

# **Geographic Description and Analysis of Factors Affecting the Demand for, and Supply of General Practice Services in New Zealand**

A thesis

submitted in fulfilment

of the requirements for the degree

of

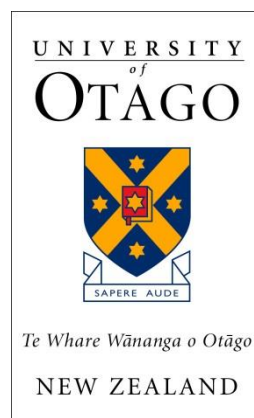
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by

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# Table of Contents

Table of Figures .....	vi
List of Tables .....	vii
Acknowledgements.....	viii
Abstract.....	ix
Abbreviations.....	x
Definition of Terms.....	xi
1 Introduction.....	1
1.1 Crisis in GP supply.....	1
1.2 International GP shortages .....	3
1.3 Definitions of Accessibility to Healthcare .....	4
1.3.1 Health Inequities Due to Poor Accessibility .....	6
1.4 Barriers to Accessibility .....	7
1.4.1 Functional Barriers.....	7
1.4.2 Financial Barriers.....	8
1.4.3 Cultural and Information Barriers.....	8
1.4.4 Geographical Barriers .....	9
1.5 GIS and Primary Care Research.....	9
1.6 Research Objectives .....	11
1.7 Thesis Structure.....	12
2 Primary Care: Definition, Challenges and Solutions.....	14
2.1 International Definitions of Primary Health Care.....	14
2.2 Primary Health Care in New Zealand .....	16
2.2.1 The Primary Health Care Strategy .....	16
2.2.2 Effects of the PHCS .....	19
2.2.3 Future Challenges for NZ Primary Health Care .....	19
2.3 Measurement of GP supply .....	20

2.4	Workforce issues affecting GP supply .....	21
2.4.1	Profession/Speciality Imbalances .....	21
2.4.2	Gender Imbalances and the Increasing Feminisation of the GP workforce.....	22
2.4.3	Geographic Imbalances and the Rural GP Workforce.....	23
2.4.4	Role of nurses in rural primary care practice.....	25
2.4.5	E-health technologies.....	25
2.4.6	International Medical Graduates.....	26
2.4.7	Māori and Pacific Health Workforce Development .....	27
2.5	Medical Education and Training Capacity of General Practices .....	29
2.5.1	Teaching Practices and Increased Student Numbers .....	29
2.5.2	Medical Student Perceptions of General Practice.....	31
2.5.3	Medical School Social Accountability.....	33
2.6	Definitions of Need for Health Care .....	34
3	GIS and Primary Care Research .....	38
3.1	Definition of GIS.....	38
3.2	GIS Uses in the Geography of Health.....	38
3.2.1	Examples of Web-Based GIS applications in Health .....	40
3.3	International GIS applications in Primary Care .....	41
3.3.1	International Examples of Mixed Methods in Primary Care Research Using GIS	
	42	
3.4	GIS Primary Health Applications in NZ.....	43
3.5	Barriers to Use of GIS in Health Settings .....	46
4	Methods.....	48
4.1	Mixed Methods Design .....	48
4.2	Ethical Considerations.....	49
4.3	Participants .....	50
4.4	Data collection.....	50

4.5	Geospatial analyses: Quantitative data.....	50
4.5.1	Geocoding.....	51
4.5.2	Census Meshblocks.....	51
4.5.3	General Practices .....	52
4.5.4	Teaching Practices .....	54
4.5.5	Medical Student Origin.....	54
4.6	Qualitative data .....	54
5	Results.....	55
5.1	Quantitative Geospatial results.....	55
5.1.1	General Practices .....	58
5.1.2	Teaching Practices .....	66
5.1.3	Medical Student Origin.....	71
5.2	Qualitative results.....	74
5.2.1	Difficulties with context, language and inputting data .....	74
5.2.2	Concerns over anonymity and information privacy in geotechnologies .....	76
6	Discussion.....	78
6.1	General Practices.....	78
6.1.1	Limitations .....	79
6.1.2	Research Implications.....	81
6.2	Teaching Practices.....	81
6.2.1	Limitations .....	82
6.2.2	Research Implications.....	82
6.3	Medical Student Origin .....	83
6.3.1	Ethnicity.....	83
6.3.2	NZDep Scores.....	83
6.3.3	Research Implications.....	84
6.3.4	Limitations .....	85

6.4 Feasibility of GIS in Primary Care Research .....	86
Bibliography .....	88
Appendix A.....	107
Appendix B .....	108

## Table of Figures

Figure 2.1: Structure of Primary Health Care in NZ .....	17
Figure 2.2: Deprivation Variables in the NZDep Score 2013 .....	36
Figure 4.1: Action Research Spiral .....	49
Figure 5.1: Population density of NZ: 2013 Census Data .....	56
Figure 5.2: NZDep Scores 2013 by meshblock .....	57
Figure 5.3: Thirty minute service areas around all NZ general practices .....	59
Figure 5.4: Average number of General Practices in the South Island per NZDep Score 2013 .....	60
Figure 5.5: Density of General Practices over NZ.....	62
Figure 5.6: Density of General Practices over the Greater Auckland Area.....	63
Figure 5.7: Location of General Practices in Counties Manukau DHB with the highest deprivation scores and population density as represented by meshblocks .....	65
Figure 5.8: University of Otago Teaching Practices with NZDep Score 2013 .....	66
Figure 5.9: Teaching Practice Locations for the University of Otago Schools of Medicine 2014 within each DHB.....	67
Figure 5.10: Teaching Practices in the Dunedin urban centre compared to high deprivation areas .....	69
Figure 5.11: Teaching Practices in the Porirua region compared to high deprivation areas ...	70
Figure 5.12: Percentage of 2nd year medical students from NZDep Scored areas compared to NZ 18-24 year olds .....	71
Figure 5.13: Ethnic Origin of 2nd Year Medical Students .....	72
Figure 5.14: Ratio of Medical Students Admitted compared to the 18-24 year old population resident within the DHB boundary with the DHB FTE GP ratio .....	73

**List of Tables**

Table 1: Percentage of General Practices per DHB that trained 4th-5th year medical students in 2014 from the University of Otago Medical Schools .....68

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## Abstract

General Practitioner (GP) shortages are an international problem. NZ is simultaneously experiencing an increase in GP demand due to a rising chronic health burden and a decrease in GP supply due to problems with recruitment, retention and retirement. This study used a mixed methods research methodology, mixing qualitative Action Research principles with quantitative analysis. These methods were applied to data collected on the location of 1064 general practices, 186 teaching practices and 495 medical students' origin in order to determine the feasibility of utilising GIS technology in primary care research. This geographic data was combined with demographic data from the 2013 census in a GIS database to analyse for factors related to need and supply of general practice services. The network analysis has produced the most current and up-to-date picture of general practice accessibility in New Zealand. The data resulting from these analysis comprises of general practices or 'points of supply', linked to thirty-minute service area polygons containing 2013 census demographic information including the NZDep Score. This method has shown that physical accessibility to general practices varies considerably throughout New Zealand but that inaccessibility in the South Island of NZ is related more to rurality than socio-economic disadvantage. Urbanisation of both population and health services is having a marked effect upon accessibility for rural regions. However the presence of clinics in rural areas is reducing the shortage of medical services and increasing the access of these populations to health professionals. The analysis of the teaching practice data showed that practices that are located within moderately to high deprivation areas were more likely to have trained students in 2014. This may have beneficial effects on GP shortages in high need areas as positive training exposure is linked to a higher likelihood of selecting General Practice as a speciality. The geographical origin of students is also associated with future career choices. This study found that the medical students were more likely to originate from the least deprived regions of NZ so exposure to high need communities is particularly important. GIS has much to offer primary care research, however its' most effective use relies on an understanding of the software, its application to the NZ context and potential access to a specialist for assistance with data analysis.

## Abbreviations

DHB- District Health Board

FTE- Full-time Equivalent

GIS- Geographic Information System

GPs – General practitioners

HWNZ – Health Workforce New Zealand

IMG- International Medical Graduate

LINZ- Land Information New Zealand

MOH – Ministry of Health

NP- Nurse Practitioner

NZ – New Zealand

NZDep - New Zealand Deprivation index

OECD- Organisation of Economic Co-operation and Development

PGY1, PGY2 – Postgraduate Year 1, Postgraduate Year 2

PHCS- Primary Health Care Strategy

PHO- Primary Health Organisation

RNS- Rural Nurse Specialists

RNZCGP – Royal New Zealand College of General Practitioners

TI- Trainee Intern

WHO- World Health Organisation

## Definition of Terms

Attribute- GIS terminology used to describe aspatial information about a geographic feature that is stored in a table and connected to the feature by a specific identifier

Capitation- model of health care provider payment in which they are paid according to the number and demographics of the patients enrolled with them

Co-payment- a payment made by the individual at the time of the GP visit to top-up the government subsidy to the general practice

Fee-for-service- model of health care provider payment in which they are reimbursed for every procedure/service they provide for a patient

Full Time Equivalent- based on 40 hour working week e.g., one GP working 60 hours is equivalent to 1.5 FTEs

Geocoding- a GIS process that converts street level address information into specific latitude and longitude coordinates to the individual household level

International Medical Graduate- doctors who obtained their primary medical qualification in a country other than New Zealand

Line- GIS terminology used to describe a series of ordered geographic co-ordinates that may have no area or are too narrow to be shown as an area at a particular scale e.g. land contours, street centrelines, rivers or country boundary lines

Locums – doctors who work short-term for more than one DHB and who are not permanently employed by one DHB

NZDep- NZDep2013 combines nine variables from the 2013 census which reflect eight dimensions of deprivation. NZDep2013 provides a deprivation score for each meshblock in New Zealand. The NZDep2013 index of deprivation ordinal scale ranges from 1 to 10, where 1 represents the areas with the least deprived scores and 10 the areas with the most deprived scores.

Point- GIS terminology used to describe an object represented by a single X,Y co-ordinate e.g. the location of a general practice or an individual's house

Polygon- GIS terminology used to describe a feature that represents an area. A polygon has defined boundary lines and an identification point within its boundary

Polyline- GIS terminology used to describe a line that is made up of a series of line segments

Practice nurses (also called primary health care nurses) are registered nurses with particular expertise in primary health care practices such as screening, health promotion and preventative care programmes. They are a key part of the primary health care team.

Primary care- level of care provided by health professionals in general practices; is first point of access and is personalised with continuity of care

Primary health care- philosophy and level of care promoted by WHO that is based on principles of social justice and equity. It recognises that personal well-being relies on social, economic, political and environmental factors

Primary Health Care Strategy – fundamental part of the New Zealand Health and Disability Strategies that details how primary care should be organised and delivered through non-profit PHOs

Primary Health Organisations – groups of primary health care providers that were established through the Primary Health Care Strategy

Public health- level of health care focused on the community, on measuring and analysing disease, and developing interventions to prevent and/or treat illness

Trainee Intern year – final year before graduation that is mostly spent in clinical learning situations

Vector- GIS terminology used to specify a method used to store spatial data. Vector data represents lines or arcs that are defined by specific start and end points that meet at nodes. These points and nodes have precise X,Y co-ordinates attached to them.

Vocational qualification – A qualification from a medical college vocational training programme that shows the medical field the person is registered in (e.g. general practice, public health, anaesthesia)

# 1 Introduction

In this section, I present the current picture of GP supply and demand in NZ and overseas; definitions, measurements and barriers to health care accessibility are outlined; and an overview of the use of Geographic Information Systems (GIS) in primary health care research is described.

## 1.1 Crisis in GP supply

New Zealand is experiencing growing health inequity resulting at least partially from specific populations suffering from poor access to primary care services (1-3). Maori (4-7), low socioeconomic population groups (4, 8-10) and rural regions (11-14) have a high, yet unmet demand for health care. In the 12 months from 2011 to 2012, 27% of NZ adults reported an unmet need for primary health care services due to an inability to get an appointment with 24 hours at their usual medical centre, or not visiting their GP or after-hours medical service due to the financial cost (4). The level of unmet need was experienced by 35% of adults in the areas with the most deprived NZDep scores compared with 23% of adults in areas with the least deprived scores (8).

This demand for health services is predicted to increase as New Zealand's population grows in size, as the 'baby boomer' generation ages and the burden of disease from obesity and lifestyle factors escalates (15-17). Two thirds of New Zealand adults have at least one diagnosed chronic condition or long-time condition (4). These patients with chronic health conditions and those with a physical disability have reported an inability to access primary healthcare (18-20). Lack of personal transport can also cause an unmet need for primary health care (21, 22), particularly among the elderly, Maori, Pacific peoples and those living in highly deprived and rural areas (4, 23, 24) as they may be dependent upon walking access or public transport that is erratic, expensive or non-existent, as in many rural and regional NZ towns.

The demand for GPs in NZ is already high; New Zealanders made approximately 12.2 million visits in 2013 (25). This makes an average of 2.8 visits per head of New Zealand's 4.4 million population. In the 2011/2012 NZ Health Survey 79% of adults and 75% of children had visited a GP over the past year (8). Over 90% of adults aged 65 years and over had visited a GP in the 2011/12 NZ Health Survey (4).

But this actual and anticipated demand is not being met by an increased supply of GPs. In fact, quite the opposite, as crisis point is being reached in many regions, particularly in rural areas.

Nationwide in 2001, there were 83 GPs per 100,000 population but since 2004 this ratio has dropped and stayed in the low 70s (26). This equates to around 1 GP for every 1400 residents. The OECD ranked New Zealand third worst in equality of access to general practitioners as GP services were more likely to be used by people from higher incomes than lower (27). At 2.2 practicing GPs per 1000 population, New Zealand is well below the average of OECD countries at 3 per 1000 (26). The president of the Royal New Zealand College of General Practitioners (RNZCGP) stated that the NZ health sector needs approximately 1000 GPs to fulfil the shortage (28).

The level of service gap varies across NZ District Health Boards (DHBs). The 2012 Health Workforce survey found that Auckland DHB had a Full-Time Equivalent (FTE) GP per population ratio of 1:1030, while in neighbouring Counties Manukau, the ratio was 1:1851 (8). Counties Manukau also has a very young population profile with a disproportionately high number of Maori and Pacific peoples living in more highly deprived communities compared to the rest of New Zealand (20). These factors markedly increase their need for primary care services.

DHB regions with predominately rural population such as Taranaki, Mid Central and the West Coast experience similarly poor GP service provision. The 2012 survey found that main urban areas have 342 doctors per 100,000 population compared with just 140 doctors per 100,000 in rural areas (29). It is likely that these communities have even more inferior GP access than can be indicated by the use of GP to population ratios because provider to population ratios do not include measures of travel distance and time (11), nor do they consider the demographics of the patient population such as a high percentage of elderly people who require more frequent (30) and longer GP consultations than younger people (26). In addition they assume that individual GPs have a uniform capacity for patients when this has been shown to vary according to the gender and age of the GP (26, 31).

In contrast to using ratios, the NZ Medical Training Board models the future medical workforce supply and population demand through a needs-based framework. The 'needs' taken into consideration include the population demography, epidemiology, standards of care and provider productivity (32). Using this model, the Board estimates that the health service needs to redirect a significant proportion of the medical school intakes into general practice in order to meet the forecasted demand over the next three decades (15).

## 1.2 International GP shortages

This issue is not isolated to New Zealand as health professional and GP shortages are evident internationally (33, 34). The World Health Organisation (WHO) has estimated that there is a shortage of 2.3 million doctors, nurses and midwives across 57 countries worldwide (35). The decline in the USA of primary care physicians (the American equivalent of a General Practitioner) led to The American College of Physicians stating that “primary care, the backbone of the nation’s health care system, is at grave risk of collapse” (36). The shortages of providers in the USA have been especially evident recently due to the introduction of the Affordable Care Act and the increased patient demand that has resulted from this (37).

The United States designates a ratio of 1:3500 or greater as indicative of a Primary Care Health Professional Shortage Area (HPSA) (38). It is argued that this ratio does not allow for some reliance of the medical workforce upon nurse practitioners being available to cover traditional GP roles (39). Using this ratio, there is currently a shortage of 8200 primary care physicians to the approximately 65 million Americans who live in HPSA (39, 40). In the USA these areas have been found to have higher morbidity and mortality than areas with better access to primary care services (41, 42). Similarly to NZ, this geographical mal-distribution of GPs means there is a mismatch between both the spatial distribution and the needs of residents, and the health services available to them.

The UK is facing a similar crisis in the primary care workforce (43-45). Similarly to NZ, the problems in access to GPs has been partly reflected in increased non-urgent patient presentations to hospital emergency departments (46) and increased avoidable hospitalisations (10, 47). The UK’s Department of Health recommended that at least 50% of all medical students will need to specialise in general practice to address the shortage in primary care services (48). The UK GP college chair stated that the UK National Health Service (NHS) required 10,000 more GPs to cope with the increased demand (49). In 2014 the UK GP Taskforce report recommended that the number of GP trainees must be immediately increased by 450 a year. This was in order to avoid the imminent crisis in the GP workforce due to increasing patient demand and issues of recruitment, retention and retirement reducing the GP supply (50). Worryingly, UK research (51) suggests that the most important influence upon a GPs’ choice of practice was aversion to practicing in an area of high deprivation and that without financial incentives GPs would be reluctant to locate in these areas.

Research indicates that with an increased ratio of doctors to population there is an increased use of medical services (52) and reduced maternal and infant mortality (53). This is potentially especially important for low socio-economic groups as it is less costly both in time and transport to access care (54). In addition, primary care supply has been linked to a reduced perception of disease burden in aging populations (55), earlier diagnosis and treatment of disease and more integrated care between primary and secondary levels of care. Easy accessibility to, and continuity of care by primary health care providers is associated with better self-reported general and mental health (56, 57). The 1996 WHO Ljubljana Charter on reforming health care in Europe stated that European health care systems needed to be oriented towards primary health care in order to provide patients with better health and quality of life (58).

