous research has shown that dental practice to adult population ratios are higher in regions

of high wealth (Kruger *et al.*, 2012). While child and adolescent dental health services are fully-funded, with no co-payments, dental services for adults are almost entirely user-pays. There is very limited safety net funding for people unable to afford private dental care, and little private health insurance coverage for dental care. Adults in receipt of government income support assistance may be able to access welfare payment support for relief of pain care, these services are delivered through private dental practices, and a small number of people access relief of pain care at public hospitals.
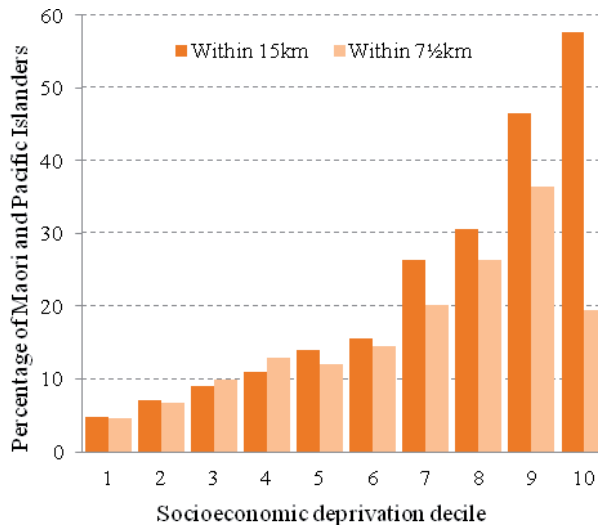
Figure 4. *The proportion of the Maori and Pacific Islander population in each socioeconomic decile within 15km of the GPO and within 7½km*

Results of this study indicate that social inequalities exist with respect to geographic access and availability of primary health medical and dental services when using area-based socio-economic measures. This inequality in availability/accessibility is far more evident for dental than for primary medical practice distribution. It is unlikely that the distribution of dental practices is explained by differences in practice size between central city and outer urban practices. The findings of this study support the findings of Broadbent (2008) who reported much higher population-to-dentist ratios in south and west than in central, east and north Auckland local authority or health board areas.

It is well known that dental care use is strongly conditioned by price and income (Grignon *et al.*, 2010; Leake and Birch, 2008). Studies across high-income countries consistently demonstrate an income gradient in dental service utilisation (Listl, 2011). Reliance on private financing clearly generates SES-related inequity in utilisation (as it is the market that drives dental practice locations). Previous studies also indicated that dental care utilisation is little affected by needs-adjustment: the rich (and insured) simply use more dental services, and oral health never plays a substantial role in the concentration of utilisation (Grignon *et al.*, 2010; Leake and Birch, 2008; Listl 2011). In contrast, primary medical services appear better distributed to the geographic distribution and socio-economic diversity of Auckland city and it is presumed that the significant influence of partial government funding of primary medical care services has resulted in a distribution of services better related to need.

Not withstanding this significant difference in the context of other world regions, the high level of vehicle ownership and access to a functional public transport network provides a buffer to the access issues in a city like Auckland.

Conclusion

Utilisation of primary health services (medical and dental), especially preventive services, can contribute to the improvement of health. As such, it is expected that access to care should be focused on those groups in the population at highest need. Efforts by successive governments in NZ have been focussed on improving access to primary medical care services and in the case of NZ's largest city, Auckland, there appears to be relatively even geographic access. In contrast, there appear to be significant differences in geographic access to primary dental care practices for the adult population and a greater concentration of services in the centre of the city.

References

Broadbent, J.M. (2008): *2008 Workforce Analysis*. Wellington: Dental Council of New Zealand.

Grignon, M., Hurley, J., Wang, L. and Allin, S. (2010): Inequity in a market-based health system: Evidence from Canada's dental sector. *Health Policy* **98**, 81-90.

Hart, J. (1971): The inverse care law. *Lancet* **7696**, 405-412.

Jamieson, L.M. and Thomson, W.M. (2006): Adult oral health inequalities described using area-based and household-based socioeconomic status measures. *Journal of Public Health Dentistry*; **66**, 104-109.

Kruger, E., Whyman, R. and Tennant, M. (2012): High acuity GIS mapping of private practice dental services in New Zealand: Does service match need? *International Dental Journal* **62**, 95-99.

Leake, J.L. and Birch, S. (2008): Public policy and the market for dental services. *Community Dentistry and Oral Epidemiology* **36**, 287-295.

Listl, S. (2011): Income related inequalities in dental service utilisation by Europeans aged 50+. *Journal of Dental Research* **90**, 717-723.

Ministry of Health (2001): *The Primary Health Care Strategy*. Wellington: Ministry of Health.

Ministry of Health (2006): *Good Oral Health for All, for Life*. Wellington: Ministry of Health.

Ministry of Health (2008): *A Portrait of Health: Key results of the 2006/07 New Zealand Health Survey*. Wellington: Ministry of Health.

Ministry of Health (2009): *Request for Expression of Interest (EOI) for the delivery of Better, Sooner, More Convenient Primary Health Care*. Wellington: Ministry of Health.

Ministry of Health (2010): *Our Oral Health: Key findings of the 2009 New Zealand Oral Health Survey*. Wellington: Ministry of Health.

Ministry of Health (2012): *About primary health organisations*. Wellington: Ministry of Health.

New Zealand Dental Association (2006): *NZDA Workforce Project. Final Report*. Auckland: NZDA.

Salmon, C. and Crampton, P. (2001): *The NZDeP2001 Index of Deprivation* Wellington: Department of Public Health, Wellington School of Medicine.

Statistics New Zealand (2001): *Census of Population and Dwellings*. Wellington: New Zealand Government.

Thomson, W.M., Poulton, R., Milne, B.J., Caspi, A., Broughton, J.R. and Ayers, K.M. (2004): Socioeconomic inequalities in oral health in childhood and adulthood in a birth cohort. *Community Dentistry and Oral Epidemiology* **32**, 345-353.

Thomson, W.M., Williams, S.M., Dennison, P.J. and Peacock, D.W. (2002): Were NZ's structural changes to the welfare state in the early 1990s associated with a measurable increase in oral health inequalities among children? *Australian New Zealand Journal of Public Health*; **26**, 525-530.

Widstrom, E. and Eaton, K.A. (2004): Oral healthcare systems in the extended European Union. *Oral Health Preventive Dentistry* **2**, 155-194.