### 1.3 Definitions of Accessibility to Healthcare

The concept of ‘accessibility’ within health care has been notoriously difficult to accurately describe due to the many factors that affect a population’s accessibility to facilities. So while Wang (21) states that accessibility is “the relative ease by which services... can be reached from a given location”. Other researchers have expanded such simplified ideas of accessibility. Penchansky and Thomas (59) suggested that there are five dimensions to accessibility: availability, accessibility, accommodation, affordability and acceptability. Availability assesses whether a population’s healthcare needs are adequately met by the supply of health services. Accessibility compares the geographic location of the population to any health facilities. Accommodation examines the fit between the needs of the population and the services provided. Affordability considers the connections between cost of the health service and the potential for the patient to be able to pay. Acceptability studies the level of patient satisfaction with the health services received by them. Availability and accessibility are spatial in nature so have typically been studied using Geographic Information System (GIS) technology.

The WHO has stated that equal accessibility and availability of appropriate quality healthcare is the requisite goal of any country’s health system (60). This is because these factors have a direct and measurable impact on health outcomes and the experienced disease burden in a community. Accessibility as defined by the WHO has four dimensions: non-discrimination, physical accessibility, economical accessibility and information accessibility.



Information accessibility acts to overcome issues with poor health literacy as this restricts an individuals' ability to obtain and understand health information and make informed health decisions. Health literacy (HL) is defined as "the degree to which individuals have the capacity to obtain, process and understand basic health information and services needed to make appropriate health decisions" (61). Low HL is associated with negative health behaviours, poor health and socioeconomic disadvantage therefore it is an important contributor to health inequalities. GPs have an important role to play in addressing these inequalities, particularly through providing advice on lifestyle modifications to promote better health behaviours (62). Crucially, HL is a two-way process as a healthcare provider needs to communicate in such a way to enable the patient to make an informed choice through being health literate (63).

In October 2011 WHO sponsored the World Conference on Social Determinants of Health which saw a renewed determination by governments to achieve health equity through accessibility and affordability (64). OECD countries use horizontal equity of access to health care as a key comparative goal across countries in order to achieve equal access for equal need (27). However, Goddard and Smith (65) argue that equity of access only considers the supply of health care providers thereby overlooking the many interactions between supply and demand. These interactions lead to inequalities in treatment due to the "preferences, perceptions and prejudices of both the patient and health care provider".

Goddard and Smith (66) stated that equitable access to health care results from three contributing factors: population need, health care supply and "realised access". Population need could include both clinical measurements of need through the patient's 'level of illness' and non-clinical factors such as the social circumstances that affect need. Health care supply included the range, quality, information about, and cost of services available to different population groups. Realised access characterises the actual use of available services by a population.

The concept of realised access originally stems from work by Aday and Andersen (67) who theorised that there were two forms of access: potential and realised. Potential access refers to the extent a population could utilise existing health services based on characteristics such as the health service supply and location and the population size and demographics. The calculation of potential access naturally lends itself to the formulation of ratios of GP to population size. However these measures disregard the impact of realised access to healthcare as this is inherently more difficult to measure.

Following on from Aday and Andersen's work, Joseph and Phillips (68) described accessibility of health services as being either "locational" or "effective". "Locational" accessibility is simply how close the health service is to an individual whereas "effective" accessibility relates to features of the services such as how expensive it is to access and its opening hours. This has obvious similarities to Aday and Andersen's concepts of "potential" and "realised" access (67).

Meade and Earickson (69) instead considered that there are four variables that result in access to health services: service availability; financial means of access; non-discriminatory systems, services and professionals; and attitude and knowledge of consumers. In this definition Meade and Earickson attempted to reflect the increasing integration of primary health services that has enabled care to be delivered by other members of a primary care team such as nurse specialists. Miller, an American Professor of Health Economics has written about the changes to the concepts of accessibility through integration of primary care:

*As care becomes more clinically integrated access to care measures must take into consideration proactive secondary preventive care that may involve telephone communication; non-physician personnel use; and education, involvement and support of patient in self-care 'services' that might substitute for specialist visits or hospital stays that are sometimes markers for access to care (70)*

### 1.3.1 Health Inequities Due to Poor Accessibility

Regardless of the method of definition, access to primary health care is a critical determinant of population health (71). The health inequalities and problems of access to GPs in NZ's rural and more socioeconomically deprived areas appear to illustrate Julian Tudor Hart's 1971 "inverse care law" (72) which states that:

*The availability of good medical care tends to vary inversely with the need for it in the population served. This operates more completely where medical care is most exposed to market forces, and less so where such exposure is reduced*

Additionally because GPs are the 'gatekeeper' to secondary services in the NZ health system, the reduction in their numbers and geographic mal-distribution has profound implications for the health of NZ citizens. The WHO has stated that imbalances in health human resources occur when a health care system is not made up of the appropriate people, at the right amounts and the right level of use to meet optimal health system goals (52).

Social determinants of health and health inequalities such as differences in morbidity, life expectancy and health care access, result from the socio-political climate in which an individual lives (73). As Pearce (74) stated, in NZ health inequalities are present “between individuals, between socio-economic and ethnic groupings of individuals, and between spatial or geographic groupings of individuals”. Research has found that Māori suffer worse health outcomes from diseases that have effective preventive treatment available through GPs, such as asthma (5, 6) and much higher mortality rates from controllable diseases such as diabetes and ischaemic heart disease (75), illustrating the difficulties Māori experience in both “access to” and “access through” health care (2). Māori experience approximately ten years lower life expectancy than non-Māori (3).

It is possible to measure access to primary care services through calculating the number of ‘potentially avoidable hospitalisations’. These hospitalisation events result from conditions such as asthma or diabetes that could have been successfully treated by a GP but were not (76, 77). Ministry of Health data (76) shows that Māori rates of avoidable hospitalisations were over 1.5 times higher than those of non-Māori. Rates of avoidable mortality were over 2.5 times higher for Māori than non-Māori. The cost to New Zealand society for these both economically and socially is significant (78).

This encapsulates the idea that access is not just the geographical location of facilities but that access also relates to culture, economic status and resources, language and knowledge of how the health system operates (79).

#### 1.4 Barriers to Accessibility

Accessibility to primary healthcare was identified in the Declaration of Alma-Ata in 1978 as being reliant on geographic, financial, cultural and functional factors (80).

##### 1.4.1 Functional Barriers

Functional or organisational barriers result from how a nation’s health system is structured. As an example of this, this barrier directly affects adolescents as there are few primary health care youth-specific services targeting this age group and their health concerns (81, 82). These concerns typically centre around a history of poor communication with GPs, a high need for confidentiality due to consultations around sexual and mental health issues and a perceived lack of respect from health providers about teenage health (83). Additionally, young people aged 15-24 years have reported deferring visits to GPs because of the financial costs acting as a barrier (18). A trial of a youth-specific service in Tauranga, NZ found that 54% of the

adolescents seen were Māori with a high proportion of patients from low socioeconomic neighbourhoods who were participating in high risk activities including drug and alcohol use. These highly vulnerable adolescents typically have a high but unmet need for health care yet through this youth-specific service high proportions of these people were successfully accessing suitable care (82). This reflects how changes to how a health system is organised can have positive effects on functional barriers.

#### 1.4.2 Financial Barriers

Financial barriers directly affect an individual's use of a health system as inequalities in health care access are greater in countries that have higher co-payments (27). Financial cost has been cited as a barrier to accessing primary care in NZ by young adults aged 15-24, Māori and Pacific peoples, people living in areas with the most deprived NZDep scores and with a high individual level of deprivation, current smokers, people with co-morbid conditions and those reporting very high levels of psychological distress (18). Financial barriers are a particular concern in NZ because GPs have retained the right to charge co-payments for care (18). Deferred access to care can lead to higher rates of emergency visits (42) and preventable hospitalisations for conditions such as acute rheumatic fever (84) which substantially increases costs in the publicly funded NZ health care system (85).

#### 1.4.3 Cultural and Information Barriers

Information barriers perpetuate health inequalities as they act to limit people understanding how to seek care, this particularly affects new migrant population groups who may have higher health needs (86). In NZ cultural barriers affect Māori and Pacific populations who may have a preference for receiving care from Māori and Pacific GPs, but are unable to due to the low numbers of doctors practicing from these groups (87). American research indicates that when patients have a choice in their selection of a doctor, they are more likely to select doctors that are from the same ethnic group. In addition, these patients report greater satisfaction with their doctor (88). Only 2.7% of GPs were Māori and 1.6% were Pacific in the latest GP workforce survey (26), compared to the percentage of the population who identify themselves as being Māori in the 2013 census at 14.9% and Pacific at 7.4% (89). This may impair the ability of these groups being able to access GPs that operate in a culturally safe manner (90). Rural areas in particular are more likely to be staffed by IMGs (29) but because of their lack of training in NZ they may not understand the cultural nuances of this country.

The 2012/13 NZ Health Survey found that Māori adults and parents of Māori children had the lowest amount of trust and confidence in their GP of all ethnic groups (8). In a qualitative study investigating Māori views about health and their experiences of health care it found that participants' experienced conflicted relationships with Pākehā doctors. Cram et al. (91) reported that Māori patients required "persistence and assertiveness... often in the face of cultural misunderstandings, if good health care was to be obtained from existing systems". Cultural safety methods such as working to build rapport with Māori patients before discussing the presenting problem were reported as crucial in overcoming *whakamaa* (shyness) and to enable full disclosure to the consulting doctor.

#### 1.4.4 Geographical Barriers

Geographic imbalances in healthcare access tend to have the greatest impact upon rural and highly deprived communities. They suffer from the increased "friction of space" (67) that is a result of the travel time, physical distance and economic resources required to overcome the distance in order to access primary care services. This has been termed "distance decay" as the likelihood of a population in need being able to access health care decreases with increasing travel time and distance (92, 93). So for example, GP consultation rates may decrease as the distance from the practice increases. A higher travel time is linked with an increased clinical risk for emergency care as preventative care is less easily available (46).

In the 2006 census more than half of the Māori population (54%) lived in areas ranked in NZ Deprivation deciles 8 to 10, the most deprived of the index compared to 24% of non-Māori (94). Additionally, according to the NZ Statistics Urban/Rural Profile categories, 69% of Māori live in urban areas compared to 76% of non-Māori, indicating that a higher proportion of Māori are resident in independent urban and rural areas (95). These regions are typically reliant on residents having personal transport to access GP services as public transport is not available.

Geographic accessibility is usually estimated using GIS as an analytical tool. GIS are able to bring together spatial and aspatial data from a variety of sources, for example, health, census and socioeconomic data and integrate these into a common framework for analysis. The analysis of health accessibility is enhanced by GIS as they can include the impact of variables such as the number of available GPs, and travel time to primary care services (96).

#### 1.5 GIS and Primary Care Research

Internationally GIS have been used to integrate and visualise data relating to health services supply and demand. Primary care uses have commonly focused upon issues of accessibility to

and utilisation of healthcare services (96-99). Recent studies in New Zealand, including a pilot of this proposed study (100) highlighted the potential of GIS to map health care provision and access (101, 102) against demographic factors that affect demand for services such as ethnicity, socioeconomic status and age.

However, GIS technology have been under-utilised in New Zealand primary care health planning. This is surprising given the geographical spread of NZ's urban and rural communities which determines the level of accessibility experienced by patients (99). Without the use of mapping technology, planning for provision of new general practices could remain an arbitrary process, occurring without consideration of the underlying population needs. Evidence indicates that the effectiveness of a country's primary care system relies upon five critical factors, of which one is that countries that regulate where primary care services are located through permits and incentives achieve better health outcomes at a lower expense than countries that do not (103). Luo stated (38) that the first step in creating an accessible and effective health care system is to identify whether there is a spatial mismatch between the supply and demand of services.

GIS would be a particularly useful tool to assist planning for medical student training in general practice, especially because of the increasing student numbers and the capacity constraints this places upon teaching practices. To overcome the shortages in GP provision, adequate teaching spaces for both undergraduate and postgraduate students becomes a critical issue. A GIS combining the geographical spread of all general practices compared to teaching practices could allow the three Otago schools of medicine and Auckland to visualise their regional picture of potential teaching capacity.

While research exists on the origin of NZ medical students, it has not been included into a GIS database and linked to the wider population demographics in a visual format. It is important to monitor the sociodemographic characteristics of NZ medical school intakes to determine if secondary and tertiary programmes targeted at under-represented populations are effective in developing a diverse health workforce (104).

Primary care research in GIS using a mixed methods methodology are rare in primary care. This is unexpected considering the ability of this research design to combine the generalisability of quantitative sampling and the interpretative strengths of qualitative methods (105), and because of the international shift toward attempting to integrate qualitative understandings and methods within traditionally quantitative, positivist GIS (106). The mixed

method studies that do exist have focused upon incorporating GIS technology into healthcare delivery through 3<sup>rd</sup> person accounts rather than from a direct 1<sup>st</sup> person perspective (107, 108).

## 1.6 Research Objectives

The intent of this concurrent mixed methods study is to explore the feasibility of developing a GIS database to answer questions on GP supply and demand. In the study, data from varied sources: the 2013 NZ Census, medical student origin and general practice and teaching practice locations will be used to measure the relationship between GP supply and demand. At the same time, the process of developing the GIS database will be explored using qualitative Action Research principles through a personal journal maintained by the researcher. The reason for combining both quantitative and qualitative data is to better understand the problem of developing a GIS database that is capable of answering questions on GP supply and demand.

This project aims:

1. To document the challenges involved with developing a GIS database that will be capable of fulfilling the following three objectives:
2. To determine whether the quantity and distribution of general practice services in New Zealand reflect the distribution of demographic factors that influence primary care need
3. To determine whether the distribution of NZ medical students' home origins reflects the distribution of demographic factors that influence primary care need
4. To determine whether the distribution of general practices offering undergraduate training places in New Zealand reflect the distribution of demographic factors that influence primary care need

This project intends to incorporate qualitative understandings of using GIS as a 'layperson'. By this, I mean a person without a tertiary qualification in GIS and with only limited prior use of the software in order to better understand the hurdles health organisations face in implementing this technology into their workplaces.

A GIS database that combines the underlying population demographics and where medical students are receiving general practice training would be invaluable for medical schools to assist in planning. Currently it is unclear whether students are exposed to training in high need areas with, for example, high Māori or Pacific populations. Data of this type could be used to redress any imbalances in training exposure as it will be possible to see regions that would be

beneficial for students to have general practice attachments in. It could allow for medical schools to target capacity building in general practices that are not currently participating in teaching students but that would offer valuable training experiences due to the population demographics. If students were to receive training in these areas then it may assist in addressing future shortages in primary care services and also increase students' cultural competency in knowing how to appropriately treat other ethnic groups in a general practice setting.

Currently Māori and Pacific students are under-represented in both medical schools and the health workforce. This study may identify communities with low medical student recruitment and that are underserved with high health needs. This data could be used by educators to assist in forming targeted secondary school student training and recruitment programmes to increase their representation. The database will facilitate the ongoing monitoring of the impact of any changes made to address any disparities should they be present.

Long term benefits of this GIS database include the ability to better plan the ideal location for primary health care provision in regions that are currently underserved but have high health need. Because maps provide powerful visual statements, this study aims to provide policy makers with the tools to implement change in how general practices are situated and to target appropriate interventions to the populations there. In particular, for high need and underserved populations such as Māori and Pacific peoples, it may assist future health provision planning to have the location of general practices mapped and linked to the population demographics.

## 1.7 Thesis Structure

Chapter 2 begins by discussing the international definitions of primary health care and continues by examining how these definitions have been interpreted and implemented in the NZ context.

It then goes on in Chapter 3 to consider how GIS have been used in primary care research both internationally and nationally. Two examples of mixed methods applications of GIS research are described.

In Chapter 4 I outline the methods that I used to achieve the aims of the study.

Results are presented in Chapter 5. These include data from the geocoding and travel time models as well as the qualitative results.



In Chapter 6 I discuss the findings and implications of the methodological approaches that I have taken as well as the limitations of the study.

## 2 Primary Care: Definition, Challenges and Solutions

In this chapter I present international and NZ definitions of primary care, the challenges facing GP supply in NZ and potential solutions.

### 2.1 International Definitions of Primary Health Care

Primary health care was first defined and launched as the ideal global approach to healthcare at the landmark 1978 WHO conference in Alma Ata. It was defined as:

*Essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination... It forms an integral part of the country's health system...and of the social and economic development of the community. It is the first level of contact of individuals, the family and community... bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process(80)*

This definition includes the personal, comprehensive, community oriented, equitably distributed, high quality and cost effective qualities seen essential to the primary health philosophy of care (109). The principle of 'health for all' and access to health care as being basic human rights were central to the Declaration of Alma Ata. Primary health care was also prioritised at this conference as it was seen as the most socially just way governments could achieve health for their people and reduce population health disparities (79). This is because primary health care achieves more equitable health outcomes and are more cost effective to society (110, 111).

The American Institute of Medicine has defined primary care as:

*the provision of integrated, accessible health care services by clinicians who are accountable for addressing a large majority of personal health care needs, developing a sustained partnership with patients, and practicing in the context of family and community (112)*

Barbara Starfield, a prominent American academic on primary care, states that this definition encompasses the four key attributes of primary care services: "first- contact access for each new need; long-term person- (not disease) focused care; comprehensive care for most health

needs; and coordinated care when it must be sought elsewhere” (42). She has previously defined it (113) as:

*That aspect of a health services system that assures person focused care over time to a defined population, accessibility to facilitate receipt of care when it is first needed, comprehensiveness of care in the sense that only rare or unusual manifestations of ill health are referred elsewhere, and coordination of care such that all facets of care (wherever received) are integrated*

This definition emphasises the ability of primary health care to promote both equity and resource redistribution (71). In American literature primary care has been described as the “patient-centred medical home” where patients should be able to access regular care that displays both family and community orientation, and cultural competence (103). Safran et al. (114) defined primary health care as having seven key characteristics: access, continuity, integration, comprehensiveness, ‘whole-person’ orientation, clinical interaction and sustained clinician-patient relationship.

The importance of the ‘doctor-patient’ relationship to successful primary care is not to be under-estimated especially with the continuity of care that it potentially offers to a therapeutic relationship. Agarwal (115) states that this relationship “involves chronologically mapping out the patient’s life and is dependent upon the continuous contact between patient and doctor”. This continuity of relationship can improve health outcomes and patient satisfaction as the consultation time can be used to explore new problems rather than being used to explain a patient’s medical history to a new doctor. But it is detrimentally affected in many rural regions such as NZ’s West Coast as its’ GP service is heavily reliant upon locums and IMGs (116).

Haggerty et al. (117) framed five defining attributes central to the care process of primary health care. They were: clinical practice attributes (e.g., accessibility, comprehensiveness); structural dimensions (e.g., information management); person-oriented dimensions (e.g., respectfulness, cultural competence); community-oriented dimensions (e.g., equity, community participation); and system performance dimensions (e.g., accountability, efficiency).

A study of 18 OECD countries by Macinko et al (111) found that the essential features of primary care systems were: geographical regulation and access; longitudinality (how the health system performed over time); coordination between primary and secondary care services; and

community orientation. OECD countries that had stronger primary care systems demonstrated improved health outcomes as their populations suffered from lower rates of all-cause mortality and cause-specific premature mortality from conditions such as pneumonia, heart disease and stroke. Additional benefits of accessible primary health systems are earlier detection of health problems and more efficient use of emergency services and secondary and tertiary levels of care (118).

Primary care differs from secondary health care in that secondary is typically provided by hospital-based specialists that focus on a particular set of problems so that the care they provide is more episodic and limited in scope than primary health care providers. Primary care is intended for first-contact care to enable referrals to be made to secondary care providers (79). Secondary health care is also more expensive to provide so a properly functioning primary health care system should be able to reduce the numbers of people seeking secondary care services (119).

## 2.2 Primary Health Care in New Zealand

Primary health care and general practice in New Zealand have evolved steadily since the Social Security Act of 1938. This act aimed to provide universal free health care through self-referral to general practitioners as part of a national health service, similar to the British model. The government succeeded in establishing free public hospital and maternity care but the medical profession resisted full funding of general practice services. ‘Fee-for-service’ subsidies were instituted where GPs were partially reimbursed for the cost of the consultation through taxes but they retained the right to influence their income by charging their patients an additional co-payment (120). In 1972 The Royal New Zealand College of General Practitioners was formed and in 1996 the Medical Council General Practice Vocational Registration was developed. The NZ Ministry of Health defines primary care as it “relates to the professional health care received in the community, usually from a general practitioner (GP) or practice nurse” (121).

### 2.2.1 The Primary Health Care Strategy

In 2001 the New Zealand Ministry of Health responded to the Alma-Ata Declaration with the Primary Health Care Strategy (PHCS). The PHCS is a fundamental element of the New Zealand Health and Disability Strategies (122). The PHCS outlined how primary health care would be organised and delivered in New Zealand through non-profit non-government Primary Health Organisations (PHOs). These PHOs are required to have representatives from the primary care sector, the wider community and Māori. This highlights the importance of

community participation as stated in the Declaration of Alma-Ata being upheld in the NZ Strategy (123).

The strategy's four main concerns were: differences in the health of different groups of people; high levels of preventable illness; high levels of preventable hospital admissions; and barriers to accessing primary health care services. These concerns had partially resulted from the fee-for-service subsidy barely covering one third of the cost of a consultation by the mid-1980s causing an increasing level of unmet health need in the community (124). It included three priority objectives to reduce inequalities that aimed to ensure accessible and appropriate services for people from low socioeconomic groups, Māori and Pacific peoples (122) and to avoid issues of overuse, underuse and misuse of health services (125). Funding was targeted toward reducing the costs of primary care services to improve population health and reduce health inequalities (126). It was also hoped that better coordination of care between providers would be achieved (120).

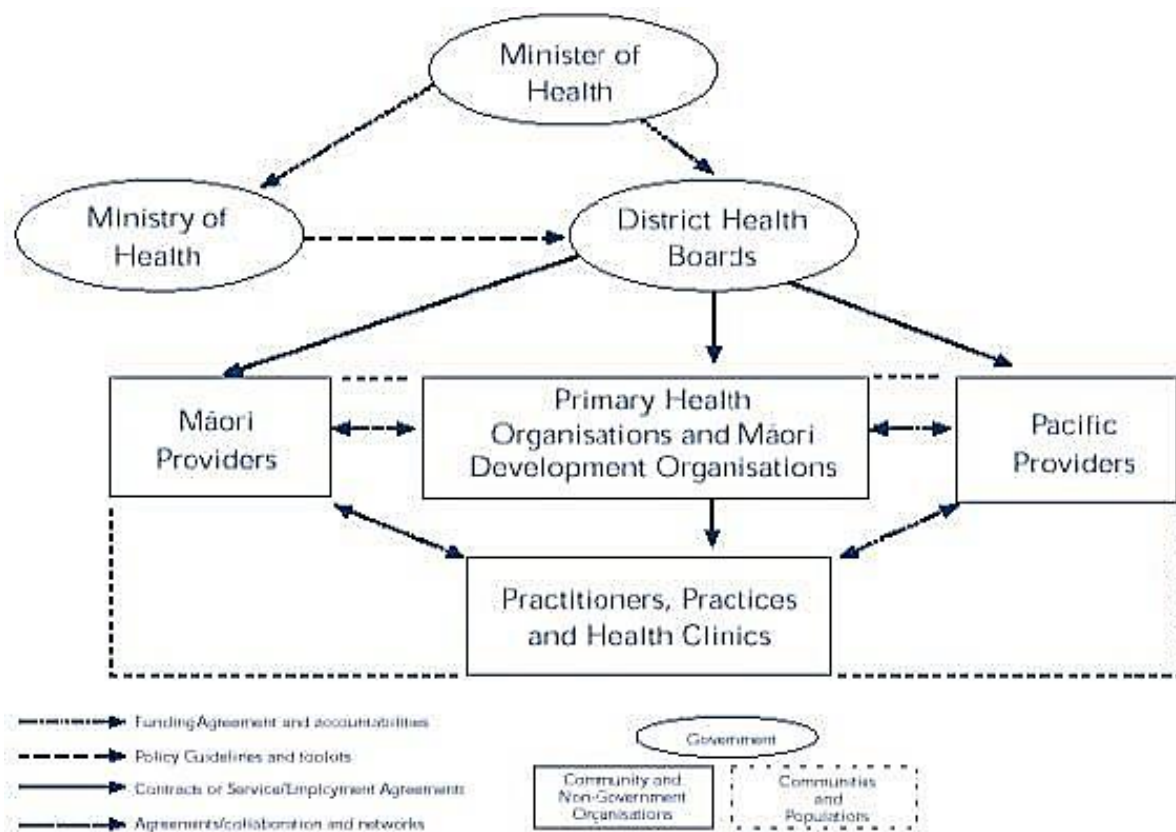


Figure 2.1: Structure of Primary Health Care in NZ (122)

The implementation of the PHCS in 2001 initiated a reorientation of health funding and structures toward focusing upon the health of populations rather than individuals. This

approach ideally leads to a greater emphasis upon population-targeted strategies that promote health and prevent illness (127). In 2000, District Health Boards (DHBs) were established in the New Zealand Public Health and Disability Act. DHBs oversee the health of the population living within their defined geographical boundaries, focusing on hospital, community and primary care services. There are currently twenty-one DHBs in New Zealand.

DHBs fund primary health care provider networks called Primary Health Organisations (PHOs). There are currently 32 PHOs (128) which have almost universal affiliation with NZ General Practices. PHOs are assessed to determine how successful they are at reaching specific high need clinical objectives such as immunisation rates for children and the elderly, and breast screening and cervical smear rates. PHOs receive capitation funding from DHBs and the Ministry of Health (MOH), the level of which depends upon the number and demographic characteristics of the patients enrolled in the PHO. This funding subsidises the costs of GP consultation for enrolled patients enabling lower cost access to primary health care services than the traditional fee-for-service and patient co-payments allowed (129). Capitation funding also facilitates a 'needs-based' formula to take priority so that populations with high needs receive the most subsidised care (130).

#### *2.2.1.1 Māori Health Providers*

In an attempt to meet Māori health needs and overcome issues with inaccessibility (2), Māori primary care services that are community-governed and not-for-profit were established in the late 1980s' (131, 132). These services also represented the government's commitment to honour the principles of partnership in the Treaty of Waitangi and enable Māori to become actively involved in designing and delivering health services that meet their needs. The services are adaptable, using both mobile and satellite clinics to enable patients to access care.

They act to overcome multiple barriers including: geographical barriers to access; financial barriers through being free or charging cheaper co-payments; and organisational barriers through being more flexible with appointments and allowing people to walk-in and be seen within a day. Another significant barrier overcome by these services are cultural issues through the employment of Māori staff and providing services in familiar, non-clinical and less intimidating environments such as on marae (2, 77, 123).

Similar third sector (neither government nor private) services exist to target Pacific populations in urban settings. These are also effective through offering church-based services (77, 133). Because of their community orientation these services are able to act as both public and primary

health providers at a local level through promoting health and illness prevention practices (127).

### 2.2.2 Effects of the PHCS

An analysis of the effects of the PHCS found that fee reduction, has led to increased consultation rates especially in higher need and higher funded practices (134). The past two NZ Health Surveys seem to support this as it found that there were no differences in the proportion of GP visits by level of neighbourhood deprivation and between the proportion of visits made by Māori and Pacific adults and the national average (4, 8). But considering that Māori and Pacific people have poorer health statuses than Europeans it may be expected that adjusted utilisation rates would be higher. This may explain the continuing health disparities and inequalities in NZ (1).

These disparities may still exist because practices were not legally required to reduce their fees in response to the increase in government funding. Studies have found that patient co-payment fees had not reduced by as much as expected (135, 136). In 2011/12 the average cost of a GP visit in NZ was \$32 (4). After-hours GP is more expensive with the average cost to the patient being \$56 (4). Since 2008 children under the age of six have had free GP and after hours visits which has reduced the level of unmet need in this age group. However cost still acts as a barrier to older children accessing care as their level of unmet need for primary health care has increased, particularly in the 10-14 year old age group (8). Current government policy aims to remedy this disparity in access for older children through extending the provision of free GP visits to under 13 year olds (137). This is predicted to benefit 400,000 children and reduce the pressure on hospital emergency departments as children will ideally present to their GP earlier for preventative treatment.

However, while access to GP visits may have improved there still remains a cost barrier to filling prescriptions for children in highly deprived areas (8) and for people of Māori and Pacific ethnicity (18). Geographic barriers rather than cost act as the barrier to accessing pharmacies for rural residents as a recent NZ study using GIS found that the urbanisation of the NZ population has been matched by the loss of pharmacies in rural towns (102).

### 2.2.3 Future Challenges for NZ Primary Health Care

Achieving integration and coordination across all levels of health services is seen as one of the major challenges of the NZ health care system (120). This challenge has prompted the government since 2007, to shift the focus of care toward greater use of services that are “closer

to home” in primary and community care through their ‘Better, sooner, more convenient’ health model (138 - 140). This model aims to create integrated family health centres that house a variety of health professionals to enable better community access and better integration from primary to secondary care services (120).

Increased integration of the primary care workforce aims to ensure that a variety of health team members are involved in patient care and that some traditionally GP-led tasks are delegated to practice nurses e.g., immunisations and cervical smears (39). Integration is also hoped to have a beneficial effect on mental health patients who suffer from poor transitions between primary and specialist care (141). The Medical Training Board believes that the community care models and a more cohesive health system with clear system-wide leadership will assist in the increased retention of New Zealand medical graduates. They hope this will lead to improved nationwide health care provision (15).

### 2.3 Measurement of GP supply

GP resource supply is typically measured through the use of GP provider to population ratios. Section 51 of the Health and Disability Services Act 1993 states NZ’s official GP per population ratio of 1:1400 as the level for a practitioner to issue a notice to practice in an area and as the capacity for a full-time work load (142). Attempts have been made to formulate the ideal ratio for NZ in order to provide a benchmark GP workforce and to measure the level of service gap, however no agreement has been reached yet (143). The Rural Expert Advisory Group recommended to the Minister of Health in 2002 that the “alert” level of FTE GP supply to population should be set at 1:2000 (144). In the 2002 surveys of NZ rural workforce supply, this level was reached in 32% of rural “Shared Roster Areas” (SRAs) while a ratio of 1:1800 was reached in 56% of SRAs (145). An SRA is an after-hours call roster shared by a group of GPs for a particular area (146).

Some have argued that GP to population ratios should only serve as a starting point for understanding workforce distribution as they can be misleading, leading to skewed results in analysis (33, 147). Errors in ratio calculation can occur through the inclusion or exclusion of locum GPs or if GPs that work in more than one practice in different geographical areas, which is especially evident in rural regions, are counted incorrectly (148). Fretter argues (142) that to derive an accurate estimate of the current NZ GP workforce, the formula should necessarily include: the number of practicing GPs; numbers of other primary health professionals and their scope of practice e.g. the number of Nurse Practitioners assisting; and average GP workloads



e.g. FTE hours, patient disease burden and utilisation of GP services. These results could then be combined with the numbers of GPs that are currently in training, being recruited or leaving the speciality to forecast future workforce supply issues.

The consideration of FTE workload has been an important addition as a standardised unit of human resources measurement to the traditional ‘headcount’ of GP per population ratio. However it has the disadvantage of ‘capping’ GPs to a standard full-time level of service of 1.0 FTE. In Australia the Full-time Workload Equivalent (FWE) is used as an alternative measurement because it allows GPs to work more than a full-time load e.g. if a GP works 50% more than a standard full-time load then they would be 1.5 FWE rather than 1.0 FTE. This allows for the inclusion of, and compensation for, GPs working part-time or in casual positions which is becoming increasingly common in the GP workforce (149).

## 2.4 Workforce issues affecting GP supply

Zurn et al. (150) argue that health care systems are affected by five different types of imbalances: profession/speciality imbalances, gender imbalances, geographic imbalances, institutional and services imbalances, and public/private imbalance. Examples of these imbalances are all evident in the NZ health workforce, some of which principally impact upon the GP supply. Those that do will be addressed in the following sections.

### 2.4.1 Profession/Speciality Imbalances

The inequality in health outcomes between Māori and European and between communities of different levels of deprivation have not been helped by the changing dynamics of the NZ health workforce. These are affecting the accessibility and level of GP supply as fewer junior doctors are choosing to specialise in general practice, particularly in rural areas (14). Clinical specialists now outnumber GPs in the NZ medical workforce (29). But this growing trend toward medical specialisation that is not involved in providing primary care, directly conflicts with the aims of the New Zealand’s Health Strategy.

Countries such as Denmark, Finland, Spain, and United Kingdom whose national health systems are oriented toward primary care typically have lower morbidity and lower total health care costs, than countries with a high level of specialisation such as the United States (151, 152). The health of infants and children particularly benefits from a strong primary care system (152) as it can act to mediate the negative health effects of income inequality and socioeconomic deprivation (153).

New Zealand has a relatively low level of medical generalism and a higher degree of specialisation, with approximately 4000 of the 10,000 doctors in NZ being generalists (29). The President of the RNZCGP has stated that the ratio of specialists to generalists should be 50:50 (28). This lack of generalism and the resulting difficulties in accessing appropriate primary health care may be reflected in our high rates of preventable childhood illnesses such as rheumatic fever (84).

#### 2.4.2 Gender Imbalances and the Increasing Feminisation of the GP workforce

Of the GPs that are actively practicing in NZ, a growing proportion are nearing retirement (29) or are reducing their workload (154). The average age of GPs has been steadily increasing over the past decade reaching 50 years old in the 2012 Medical Workforce Survey (29). In addition, there are concerns about the increasing feminisation of the remaining GP workforce as female GPs tend to work a lower average FTE workload than male GPs (29, 155) in their General Practice role so are viewed as potentially less productive than men (156). Typically women have different career paths compared to male GPs, particularly in the 35-39 year old age group, as women tend to take time out from the workforce for family reasons.

Medical school intakes have been predominately female for at least the past two decades (104, 157, 158). These intakes are having flow-on effects in the vocational training choices with 59% of GP vocational trainees being female in 2012 (29). Previous research has found that women are more interested in a career in General Practice (159, 160). Currently the percentage of women in General Practice training in NZ is about the same as the proportion of women medical students (104). There have been suggestions that the status of the medical profession may change with an increasingly female workforce (161).

However a recent systematic review of the feminisation of the GP workforce found that while female GPs self-report fewer work hours and see less patients than male GPs, they spend longer with individual patients and deal with more presenting problems in a single consultation (162). The authors of this review concluded that workforce feminisation is likely to have a small negative effect on GP supply. A 2014 study of Auckland medical students found that both male and female students valued flexibility in their speciality choice (163). Perhaps the preferences of generation Y (born 1980-1994) for more flexibility and a better work-life balance could pose more of a threat to the sustainability of the future workforce than its feminisation (164).

### 2.4.3 Geographic Imbalances and the Rural GP Workforce

NZ rural regions have long suffered from workforce shortages. NZ's Primary Health Care Strategy noted that the "misdistribution of workforce is a particular issue for rural areas" and "the difficulties of attracting and retaining basic health services in rural communities have not lessened in recent years" (122). The current rural GP workforce consists predominately of men aged over 40 with many trained overseas, nearing retirement or intending to leave rural practice (29, 155).

The increasing urbanisation of NZ's population has caused a parallel urbanisation and centralisation of health care services increasing the physical distance rural residents must travel to access health services. However, while rurality does not always lead to disadvantages in health (165) there is still a high level of service demand in these regions as rurality is often associated with low socio-economic status and, in New Zealand, Māori ethnicity, which both affect measures of health and morbidity (95).

In developed countries mortality rates from some types of cancer (for example cervical due to lower screening rates), suicide due to delayed treatment seeking for mental health issues and motor vehicle crashes are markedly higher in rural areas than in urban (165). But as Smith et al states (165) the "health status of any place is a product of more than just location". They relate poorer health outcomes to: low socioeconomic status; ethnicity; reduced access to health services; personality traits such as a higher level of personal risk-taking and stoicism in the face of adversity; and greater exposure to risks of injury through more challenging environmental, occupational and transportation situations. They conclude by saying that unless policies to address rural health and its workforce issues, additionally address the issues surrounding poverty, racial discrimination and inequality, then the policies will be ineffective.

The challenges that affect rural areas have been listed by the New Zealand Ministry of Health as:

- *“large distances and obstructive geographical features that affect ease of access to health services*
- *small, isolated populations that lead to diseconomies of scale when planning and funding local health services*

- *high levels of deprivation that are a feature of some rural regions and some rural communities in otherwise more affluent regions which impact on the health status of the local population and their ability to access services*
- *[a] high concentration of Māori in some regions (e.g., in the Far North and East Coast of the North Island) [which] present[s] both challenges and opportunities for the organisation and delivery of culturally appropriate health services and the reduction of health inequalities*
- *sharp seasonal fluctuations in population numbers experienced by some rural areas pose workforce difficulties when organising and funding health services on a population basis”. (144)*

The reducing rural workforce means that remaining GPs have a larger and more complex patient caseload with reduced ability for time-off and increased on-call hours (14, 145, 154, 155, 166). These reasons and others, such as: a preference for urban living, onerous working conditions and hours, work challenges, diversity of practice, career opportunities, partner flexibility and preferences, family location and educational opportunities (167) make it difficult to recruit GPs into rural worksites.

The NZ Rural General Practice Network developed the Rural Ranking Scale (RRS) in the 1990s in order to recognise the more difficult working conditions in rural regions and to establish a level of rural funding bonus for GPs. Individual practices are allocated a score which accounts for: costs resulting from travel time to the nearest hospital and nearest GP colleague; GP-call rostering; trauma-call duties; and peripheral clinic duties (168). If a practice scores more than 35 points than they are defined as rural. The level of bonus attempts to reflect the additional skills required by rural GPs due to their geographical distance from secondary care hospital services (155). Rural GPs are more likely to be involved with acute and emergency situations while urban GPs are able to take advantage of the many resources available in urban centres by referring patients on to specialist care.

To address the shortage issues from the level of medical education, various initiatives have been undertaken. From 2006 both Otago and Auckland medical schools have received extra funding to provide places for rural origin students. This was in recognition of the international research that suggests rural origin students are more likely to return to practice in similar areas (169-172). Also, in 2006 the government allocated additional funding for 30 rural GP trainee

placements. Rural GPs have now been registered as a vocational scope of practice which allows for a dedicated training pathway.

#### 2.4.4 Role of nurses in rural primary care practice

More recently there has been an increase in the number of rural primary health care nurses in comparison to the number of rural GPs. This allows for some compensation in the reduction of the rural GP workforce (155). West Coast DHB in particular relies on nurse-led clinics by Rural Nurse Specialists (RNSs) that work from standing orders of the GP as general practices have found it difficult to maintain their GP workforce (116, 155).

There has been some debate in NZ over the disciplinary boundaries in primary care duties between health professionals such as NPs and GPs that has slowed the broadening of scope of some professions (173, 174). This is partially due to the NZ government having been risk averse in legally allowing other health professionals to provide such services, especially prescribing medications (175). This is changing however as by 2014 it becomes a Nursing Council New Zealand (NCNZ) requirement that all NPs are qualified to prescribe (176). Both international (177, 178) and national (179) evidence suggests that better population health outcomes and more cost-effective care are associated with the number of nurses per population, particularly NPs. This has been called the “Nurse Dose” concept (180, 181). This relationship would be crucial to exploit in NZ because nurses are the largest group of regulated health professionals nationally (175). Nurse practitioners in particular may increasingly fill the shortage of GPs in coping with the massive increase in the burden of chronic disease from cardiovascular disease and diabetes (39).

#### 2.4.5 E-health technologies

E-health is viewed as having the ability to address the challenges in maintaining adequate quality healthcare services in rural and remote areas by bridging the service gap (182). The NZ Ministry of Health stated that it is able to “link specialist services, the health care team and the rural patient to provide enhanced quality services close to where the patient lives” (183). It can increase access to specialist expertise through reducing travel costs which could lead to improved management of rapidly changing illness conditions (184). It also allows for rural GPs to participate in continuing professional development opportunities through videoconferencing (183). This increased contact could potentially reduce the isolation that forces some GPs to consider relocating to urban practices (184).

However researchers (182) have stressed the importance of focusing upon the community need for the technology rather than just implementing it because it is available. This is because it needs to have community support and the clinical willingness to learn the technology. A recent literature review found that e-health is safe, effective and reliable for patient interactions and allowing patients to undergo care while staying in their communities (182). However Agarwal (115) argues that technologies allowing remote consultations challenge the idea that a GP is an indispensable member of a community who understands and has knowledge about the local environment. In order to compensate for the GP potentially losing intimate knowledge of the local community contexts, Agarwal maintains that there needs to be increased inter-professional teamwork with clinic staff on site to assist these GPs in their understanding.

Unfortunately, it appears that the highly deprived rural communities that would be most likely to benefit from e-health technology due to poor community resource access (23) are also the least likely to have access to the internet (185). Access to the internet has become a proxy for having the opportunity to participate and have choices for daily living in society. This is shown by the inclusion of access to the internet as a measure in the NZ Deprivation Score (186). In addition e-health requires a certain level of health literacy and self-management of health in the individual.

#### 2.4.6 International Medical Graduates

The shortfall of GPs nationwide and in rural areas in particular, is increasingly being filled by locums and International Medical Graduates (IMGs). The 2012 workforce survey found that 54% of rural doctors were IMGs versus 38.7% in urban centres. IMGs comprise 41.4% of the entire medical workforce in NZ and 43.7% of this are GPs (29). An OECD report in 2008 found that New Zealand (46.9%) and Australia (42.9%) had the largest proportion of IMGs of all the OECD countries. At that time, for every doctor trained in NZ that lived overseas, there were two doctors living in NZ who were trained overseas (187). By comparison, in 2004 IMGs accounted for 22.3% of all doctors in Canada but 26.9% of doctors in rural areas, indicating a similar reliance on IMGs for rural areas in particular (33).

Retention rates show that many IMGs arrive in NZ to fill locum or other short-term positions rather than intending to stay long-term (29). This, the divergence of the medical workforce from the ethnic and cultural mix in NZ (15), and the impact upon their home country's medical workforce of leaving to practice overseas (188) means that IMGs cannot be a long term solution

to the NZ's GP shortage. In addition, increasing international competition for medical practitioners means that New Zealand could face difficulties sourcing doctors in the future (15).

The 2010 WHO Global Code of Practice on the International Recruitment of Health Personnel aimed to highlight the importance of richer countries reducing their recruitment of healthcare workers from poorer nations that have health workforce shortages as this could worsen access for needy populations (127). The NZ Medical Training Board has recommended that NZ should aim for an overall net self-sufficiency in the medical workforce so that the numbers of medical students trained in NZ are enough to meet the population needs (15).

#### 2.4.7 Māori and Pacific Health Workforce Development

The Health Workforce Advisory Committee (HWAC) has stressed the importance of increasing Māori and Pacific students studying health sciences, specifically through the use of role models, encouragement and career promotion to both the students and their whānau (189). This is crucial as currently many Māori and Pacific students are prevented from entering health professions as they do not have the necessary secondary school science qualifications in Chemistry, Physics and Biology. These subjects are a particularly important foundation for the competitive Health Sciences First Year programme at the University of Otago and the First Year Biomedical Science courses at the University of Auckland. Students' marks from the prescribed papers over the year are collated with their weighted achievement in UMAT (Undergraduate Medical and Health Sciences Admission Test) and, in the case of Auckland, an interview, to achieve entry into the 2<sup>nd</sup> year medical classes.

The latest statistics available from the NZ Ministry of Education's 'Education Counts' website from 2009 show that only 8.4% of Māori and 7.2% of Pacific Year 13 students participated in Chemistry and of these, 36% of Māori and 32% of Pacific students attained the NCEA credits. For NCEA Physics at Year 13 level, 7.8% of Māori and 6.5% of Pacific students participated in Physics and of these, 38% of Māori and 33% of Pacific students attained the necessary credits for University Entrance requirements.

These numbers are in comparison to the participation and attainment rates of Asian students in particular, with 34% participating in Chemistry and 61% attaining the NCEA credits. Thirty-one percent of Asian Year 13 students participated in Physics with 65% of them attaining NCEA credits (190). This foundation leads to higher numbers of Asian students attaining University Entrance. In 2011, 31% of Māori and 26.1% of Pacific Year 13 students attained University Entrance compared to 54.2% of Asian and 57.3% of European students (191).

Preferential entry pathways exist at both Otago and Auckland for students with Māori and Pacific descent and for those with a rural origin as determined by their home residence and/or the geographical location of their schooling. The Rural Origins Sub-Category was started in 2003 at Otago. However selection through these pathways relies on having a large enough group of students with the necessary educational foundations (192).

The University of Otago has initiated various programmes in order to increase the number of students with the requisite background for tertiary study in the health sciences and their likelihood of gaining entry into 2<sup>nd</sup> year professional courses. These include: the Foundation Year Bridging Programme; the Pacific Foundation Programme to support Pacific students; and Tū Kahika to prepare Māori students academically (193).

#### *2.4.7.1 Growing Your Own Workforce: Case Study of Counties Manukau DHB*

Counties Manukau DHB is taking a unique approach to ‘growing’ their own workforce from their own community as currently the workforce is not reflecting the predominately Māori and Pacific people the DHB is serving. The vision of “Grow Our Own Workforce” (GOOW) is “to grow and develop a workforce that serves the health needs of our community with competence and respect and reflects the diversity of Counties Manukau” (20). Currently 5.7% of their workforce is Māori and 10.3% is Pacific compared to 16.7% and 21.0% of the population served by the DHB being of Māori and Pacific ethnicity respectively (194). Due to a rapidly growing population and predicted GP retirement rates, it is projected that to maintain the DHB’s current GP to population ratio, an extra 22 new GPs per year are needed for the five years from 2011 to 2016 (20). Already Counties Manukau has the lowest FTE GP to population ratio in NZ at 1:1851 (54 per 100,000 population) (29).

Of particular interest in the four-pronged approach that Counties Manukau is taking to increase workforce supply, are their programmes targeted at secondary schools in South Auckland. These aim to encourage students to study science subjects and health-related courses with school career programmes. Three South Auckland schools have formed Health and Science Academies modelled upon similar ‘pipeline’ approaches in underserved or underrepresented populations in the USA (195). Students selected for the academy have an individualised study plan with health science subjects predominating. This is supported by study skills and exam practice sessions, first aid training and work site visits to hospitals (196).



## 2.5 Medical Education and Training Capacity of General Practices

Training in general practice at all levels, whether undergraduate or postgraduate, necessarily occurs within a community setting. The Declaration of Alma Ata (80) advocated for community-based teaching of medical students away from tertiary care centres as the belief was that more students would then choose to specialise in primary care, potentially in communities similar to where they had trained. This idea is supported by the evidence of students who report positive GP training experiences being more likely to intend to train in general practice (197-199).

Research into the training capacity of general practices is a growing field (200, 201). This is because awareness is increasing of the pressure upon both medical schools and existing teaching practices to provide sufficient General Practice placements for undergraduate medical students, postgraduate junior doctors (202) and GP registrars. Most of the research up until very recently has focused upon GP-teachers' views on the challenges of teaching in general practice (203, 204) rather than training capacity. However it has already been identified that there is an inadequate number of training places in General Practices in NZ (15). In addition, it is currently unclear what the nationwide geographical picture of general practice training is for NZ medical students and graduates which makes planning for future training capacity problematic. Both internationally and nationally, this study was unable to find any research that have utilised the capability of a GIS to visualise the geographical distribution of teaching practices within a region.

In 2009, the government established Health Workforce New Zealand Board (HWNZ) whose mandate it is to coordinate the education and training of doctors and other health professionals (205). This Board aims to centralise the planning and funding of health workforce training to improve the workforce's recruitment, training and retention. It could be argued that this organisation, or something similar, is required to coordinate General Practice placements to ensure that there are sufficient spaces available.

### 2.5.1 Teaching Practices and Increased Student Numbers

In the 2009 government budget, there was funding allocated toward a gradual increase in the number of medical students over the next five years up to a maximum of 200 extra places per year and an additional 50 new training places for GPs over the 2009-10 year (206). However, it is acknowledged that any increase in medical student intake numbers places increased pressure on the General Practices that participate in teaching (200, 204, 207-210). Universities

may need to recruit new teaching practices or increase the teaching commitment of existing practices in order to absorb the rise in medical student intakes (211, 212).

While GP-teachers report many rewards with student placements including enhanced practice morale (211) and the feeling of repaying the profession (200), there are some significant costs and challenges to be acknowledged. The most detrimental of which are resource and infrastructure constraints (203, 207, 210, 212, 213), decreased productivity, increased time pressures and an increased workload on the GP-teacher (211). Because there may be greater financial benefits for a practice to teach either postgraduate junior doctors or GP registrars versus a potential financial loss for teaching medical students (214), it may become difficult for undergraduates to find training placements unless subsidies for teaching practices are increased (200, 213, 215).

Rural practices suffer additional burdens with the acute workforce shortages causing higher workloads on rural GPs. There may also be higher infrastructure costs associated with being a rural teaching practice (216) which could act as a major disincentive for rural practices to participate in teaching. However these are precisely the areas in which students need exposure to in order to increase their interest in future rural career possibilities and potentially solve the shortage problem. Training in rural practices has many benefits for undergraduate medical students as they may be working at a higher clinical level than that expected or required of them in an urban hospital setting (217).

Exposure to rural learning experiences has been found to increase student intention to practice in rural areas (218, 219). It has been suggested that this provides evidence to support the existence of social based learning theory in medical school education (220). This theory states that the physical location in which students' initially develop their skills determines their self-perception of their proficiency in those skills. If these perceptions are positive then students may be more likely to return to similar sites to practice in the future.

Initiatives like *Pūkawakawa* at Auckland Medical School are valuable in placing students in these high need, hard-to-staff regions. This programme places students at regional and rural sites in the Northland DHB using Whangarei as the educational 'hub' (221). Otago Medical School has used the Rural Medical Immersion Programme (RMIP) since 2007 to send 5<sup>th</sup> year medical students into rural communities to train for one year. Ideally these schemes will act to reduce the GP shortage in both rural and underserved regions.

More recently there have been calls for PGY2 and PGY3s to have rotations in general practice as already occurs in some rural practices and in the West Coast, Nelson Marlborough, MidCentral and Counties Manukau DHBs (202). Evidence from the UK suggests that these rotations expose junior doctors to a wider variety of patients and conditions than hospital attachments (222). This enables these doctors to have greater responsibility for patient management while concurrently learning the importance of continuity of care (223, 224). Boyle et al. (163) argue that without postgraduate placements in general practice there is the risk that it could be a fall-back option that doctors “end up” (198) in after other specialities are tried, or because they don’t gain a specialist training position, rather than being confirmed as the speciality of choice at an earlier stage of training.

## 2.5.2 Medical Student Perceptions of General Practice

### 2.5.2.1 *Negative Perceptions*

Training experiences throughout medical school affect a student’s specialty preference. Negative attitudes about general practice include the perception that it is “a last resort” (225), is mundane (226), lacks prestige (227) and less intellectually challenging (228-231) than specialist practice. This perception is reinforced by the ‘hidden curriculum’ that is perpetuated by hospital specialists (229). The term ‘hidden curriculum’ has been defined as “the culture, beliefs and behaviours of a community that are passed to students outside formal course offerings” (232).

Studies of NZ medical students and recent graduates have found that only 9% (188), 16% (233) and 30% (163) of them rank General Practice as their first choice of specialty. This is not peculiar to New Zealand; a 2007 survey of 4<sup>th</sup> year American medical students at eleven schools found that only 7% planned a career in primary care (234) and a UK study on recent medical graduates found that general practice was the first choice of speciality for only 28% (235).

High levels of student loan debt from covering medical school fees also affect a student’s interest in general practice (188, 233) as GP registrars in New Zealand are paid relatively poorly compared to other specialty training programmes. By PGY3 25% of registered medical graduates have left to practice overseas (26) which leaves the NZ medical workforce in a precarious position of relying on IMGs (187).

Recent discussions between Health Workforce NZ (HWNZ) and PGY1s and PGY2s found that these graduates were not tempted to enter general practice for several reasons. These included: the negative perceptions that GPs worked long hours and that they needed to become small

business owners, both of which were undesirable; that GPs were poorly paid with less beneficial terms than if employed by a DHB; that the runs needed for general practice training entry were prioritised toward those entering specialist training and were often difficult to achieve e.g., paediatrics; and finally that there were no GP role models within the DHB system (236).

The lack of a defined pathway for career advancement may also affect both potential junior doctor recruitment and the retention of mid-career GPs who are becoming dissatisfied with general practice and wish for more prestige and renewed challenges (237). GPs in the UK that are able to extend their role through a defined pathway as a GP with a Special Interest (GPwSI) report increased intellectual stimulation and self-esteem (238).

#### *2.5.2.2 Positive Perceptions and the role of student recruitment*

There is a growing body of evidence that indicates that recruitment into general practice is increased, especially in rural and underserved areas, by selecting students with a rural origin (159, 218, 239, 240) or with experience living and working in underserved areas (241). Including rotations in general practice in rural and high need settings also has beneficial effects, as learning experiences have been found to affect their subsequent choice of specialty (242, 243). Positive perceptions influencing students selecting general practice as a career choice include the perceived lifestyle and work-life balance (159, 228, 230) and flexible training requirements (244).

North American studies that have used parental occupation and educational achievements as a proxy for socioeconomic status have found that medical students with non-physician parents or parents without postgraduate qualifications are more likely to enter primary care training (160, 245, 246). In NZ older graduate entrants to medical school ('Other Category' at Otago) are more likely to stay in NZ to practice and to specialise in general practice (247). Māori students and recent graduates are also likely to be interested and enter into general practice (248) with a major motivation being able to have a positive impact upon Māori health outcomes (249). Therefore it is crucial that students from a wide range of backgrounds are recruited into medical school and that all students have training exposure to high need regions as these actions could increase the workforce supply to these areas (250-252).

The Medical Training Board argues that medical schools need "to build the confidence of medical students and doctors in training in the extended significance of general practice in the

health service” (15) as many more medical students need to be directed into general practice to meet the forecasted population demand. They believe that:

*“the end purpose of medical training is the development, by design and not good fortune, of a competent medical workforce: the right number, the right type, in the right location and providing the right care”* (15).

The increased input by HWNZ to promote general practice to graduates and the extra \$3.8 million dollar funding the government has allocated toward increasing the number of GP training places may finally be having a positive effect upon junior doctor career intentions. The RNZCGP had their largest number of applicants for the 2014/14 GP Education Programme (GPEP) intake (253).

### 2.5.3 Medical School Social Accountability

However studies of NZ medical school intakes have found that they are not as diverse as would be hoped as they do not represent the sociodemographic makeup of NZ society (104). Māori and Pacific peoples and people from low socioeconomic and rural regions have been consistently under-represented in comparison to their numbers in the NZ population, while students of European and Asian background and those from urban areas are over-represented. Because of the research associating student origin with future place of practice it is essential that there is a diverse medical student body in order to address workforce shortages in hard-to-staff areas and to ensure that patients have sufficient choice available to them for health care services.

Kuczewski and Brubaker (254) stated that creating a diverse medical workforce was an ethical obligation for medical schools, incorporating the principles of beneficence and social justice towards underserved communities and patients. They believe that fulfilling this obligation creates a diverse group of graduates that are “fit for purpose” within the health workforce and who are more likely to meet the needs of a diverse range of individuals. This has been recognised by the University of Otago’s Division of Health Sciences which states within their admissions policy:

*Ideally the make-up of health professional classes should be equivalent to holding a mirror up to society. In order to achieve this we aim to attract and support the most academically able students from a wide variety of backgrounds. The gender, ethnic,*

*socioeconomic and rural/urban composition of our graduates should, more or less, reflect the diverse communities in Aotearoa (104)*

The WHO defines the social accountability of medical schools as “the obligation to direct their education, research and service activities towards addressing the priority health concerns of the community, region and/or nation that they have a mandate to serve” (255). This emphasises the ability for social accountability to enable medical schools to address issues of equity, particularly toward those underserved by the current health care system.

In recognition of this, Deans of Medical Schools in Australasia and the Pacific have established the Medical Deans Social Accountability Coalition (MDSAC). This working group aims to look at the challenges facing medical schools in being capable of forming “the kind of doctors required by evolving health systems, and to respond to the health concerns of society” (256). It could be argued that the kind of doctors currently needed by New Zealand are those that are intent on training in general practice in order to reduce the critical shortages in this workforce and because of its’ gatekeeper role. The Medical Training Board also recognises the low representation of Maori and Pacific people in the health workforce as a priority issue but, they believe that it needs to be addressed at the secondary school level (15).

In the UK, targeted programmes for underserved communities aim to widen access to medical careers and overcome the barriers that exist for low socioeconomic students in particular (257). Gorard et al (258) stated that there are three key barriers which can stop these students from accessing higher education: situational barriers (cost, time and distance involved with travelling for educational opportunities); institutional barriers (availability and flexibility of opportunities offered by the institution); and dispositional barriers (the individual and their own attitudes and motivations toward education). Medicine suffers from an additional dispositional barrier of being stereotyped as an elitist profession for white rich men (259) or for the ‘very brainy’ (189). Various health sciences programmes, both nationally and internationally, and at the secondary and post-secondary levels, have aimed to overcome these stereotypes and rectify the ‘leaky pipe’ of the schooling system (193, 196). However, as of yet, no targeted affirmative action policy exists at either of the NZ medical schools for low socioeconomic students.

## 2.6 Definitions of Need for Health Care

Definitions of need for health care vary according to the country of enquiry. It has been stated that that health need is simply an individual’s level of illness and how that illness and its’ required level of care has been perceived by the patient and the health care system (67).

However more recent definitions of need have begun to recognise the role of the population group and the area in which an individual lives in determining, and being capable of representing, a population's level of need (65). Researchers have divided these determinants of health into macro and micro levels. Macro-level health determinants operate at a population level and include a country's environment, its' natural resources and its' socio-economic position because these all determine how wealth and health-related resources are distributed. While at the micro-level, health determinants operate at an individual level and can include personal income, housing, education, nutrition, alcohol intake, smoking habits and access to healthcare (127). These health determinants can impact and increase both a population's and individual's level of health need.

Ronald Andersen, an American professor of health services included health need within his 1968 model of factors that determined health service and that could lead to equitable or inequitable access between individuals. His three factors were predisposing factors (e.g. ethnicity, age), enabling factors (e.g. financial means, family support) and need. This need can be both a perceived and an actual, evaluated need for healthcare. Thus need is divided into a patient's subjective evaluation of their level of illness as compared to a clinician's objective evaluation and measurement of need (260).

In New Zealand it is generally accepted that relative population deprivation, and therefore, by association, need is covered by the NZ Deprivation Index (NZDep2013) (186) due to the strong associations between deprivation and morbidity. Nine variables relating to deprivation from the 2013 census are weighted to form an ordinal scale from 1 to 10, where 1 is the relatively least deprived and 10 is the most deprived. The score aims to express eight dimensions of deprivation.

<b>Dimension of deprivation</b>	<b>Description of variable (in order of decreasing weight in the index)</b>
Communication	People aged <65 with no access to the Internet at home
Income	People aged 18-64 receiving a means tested benefit

Income	People living in equivalised* households with income below an income threshold
Employment	People aged 18-64 unemployed
Qualifications	People aged 18-64 without any qualifications
Owned home	People not living in own home
Support	People aged <65 living in a single parent family
Living space	People living in equivalised* households below a bedroom occupancy threshold
Transport	People with no access to a car

\*Equivalisation: methods used to control for household composition

*Figure 2.2: Deprivation Variables in the NZDep Score 2013 (186)*

However this score has some problems when applied to the study of a communities' health need. This is because it neglects to include variables such as age and ethnicity which have a strong association with higher health need. Therefore it makes it difficult to express the increased vulnerability to poor primary care access that the very young, the very old and Māori and Pacific peoples experience. The limitations of the NZDep Score in capturing all the variables impacting upon health was acknowledged by Brabyn and Barnett (261) who included measures of age and ethnicity in order to estimate rural community access to GP services.

In addition, because Māori and Pacific peoples are more likely to be socioeconomically deprived it can be difficult to separate the ethnic inequalities in health from the socioeconomic inequalities. These inequalities result to some degree, from the inequitable access to resources (262), including health care facilities and the finances to pay for care. As Blakely et al. (263) argues: "(i)n terms of the maldistribution of health by 'deprivation' ....we not only require policies targeted at deprived people/places, but also policies that prevent deprivation in the first place". These policies may need to consider the effect of racism upon ethnic inequalities in health as Māori report the highest prevalence of experiencing racial discrimination. This is



associated with lower physical and mental health and increased rates of smoking and cardiovascular disease (264).

The other main limitation of the NZDep is that the scores apply to areas rather than individual people and so the score acts as a proxy for reality (186). To overcome this issue, Blakely et al. (262) combined individual level socio-economic measures with the neighbourhood deprivation measure of the NZDep score to allow for assessment of study participants' socioeconomic position. This is to acknowledge the fact that while area-level deprivation has some important effects on health, it is not as important as personal socio-economic deprivation effects (263).

### 3 GIS and Primary Care Research

In this chapter, I define a GIS and how they have been used in primary health care research both internationally and within NZ.

#### 3.1 Definition of GIS

Geographical Information Systems (GIS) are computer-based systems used to store, synthesise, manipulate, analyse and display data that is connected through shared geographic coordinates. They allow the user to overlay and integrate spatial, geographical features with aspatial attributes such as census statistics to form maps according to queries of a database (265). This enables GIS to act as a decision support system and problem solving tool from the scale of countries to the scale of neighbourhoods (266). Most users of GIS rely on software packages such as the ESRI ARCGIS suite, however GIS technology is becoming more accessible through the development of web-based GIS applications such as Google Maps™/Google Earth™. These act to democratise map production and the use of online geospatial data, putting “powerful mapping technologies into the hands of the masses” (267) as they are free open source software (FOSS); thus acting to counter the criticism that GIS has the potential to disenfranchise potential users as it requires specialist skills in geography, cartography and data management (268, 269).

#### 3.2 GIS Uses in the Geography of Health

The study of the geography of health hinges upon the concepts of space and place. The term ‘space’ refers to the geographical position or location of limitations and opportunities that arise and affect human activities. In contrast, place is a more personal concept that describes the human significance and social experiences associated with specific ‘space’ locations in everyday life (270).

The geography of health and GIS technology have been, up until recently, primarily concerned with space and the geographical coordinates that connect data layers together in order to identify locations in space. Mohan (270) argues that the goal of health geography is to “construct accounts of why place matters” to these fields. This is because it is impossible to separate the personal experience of health care from the place where it is given and received, and the political and economic processes which govern it. The concept of ‘place’ allows for patients lived experiences of primary care to be explored in research due to its subjective qualities (79). Increasingly there is the recognition that GIS can also depict a more qualitative interpretation of place including the social and political contexts surrounding a space (106).

Broadly speaking there are typically two types of GIS applications in health geography: to map the geography of disease through health outcome and epidemiological data; and to map the geography of healthcare systems. There are also studies that utilise methods from both of these applications, for example in relation to planning for healthcare services and assessing population needs (271). Healthcare systems research focuses on the supply and demand of medical services. It can focus on specific populations to address issues of health inequality. GIS have been used internationally to map the geographic location of medical services in relation to high need population groups to determine accessibility and to aid in the planning of new services (272-274). Using GIS to visualise spatial equity to health care services is a powerful way of communicating who has access and who does not. This can be linked to aspatial datasets in order to display the potential implications of poor access.

The ability of GIS to integrate and display complex data sets means that they have been widely used in the public health sector. They have been applied to study disease surveillance (275), neighbourhood health determinants (276) and health service planning. These applications reflect the ability that GIS have to process both retrospective and real-time data for health planning, service delivery and health promotion.

However, the use of GIS in primary care is far behind public health (107, 277). This is unexpected because successful primary care health delivery requires the integration of a variety of factors that a GIS are capable of displaying. These factors may range from being able to “see the patient population better” (277) in relation to the spatial distribution of healthcare facilities to more successfully targeting health interventions for high need communities (273).

There have been criticisms that GIS have the potential to be undemocratic as they require specialist skills and access to both computers and software to allow usage (268). In developing countries this may be exacerbated by an inability to access accurate reliable geo-referenced baseline health data (278). More recent studies, in developing countries (268, 279) in particular, have focused upon decentralising GIS capabilities to enable communities to visualise and plan their own health services. Fisher (268) found that low resource community usage of GIS improved when training exercises used data from regions known to the trainee. Initiatives such as these may help to overcome any institutional inability or ‘intimidation’ at training in and implementing GIS databases. However it is essential that users have the skills to critically evaluate and analyse data and maps otherwise it can be easy to draw the wrong conclusions or misinterpret analysed data (268).

### 3.2.1 Examples of Web-Based GIS applications in Health

While international interest in GIS appeared to peak in the late 1990s as GIS software became more affordable and accessible, there has been a recent resurgence of interest as various agencies are beginning to recognise the mapping potential of GIS and the democratic nature of the internet for visualising data. The WHO (280) stated that GIS:

- *Allows policy makers to easily visualise problems in relation to existing health and social services and the natural environment and so more effectively target resources*
- *(Is an) ideal platform for the convergence of disease- specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment*

Following on from this statement, the WHO has developed AccessMod©. This is an interactive website that uses ESRI ARCGIS technology to model physical accessibility through travel time to health care and the geographic coverage of health services in developing countries (281). Providing this accurate baseline georeferenced health service data to developing countries acts to democratise access to GIS technology for these populations.

In the USA, the Dartmouth Institute for Health Policy and Clinical Review has advocated through its web-based Dartmouth Atlas of Healthcare, that a geographic focus on health is crucial for planning and health reforms to enable equity of health care access (282).

Similarly to the above websites, the recently developed Atlas of Healthcare Variation by the Health Quality and Safety Commission New Zealand, uses interactive mapping technology in order to display variations in health service use and provision across a number of indicators including asthma, diabetes and gout. The aim of this Atlas is not to establish an ideal performance level in these outcomes but rather to “prompt debate and raise questions...amongst clinicians, users and providers of health services about why any differences exists, and to stimulate improvement through this debate” (283).

Most recently, this interactive platform has been used to display research on the variation of medication dispensing for cardiovascular disease (CVD) prevention, maps showing that particular high-risk groups such as younger people, women and those of Māori and Pacific ethnicity, were less likely to receive preventative medications. Visualising the data highlighted the gaps to patients, health providers and health planners enabling improvement to be made in CVD prevention (284-286).

### 3.3 International GIS applications in Primary Care

Internationally, GIS have had little uptake in the primary care sector despite the growing research showing its' potential applications to health care planning in particular (107, 271, 277). Most primary care uses of GIS have been quantitative, focusing upon health care accessibility and availability (272, 287) as these are spatial in nature (59) so lend themselves to GIS analysis, particularly in comparing primary care access between high and low socioeconomic neighbourhoods in urban centres (274, 288) or between urban and rural communities (33). These studies have been achieved through combining spatial datasets on general practice locations with aspatial census data. This enables the identification of underserved populations and places to be linked to demographic features such as the socioeconomic status and ethnic groupings of residents. Accessibility studies aim to quantify the equity of access to primary care services as it was a key principle of the Alma-Ata Declaration to ensure that facilities were provided because of health need, not because of individual or social characteristics (79). Equity of access can vary greatly across space.

Studies of spatial accessibility to healthcare providers is a topic of great interest to both health geographers and primary health care researchers due to concerns about the impacts of inequity in service provision. Study methods have been broadly categorised into four groups: provider to population ratios; distance to nearest provider; average distance to a set of providers; and gravitational models of provider choice (119). Provider to population ratios have inherent limitations due to being a simple 'headcount' ratio of GP supply to population number. Studies using distance measures to a provider or a set of providers typically rely upon a road network analysis method using GIS. This method allows for a "relational evaluation" of service supply to population demand within a specified area so may be preferable to provider to population ratios (289). Gravitational models study the relations between supply and demand in different regions and include measures of population, healthcare provider capacity and travel times in a ratio measure (21).

Recent reviews of GIS methodology have specifically described the Two Step Floating Catchment Area (2SFCA) method as a sophisticated and popular technique developed by Luo and Wang (38) to measure GP to population ratios and identify GP workforce shortage areas. Unique among the modelling methods, it allows for cross-boundary flow of patients (147). However it does not allow cross-boundary flow of doctors, so doctors within a specified catchment area may be labelled as accessible to patients, while others outside are labelled as inaccessible. This is likely to be unrealistic if the catchments were assessed against true patient

accessibility (21, 290). Unfortunately few of the studies using this method have been verified against real-world patient data on GP choice, so most research outcomes have been measures of potential accessibility rather than realised accessibility (272). One study that did compare real patient data with GIS measures of accessibility via bus and personal transport, found that rural areas without public transport also had the highest levels of health need but the poorest access to GP services (22).

However, using real patient data in GP catchment modelling also has its problems as Allan (291) argues that studies frequently assume that an individual's place is the space surrounding their residential address. He believes that GIS research in primary care needs to reconceptualise the concept of place and its' effect on GP catchment modelling. In contrast, Allan believes that it would be more realistic to view patient access to GPs from a "range of locational concepts" including a person's daily activity space. Activity space has been defined as the spaces or areas within which a person moves or travels through regularly (292). This could affect patient choice, because, as Wiles and Rosenberg (127) reason, people may choose their GP as they do any other consumer service, for reasons of convenience. Therefore an individual may choose a GP because they are "near their homes, where they work, where they or their children go to school or even in the shopping centres and precincts where they go to buy goods and services".

### 3.3.1 International Examples of Mixed Methods in Primary Care Research Using GIS

Mixed method approaches to assessing primary care service provision through GIS are rare despite the many advantages this methodology could offer primary care research (105). The principal advantage is the method's ability to combine the objective analysis of results from the quantitative experimental methods, with the thematic analysis of the qualitative methods (293), thus enabling a comprehensive picture of a research problem (294). Creswell et al (295) recommended that a mixed methods approach be used to "add rigor" to primary care research.

Bazemore (107) used a mixed methods approach to incorporate GIS technology into the clinical management of deprived urban communities and then qualitatively assessed the clinic leaders and stakeholders responses to the process. This study identified both enthusiasm and apprehension about the concept of using GIS to inform clinical decision making. Similarly to both Boulos (296) and Joyce (297), this study found that time, the potential cost and the technical expertise needed act to limit the use of GIS in healthcare settings.

In contrast Hawthorne and Kwan (108), used interviews with low-income urban residents to assess their views of accessibility to health providers and then combined these with a

quantitative GIS assessment of distance to healthcare. This study aimed to move the focus away from a clinical managers' perception of population need and simplistic measures of geographic accessibility towards incorporating the experiences and perspectives of affected communities themselves; thus finding that once their views are included, there is a potential added distance to access care because not all patients choose to use the closest GP, or they may be unable to get an appointment because the GP is servicing a large community.

### 3.4 GIS Primary Health Applications in NZ

Use of GIS in New Zealand primary care planning, monitoring and delivery experienced a surge of interest in the mid-2000s but has been minimal and sporadic since then. Local research has focused more on the supply and 'potential accessibility' of primary care services rather than patient demand through utilisation, "realised access" data or qualitative interviews with patients on their level of use over a period of time. Patient demand has typically been estimated through practice population characteristics such as GP to population ratio.

Supply of primary care services has been estimated through studies on: primary care access through travel time (98); distance to closest GP (11, 298); the distribution of medical practices in Auckland as compared to dental surgeries (299); neighbourhood access to health care facilities depending on the level socioeconomic disadvantage (74, 300, 301) and urban and rural settings (23); and the pilot of this study that focused on the use of GIS in rural health service planning (146). These studies have all attempted to quantify the population catchment for a general practice service.

Potential accessibility to healthcare has been a key focus area as this varies drastically in NZ communities and has a direct influence on health inequalities and morbidity (2, 78, 302). There is an association between greater morbidity and being resident within a highly deprived area. This greater morbidity leads to a higher need for primary health care services. However residents in these areas often find it more difficult, for various reasons, to access health care services than people in more socioeconomically privileged areas.

The multiple definitions of what constitutes accessibility to health care suggest that it could be a difficult concept to measure quantitatively. Accessibility measurements have varied in these studies, from using the centre of a census meshblock to the closest GP (98), to a 15km distance from the central general post office (299). These forms of measurement have attempted to approximate geographic proximity for the population to a health care facility as a result of distance or travel time. This is because use of health care facilities tends to decrease as distance

and travel time increases. However using aggregated data and area centroids rather than exact population locations can cause “spatial uncertainty” and misleading results (271). Centroids are the geometric centre of a polygon and are not based upon the real population distribution within the polygon area.

Brabyn and Gower (96) compared three GIS methods to model GP access for the NZ population. These three methods were: GP to population ratio; least cost path analysis (LCPA); and a Location-Allocation model (LAM). LCPA focused on population-weighted average road travel time to the nearest GP whereas the LAM allocated neighbouring residents to their nearest GP until the full-time workload equivalent of 1400 patients per GP was reached. LAM aims to display spatial imbalances in resource allocation and has a long history of use in health geography (303). Poor access was defined as a travel time to a GP of more than 30 minutes as has been used internationally (304). American research has found that a travel time of less than 30 minutes to health care facilities, indicating good accessibility to care, was correlated with an increase in self-reported good health (57). NZ research into accessibility of hospital care through GIS modelling used the threshold of one hour to define proximity (305). Because hospitals provide secondary and tertiary level care, a longer travel distance is more acceptable than similar distances to GP services.

The Brabyn and Gower study suffers from the limitation of estimating a GP’s practice population and assuming that patients act through “rational choice” (289), minimising their travel time by going to their closest GP. This neglects to acknowledge cross-boundary flow of patients between practices and the true “revealed accessibility” or utilisation, as patients may travel further than their closest practice to receive their required treatment (108). This crossing may be due to a deliberate choice for reasons such as, an inability to get an appointment with the closest GP as they may be serving a large community or the patient may prefer the GP service in another region due to gender, cultural or other reasons.

Hays et al. (306) found that only 19% of residents in Gisborne, NZ attended their closest general practice and that prior knowledge of the practice was an important deciding factor. This finding is supported by international studies on primary care usage. A South African study (289) found that 44.26% of patients didn’t visit or use their closest facility and in the US one study found that 32% of survey respondents had bypassed their closest primary care provider (307). Rosenberg (308) argues that an alternative method to LAM would place patients at the centre of the analysis with regards to choices and decisions made about their health provider



instead of services 'selecting' patients as multiple socio-cultural (e.g., community, family) and political-economic (e.g., government policy) influences affect an individuals' choice of doctor.

Interestingly, however, in common with Pearce et al (74), the Brabyn and Gower study found that more deprived regions with higher 2001 NZDep scores were more strongly correlated with better access to GPs through having shorter travel times to GPs than less deprived regions. Field et al. (300) also found a positive association between higher levels of access to community resources and areas of high deprivation and Stangroom et al.'s (141) study on mental health patients in NZ found that individuals who lived in the most deprived areas visited their GP more often than those who lived in the least deprived areas.

This suggests that at least for some communities and some health conditions, potential accessibility does not equal realised accessibility and that other barriers besides geographical, have a greater impact on access to care. This is supported by data from the 2011/12 New Zealand Health Survey which found that 27% of adults had an unmet need for primary health care services in the last 12 months. This unmet need was mainly due to cost and/or an inability to get an appointment with their usual GP within 24 hours and was more likely to affect Māori, Pacific peoples and those living in more deprived regions (4). Issues around lack of choice at their general practice and inability to be seen within a preferred timeframe were reported by Māori participants as a barrier to access in a qualitative study by Jansen et al. (7). Similar issues regarding lack of choice were found in Panelli et al.'s (309) study on NZ rural patients' actual utilisation of primary care services. Participants expressed concerns about travel time and costs due to working hours lost in travel and practice co-payments, GP overloading issues and an inability to see their preferred gender of GP. A recent Australian study on which dimensions of accessibility were considered most important for rural residents on selecting a GP for routine health care found that preference for a particular GP and GP availability were more important than distance to and the cost of the service (310).

Farry et al's (146) study on rural planning of health services using GIS partially fulfilled the Ministry of Health's recommendation (144) that information-gathering and research on the use of GIS in rural health needs assessment be undertaken. That is because there is a real health risk to rural New Zealanders through the physical distance they need to overcome to access care. The concerns around distance and cost to access care for rural populations are worsened by government agencies being reluctant to examine the issues. Internationally, Taylor et al (311) have argued that GIS should be used as a tool to plan for future healthcare clinics in order

to maximise access to care. This could occur through forming patient catchments based upon actual travel time measurements in order to minimise travel distance for the majority of people.

Unlike international studies, primary care research in New Zealand using GIS has not, as of yet, included a mixed methods approach through incorporating the perspectives of study participants. This means that the picture of GP supply in NZ is incomplete as the focus on quantitative studies has denied the populations affected by poor primary care services the ability to express their experiences. Studies such as Brabyn and Gower's (96) would have been enriched by the inclusion of a qualitative aspect to determine if patients choose a particular practice over another and their reasons, if any, for not using the closest practice. Jansen et al.'s study (7) could have been combined with a quantitative assessment of access to complement their qualitative findings.

In addition none of the GIS primary care studies undertaken in NZ have incorporated the perspective of a non-specialist attempting to use GIS software. Considering that much of the stated reluctance to include GIS in primary care workplaces stems from intimidation at a perceived skill level required to use the software it is important that this gap in the research is filled as then other non-specialists may be encouraged at the potential for them to make use of it. While NZ research appears to be in agreement that GIS provides a powerful method of visualising health inequality, there seems to be more work needed to convince both the key stakeholders in health care planning and delivery and general practices to incorporate GIS technology into workplaces.

### 3.5 Barriers to Use of GIS in Health Settings

Higgs (278) found that there were behavioural, cultural and organisational factors behind the slow acceptance of GIS in the UK National Health Service despite there being easy access to GIS software. The reasons included a lack of spatial data-handling skills and a low level of awareness of the potential value of GIS in spatially representing population and health-needs based information. There was the understanding that to implement GIS successfully into the NHS it needed the appropriate infrastructure including staff, training, resources and a sufficient budget. Additionally there was the understanding that the GIS application had to fit the needs and requirements of the users so that its' use was optimised rather than being tailored to suit GIS specialists only. This requirement meant that the users needed to be involved in the process of developing a potential GIS application.

Joyce (297) interviewed public health decision-makers to uncover the reasons behind the slow uptake of GIS in health settings. This study found that while participants valued GIS for its ability to inform decision making, they expressed concerns about visualised data being misinterpreted or used inaccurately. In particular participants spoke of the risk of using a partial view of reality to assume causality (271). This error arises because map interpretation is a complex process that uses both perceptive and cognitive elements. Map elements such as the scale of the image, the image chosen and the colours chosen to represent symbols are not neutral and so can be easily manipulated to reinforce a particular selected message. This can lead to the “gee whiz” effect, in which GIS are used to create visually striking maps that appear to show a pattern when in reality no such pattern is evident (312).

## 4 Methods

This section outlines the methods used in this study, including study design, ethical considerations, data collection, and analysis.

### 4.1 Mixed Methods Design

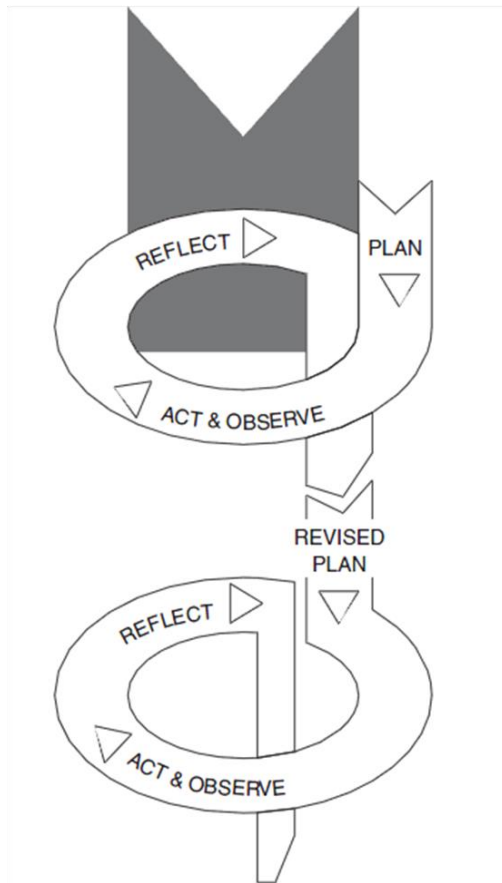
The geography of health and software systems used to visualise them, such as GIS, have traditionally been guided by, and positioned within, the epistemological positivist theoretical framework. This is because they are believed to depict a quantitative, reductionist, singular reality. However there is the growing understanding that GIS can visualise and map multiple, pluralistic realities which are increasingly including qualitative elements (106). Thus research using GIS is transitioning more toward a post-positivist epistemological worldview. Post-positivists believe that reality can only be approximated so it accepts the use of multiple methods in research as a way of capturing as much of reality as possible (313).

Mixed methods methodology is typically conducted within a pragmatic worldview that allows for a problem centred, “what works” (293) approach to addressing research questions. Mixed methods research (MMR) appeared to emerge simultaneously within multiple disciplines in the late 1980s as researchers became aware that combining both qualitative and quantitative data forms offered the most complete exploration of a research problem (293, 294, 314). It allows the researcher to merge the exploratory framework of qualitative research with the confirmatory aims of quantitative methodology (313). It is now considered as one of the three major research paradigms (315).

This study combines quantitative methodologies with qualitative Action Research thereby forming a concurrent embedded mixed methods approach to research enquiry. This ‘embedded’ design is led by a primarily quantitative approach and supported by secondary qualitative methods to expand the breadth and range of inquiry. Integration of the two research strands will occur in the analysis and discussion.

A pragmatic worldview also underpins Action Research methodology as it generates knowledge through action and experimentation (316). Action research is research done by an individual upon their own practice or within the practices of a collective, it is not research done “on” others (317). It is the research methodology of the “insider”, not that of an “outsider or spectator” (318). Therefore it allows for a qualitative subjective 1<sup>st</sup> person account of the

process involved in developing the GIS database through its critical and self-critical action-reflection cycles (318). These cycles of observation, reflection, action, evaluation and modification enable the transformation and improvement of an individual's practices leading to solutions to practical problems (319).



*Figure 4.1: Action Research Spiral (317)*

Action Research methodological practices arose from social sciences research in the 1940s. The term first being coined by Kurt Lewin in research on problems within American minority populations (320). Lewin believed that Action Research acted to help the practitioner or researcher as it generated knowledge and enabled the researcher to bring change to social systems which they belonged to. It is predominately used within educational research although it is increasingly being seen in health care settings.

## 4.2 Ethical Considerations

Prior to the project commencing, the ethical issues of the research were considered. The University of Otago Human Ethics Committee (Category A) granted ethical approval of the project in April 2014 (Ref 14/049) (Appendix A).

The Ngāi Tahu Research Consultation Committee at the University of Otago were consulted regarding the impact of this study on Māori and how the study could best represent the needs of Māori. It was recommended that the ethnicity of medical students was collected as part of the analysis on student origin. Their endorsement of the project was received in April 2014.

### 4.3 Participants

To achieve the three aims of the study there were three broad participant groups:

- All NZ general practices that were listed on DHB and PHO websites
- All general practices involved in training undergraduate 4<sup>th</sup>- 6<sup>th</sup> year medical students from the three University of Otago Schools of Medicine: Dunedin, Christchurch and Wellington in 2014
- 2014 2<sup>nd</sup> year medical students from Otago and Auckland medical schools

Exclusion criteria were 2<sup>nd</sup> year international medical students as including their home origin was beyond the scope of the study.

### 4.4 Data collection

Address location data on NZ general practices was accessed through DHB and PHO website listings. Address data on teaching practices was obtained from administrators of the 4<sup>th</sup> to 6<sup>th</sup> year teaching programmes at Dunedin, Christchurch and Wellington Schools of Medicine. Anonymised address data on 2014 2<sup>nd</sup> year student origin was obtained from the University of Otago Planning and Funding Division and the University of Auckland Faculty of Medical and Health Sciences.

Confidentiality of electronic data within the GIS database was maintained through being password-protected. The GIS database will continue to be kept securely for an indefinite period in order to allow future analysis.

A reflective journal was maintained by the researcher to identify key themes emerging through the development of the GIS database.

### 4.5 Geospatial analyses: Quantitative data

The LINZ NZ mainland contours file was the initial file downloaded to provide the base map layer on ArcMap, the ArcGIS 10.2 software platform (Esri, Redlands, CA). The database used

the NZGD Transverse Mercator 2000 projected coordinate system. This is the standard recommended coordinate system for NZ.

#### 4.5.1 Geocoding

Physical address data was spatially located through a process referred to as geocoding using the Land Information New Zealand (LINZ) NZ Street Address (Electoral) file. The dataset is released for public use under Creative Commons by LINZ. The geocoding process converts street level address information into specific latitude and longitude coordinates to the individual household level. This creates a 'point' feature that can be symbolised and identified on a map. The LINZ Street Address file was developed for electoral purposes so that all address points that may be used by electors are listed. It locates addresses within a specific meshblock which is a fundamental requirement of the NZ electoral system (Section 72 Electoral Act 1993). This allows the address to be matched with 2013 census datasets at the meshblock level for demographic characteristics such as ethnicity, age, and NZDep score. This file is updated weekly to enable events such as snap elections to be possible.

It is not possible to geocode P.O Boxes. Addresses that were not in the reference dataset were geocoded to the closest possible neighbour within the same meshblock. GoogleMaps™ was used to verify locations of addresses if there were multiple matches, unmatched addresses and if addresses were matched to the wrong location. Because of this, each geocoded record was individually checked to ensure it was accurately located as a specific point.

#### 4.5.2 Census Meshblocks

Meshblock boundaries are commonly defined by street centrelines. They are the smallest geographical unit Statistics NZ collects data on. NZ Statistics and the NZ Deprivation Score which is derived from census information can only be expressed at the minimum geographic level of the meshblock. In the 2013 census there were 46,637 meshblock units which varied in size from small urban blocks to large rural areas. They contained a median of approximately 81 people (321). The NZDep Score aggregates meshblocks so that the score covers an area containing at least 100 individuals (186). This enables generalisations to be made about an area but not about an individual.

It is preferable to use meshblock level data over the larger census area unit as larger areal units cause the 'scale effect' through reducing the number of units leading to possible increase in the measure of association. In addition, the NZDep score becomes less representative of the

population measured if a large areal unit is used as it introduces more heterogeneity into the population (322).

### 4.5.3 General Practices

#### 4.5.3.1 *Service Areas*

General practice geocoded addresses were used to calculate service areas of a 30 minute boundary limit. A service area is an area that covers all the roads that can be reached within a specified travel time limit of a location. The 30 minute boundary level was selected due to research indicating that this is the patient “ideal” limit for travel time to access primary health care (304).

##### 4.5.3.1.1 Creating a Road Network

The first step to create the service areas was to make a road network. A road network is a series of lines that are connected to form polylines which represent all the roads contained within a dataset. Every line road segment has specific attributes linked to it such as its length in metres, the speed limit and the time in minutes that it takes to travel.

To create the road network the Improved NZ road centrelines (August 2011) file was downloaded from the Koordinates website. This file is based on LINZ data but has been improved and is updated by Open GPS Maps, an open source data project. The LINZ data file required some cleaning and inclusion of necessary attribute fields. The cleaning included the removal of unnecessary line features that would create false and unrealistic travel times such as district boundary lines, railway tracks and walkways in forest parks. Some unconnected road line features required digitising through the Editor toolbar to connect them to the existing road network as they created false gaps in the service area polygons. It was also necessary to add an attribute related to travel time in minutes by relating the speed limit of the road section to its length.

##### 4.5.3.1.2 Network Analysis to create Service Areas

The road network was then analysed by the Network Analyst tool on ARCGIS to create service areas around the geocoded points in the general practice data file. The Network Analyst tool calculates distances and travel times based on the most direct and shortest route available in the road network. The analysis produces a polygon shape around each general practice point. The size of the shape represents the 30 minute travel time toward the general practice. The shape of general practice service areas can vary depending upon where they are located. In



urban areas there are typically multiple overlapping polygons because the density of practices is higher whereas in rural areas the catchments are non-overlapping as the density of practices is considerably lower. Service areas created through road network analysis provide a more accurate model than straight-line or ‘as the crow flies’ catchments based on distance alone. Using distance alone can give an unrealistic picture due to the travel time obstacles presented by different topographical features such as mountains.

The service area estimates the geographical catchment of a general practice through travel time. This geographical catchment was then used to describe the demographic composition of the patients who have access within a 30 minute travel time to the general practice. This was done through linking the service area with census demographic characteristics. In order to describe the demographic details of the service areas it was necessary to use the Union tool on the service area polygons on ARCGIS. The Union tool divided and delineated the polygons where they overlapped so that each segment of a polygon had a unique identifier attached to it. This process created a very large dataset of over 130,000 entries that was too large for the computer and ARCGIS to work with so a custom script was found by Dr Tony Moore and used to complete the process. The custom script used the dataset that contained the overlapping polygons and created a new layer with the overlaps removed so that there were no visible boundaries between service areas. The tool also added two new fields to the attribute table that contained the number of overlapping polygons and that identified the number of GPs servicing each polygon.

This dataset was spatially joined to the NZ Statistics geographic boundary file of the 2013 census meshblocks and their associated census demographic characteristics. For these to join accurately some formatting of the dataset was required as there needed to be an exact match in font and format between the joined fields. To provide some indication of the level of health need within a meshblock, this project used the readily available and widely used NZ Deprivation Score. The updated 2013 census file was available in May 2014 from the Wellington School of Medicine website, enabling this project to have the most accurate dataset available.

However, as this score does not include variables such as smoking, ethnicity or the age structure of a population in the indicators of deprivation, despite them being associated with higher health need. For this reason, these variables, and ones related to household income, level of education and unemployment rates were selected from the 2013 census to be included within

the database. The average number of general practices servicing each NZDep score (a feature linked to each polygon) was then able to be calculated for the South Island. Because data on the FTE GP number for each practice was not readily available, this calculation has the limitation of not representing the average number of FTE GPs per NZDep score.

#### 4.5.4 Teaching Practices

The teaching practices were formatted into an excel spreadsheet to be uploaded into the ARCGIS platform. They were then mapped as point features to visualise the number of teaching practices used by the three University of Otago Schools of Medicine in 2014. They were also compared to the NZDep Score of the meshblock immediately containing the teaching practice.

While data was received from the Schools and included within the database about teaching practices used by 6<sup>th</sup> year Trainee Interns, this was excluded from the mapping analysis as these students select their GP placements. It was felt that it was more important to investigate where medical schools were sending students without the individual student's choice being a factor.

#### 4.5.5 Medical Student Origin

Individual student address data was spatially joined to census meshblock data to allow NZDep scores to be allocated to each student's home address. Student address data was also aggregated within the DHB boundaries using the NZ DHB 2012 boundary file from NZ Statistics. The number of students admitted per DHB was compared to the 20-24 year old population of the DHB in order to indicate areas of low student recruitment.

The DHB boundary file had a HTML pop-up box added to each district. This contained statistical information related to FTE GP to 100,000 population ratio and the census variables previously detailed as above, to indicate health need and demand within the DHB.

#### 4.6 Qualitative data

A reflective journal was kept throughout the duration of the study, using free-flowing "text as a window into experience" (323). Inductive thematic analysis of this journal was carried out. Themes were identified from this process.

## 5 Results

This chapter presents the results of this study. Quantitative results are presented before qualitative.

### 5.1 Quantitative Geospatial results

The aim of this study was to demonstrate the feasibility of utilising GIS technology in primary care research therefore the results section aims to provide a representative sample of possible maps that can be produced using the collected data. The maps presented below are in no way exhaustive of the ways in which this data could be visualised. Two maps to be used as references for the research maps will also be presented, these are the map of NZ population density and the map of NZ Deprivation scores per meshblock.

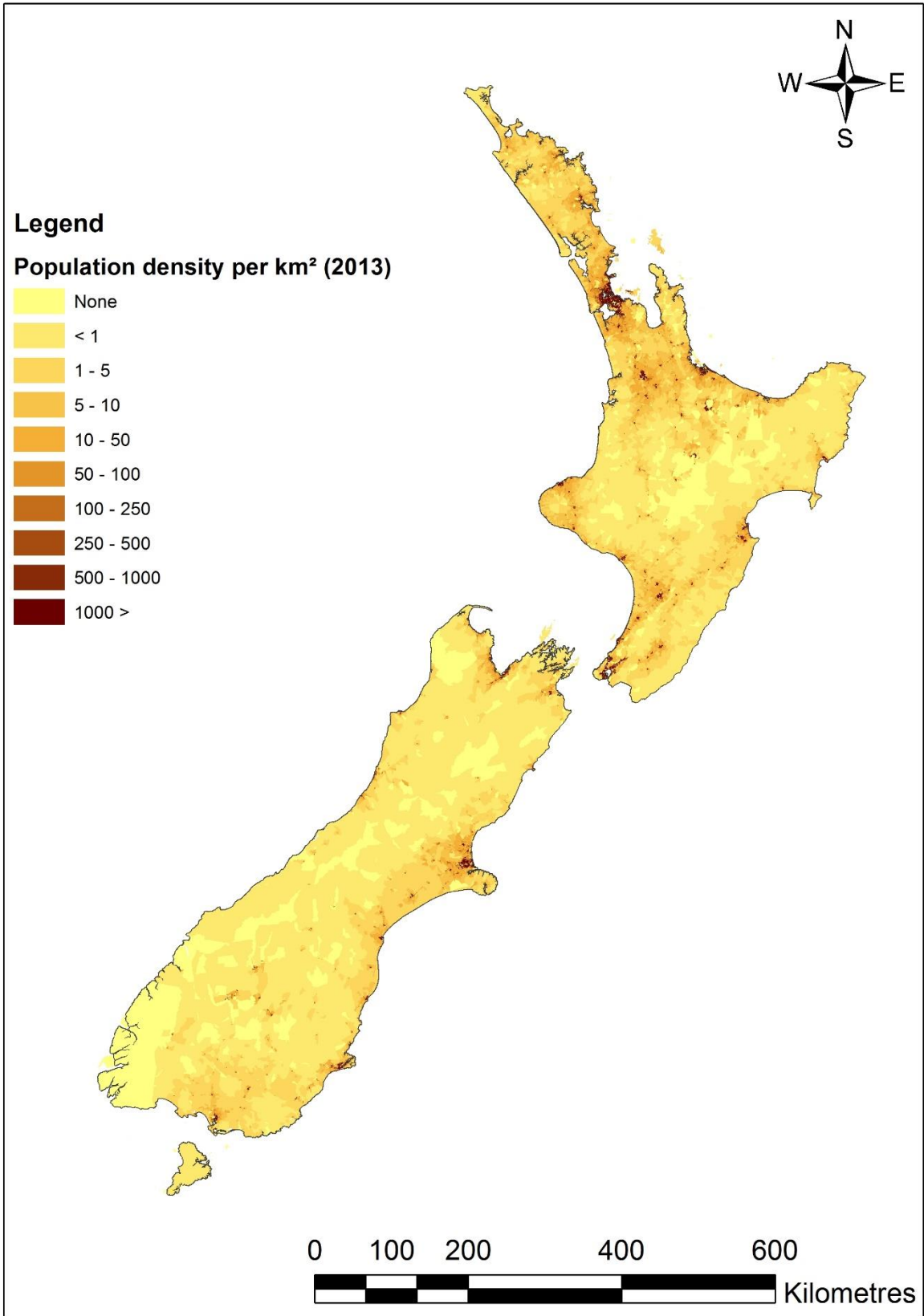


Figure 5.1: Population density of NZ: 2013 Census Data

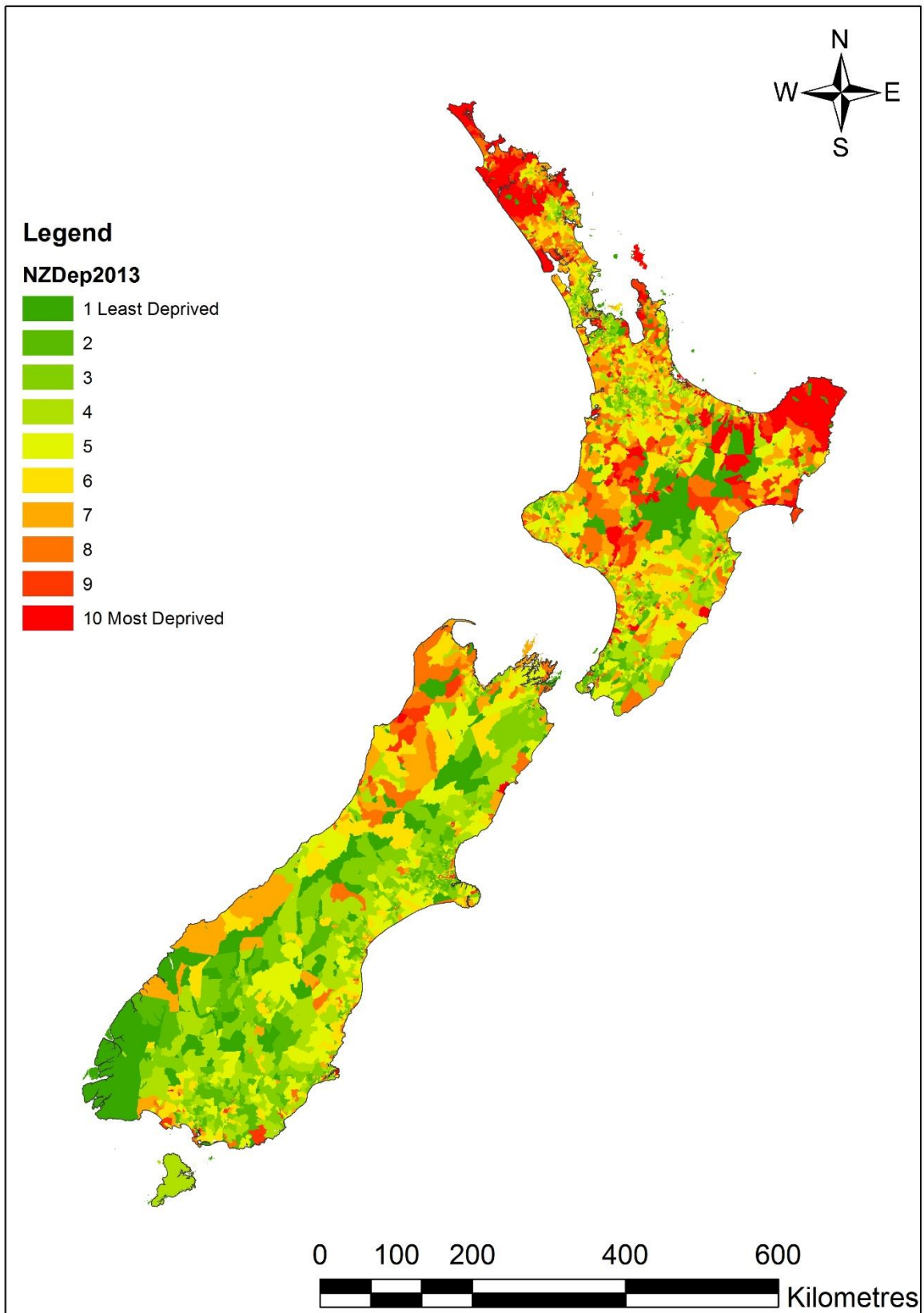


Figure 5.2: NZDep Scores 2013 by meshblock

Figure 5.1 shows the urbanised nature of the NZ population with clusters of high density populations in the main urban centres while the vast majority of the country is very sparsely populated with a very low population density.

Figure 5.2 enables the visualisation of the nationwide pattern of deprivation. Communities of high deprivation are concentrated in Northland, East Cape and Waikato. These are also predominately rural areas with high Māori populations' resident, showing the association between ethnicity, rurality and deprivation that is particularly evident in the North Island of NZ. Rural areas of the South Island are more likely to be characterised by deprivation scores in the low to middle range.

#### 5.1.1 General Practices

A total of 1064 General Practices were located and geocoded in the dataset.

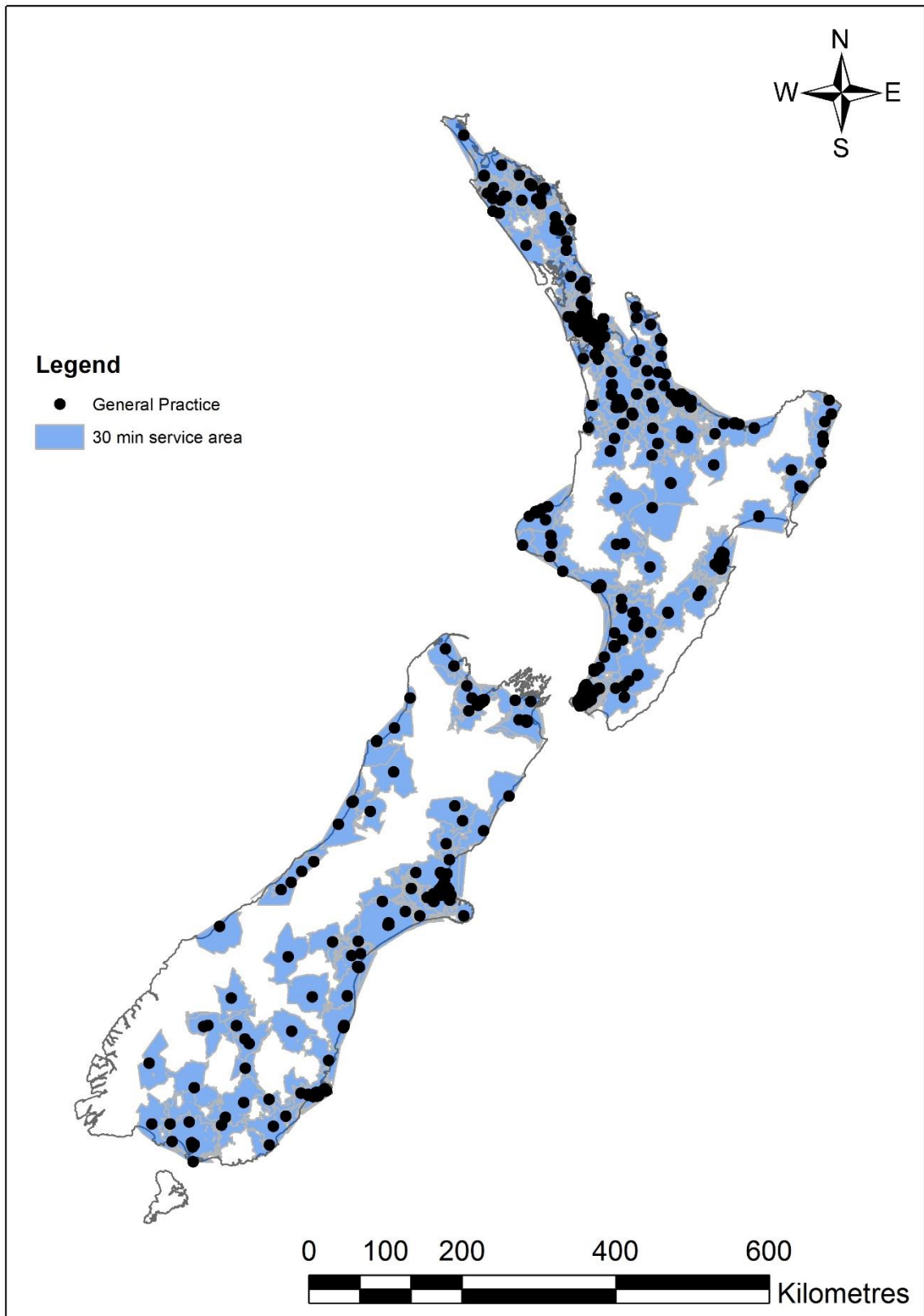


Figure 5.3: Thirty minute service areas around all NZ general practices

Figure 5.3 shows all the general practices and clinics listed on the DHB and PHO websites and the areas that are within thirty minutes travel time. The areas of very low population density are also areas missing general practice service provision. But there are low population density regions around the East Cape and Waikato which also have high NZDep Scores indicating there may be higher health need in these regions that could be unmet.

To better visualise the service level available per practice it would be valuable to have data on the FTE GP for each practice as this would more accurately depict the supply of GPs to an area. This data could then be symbolised on the map as a graduated symbol to display the level of FTE GPs per practice. In addition it would be of interest to include data on whether the rural clinics are run by GPs at a timetabled session once weekly for example, with Rural Nurse Specialists or Nurse Practitioners providing most of the care outside of that session as this would also affect GP service supply. The service areas map also does not include public transport routes. The inclusion of this would be important to pursue in future research, especially in urban regions, as many low income individuals would be likely to rely on this to access services such as health care.

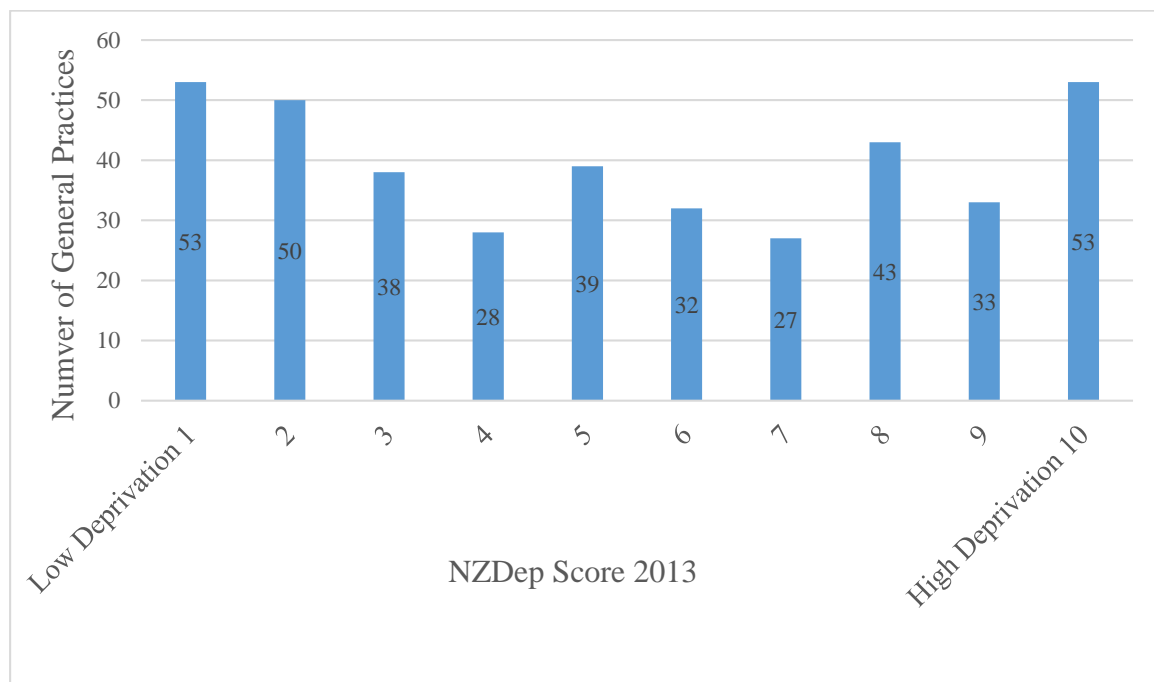


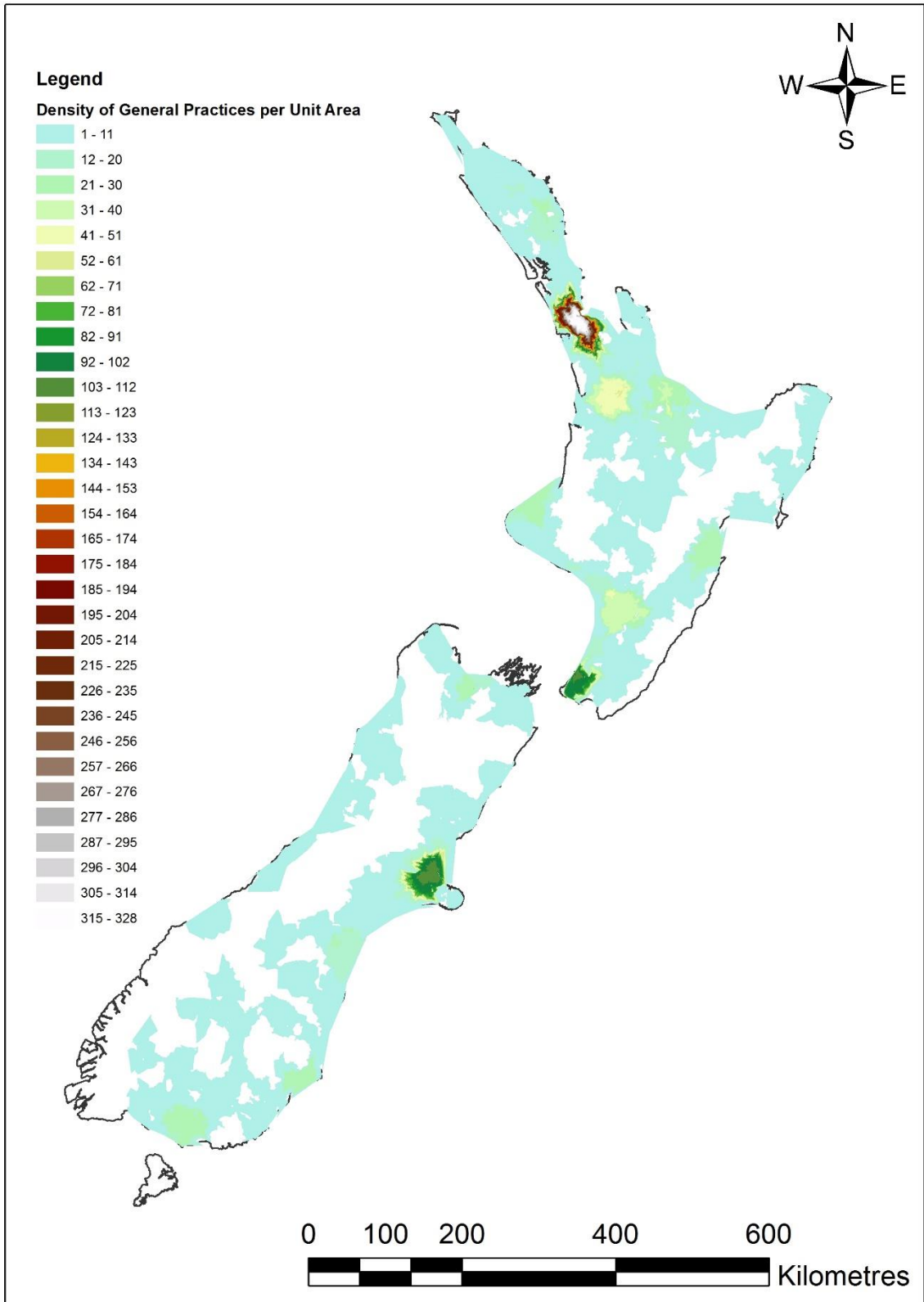
Figure 5.4: Average number of General Practices in the South Island per NZDep Score 2013

This graph shows the average number of general practices per NZDep scores in the South Island. Because the 30 minute travel time polygon of each general practice covers a number of



meshblocks with different NZDep scores the scores have been analysed to provide the average number of general practices per NZDep score.

Forty-six polygons that general practices service area boundaries covered were not allocated an NZDep Score. Missing NZDep scores are due to values being withheld from the index because of small numbers of individuals and/or missing data affecting the proportions in two or more of the nine denominators that are used to calculate the dimensions of deprivation. If the scores were not withheld then the reliability of the index value would be negatively affected (186).



*Figure 5.5: Density of General Practices over NZ*

This shows the density of General Practices over the NZ landmass with high concentrations over main urban areas compared to rural and no practices over low density population areas.

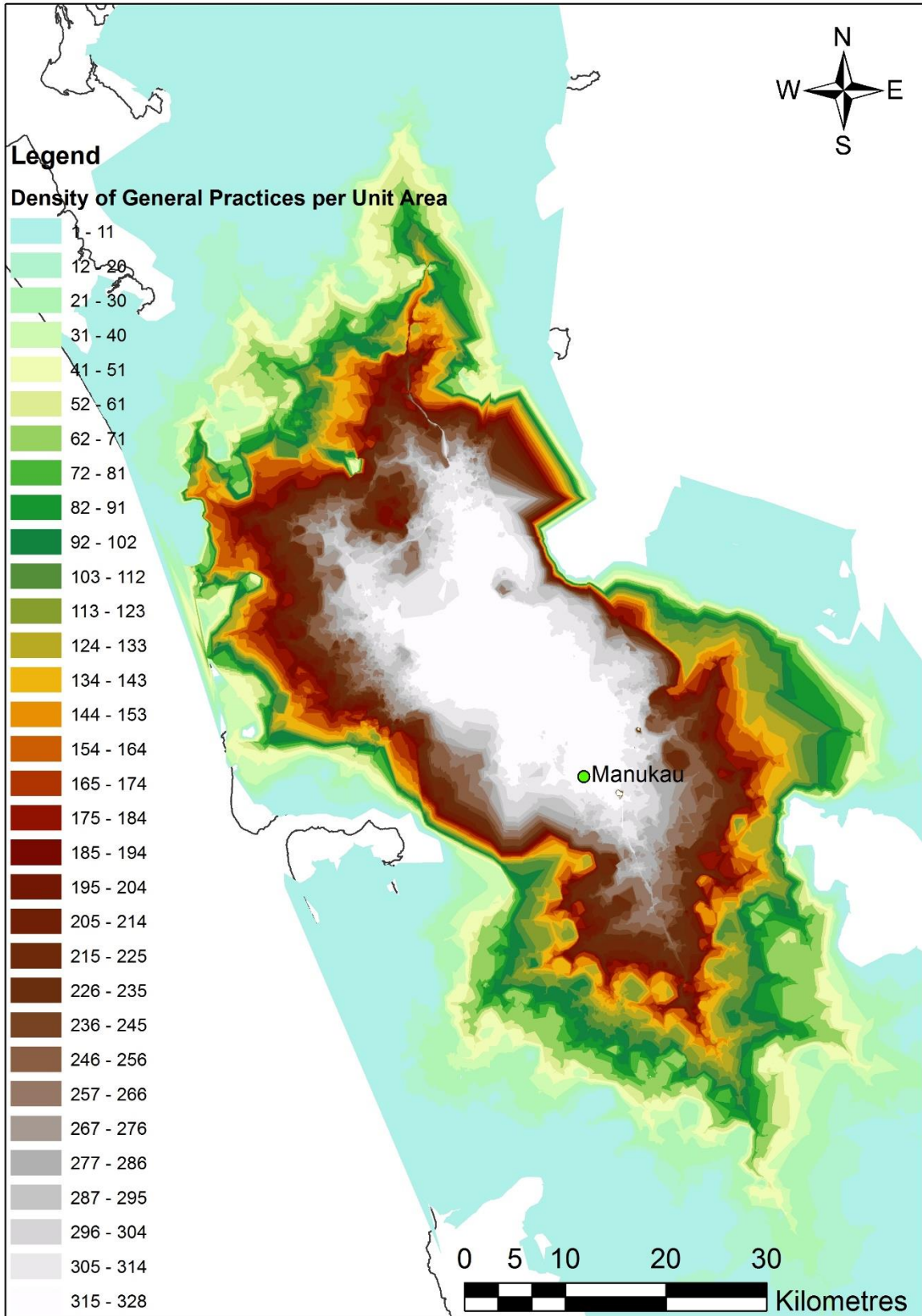


Figure 5.6: Density of General Practices over the Greater Auckland Area

It is possible with GIS to zoom in to a smaller scale to look at the general patterns of GP service provision over an urban centre or region of interest. This map shows the density of general practices increases dramatically towards Auckland city centre. This would be expected in a city where the population, jobs and services such as health care are concentrated in the centre (324) and people may select their GP based on proximity to their workplace as well as their residential address. The location of Manukau is highlighted to enable comparison with Figure 5.7 which displays the location of general practices in comparison to the highest quintile NZDep Scores over the area.

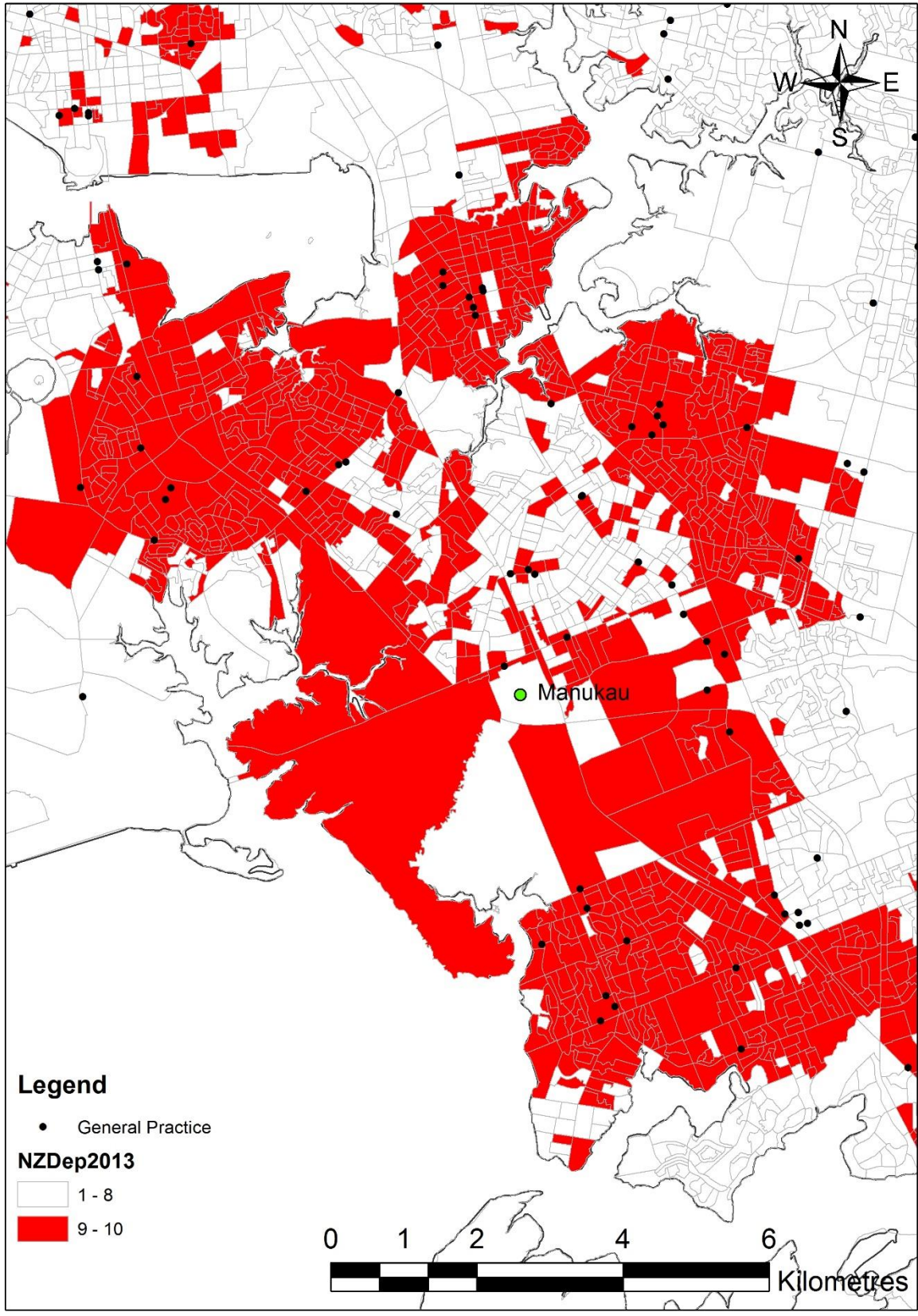
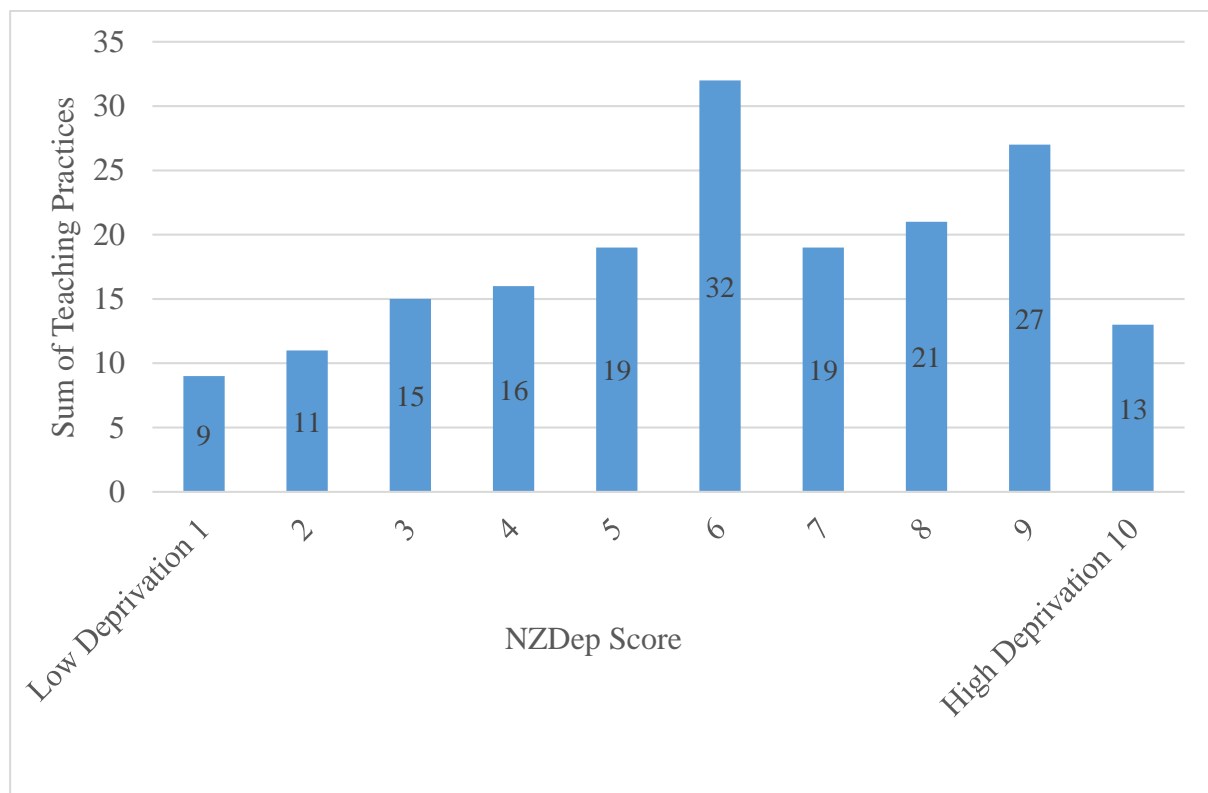


Figure 5.7: Location of General Practices in Counties Manukau DHB with the highest deprivation scores and population density as represented by meshblocks

GIS can then zoom closer in to see the actual detail of general practice locations and where they are located in relation to deprivation, and by proxy, health need. Counties Manukau DHB is of interest because there is a low FTE GP per 100,000 population and a high percentage of their population resident in high deprivation areas. This picture would be enhanced by FTE GP numbers being linked to each practice so that the practice could have graduated symbols depending on their FTE number. This would more accurately show areas that would benefit from more practices due to low FTE GP numbers and a high population density.

### 5.1.2 Teaching Practices

A total of 186 teaching practices that trained students in 2013 were located and geocoded in ArcMap. The data from the three University of Otago Schools of Medicine was merged to form one data layer.



*Figure 5.8: University of Otago Teaching Practices with NZDep Score 2013*

Figure 5.8 is based upon the NZDep Score applying to the meshblock containing the general practice and not upon the service area averages as in the general practice example. Therefore this score represents the immediate area containing 100-200 individuals within the meshblock. A great deal of caution is necessary in interpreting the above graph due to its reliance upon a meshblock level of measuring deprivation. Ideally this graph would be representing the service



<b>District Health Board (DHB)</b>	<b>% of Teaching Practices</b>
Tairāwhiti	23.1% (3/13)
Hawke's Bay	23.3% (7/30)
Taranaki	13.3% (4/30)
MidCentral	34.1% (14/41)
Wairarapa	42.9% (3/7)
Capital and Coast	50% (34/68)
Hutt	30.6% (11/36)
Nelson Marlborough	27.8% (10/36)
Canterbury	68.3% (84/123)
South Canterbury	33.3% (8/24)
Southern	54.5% (48/88)
West Coast	26.7% (4/15)

*Table 1: Percentage of General Practices per DHB that trained 4th-5th year medical students in 2014 from the University of Otago Medical Schools*

Data on DHBs north of MidCentral was excluded from the table due to the inability to access teaching practice data from the University of Auckland. In addition, it is important that these figures are interpreted with caution. The total number of general practices on the West Coast includes rural clinics which would be likely to host Rural Medical Immersion Programme (RMIP) students but this data was not included in the study. Inclusion of RMIP data would be likely to increase the percentage of practices used in DHBs that host these students such as the Wairarapa, Nelson Marlborough and Southern DHBs. If rural clinics on the West Coast were excluded then this would increase the percentage of teaching practices due to the very low number of general practices on the West Coast.



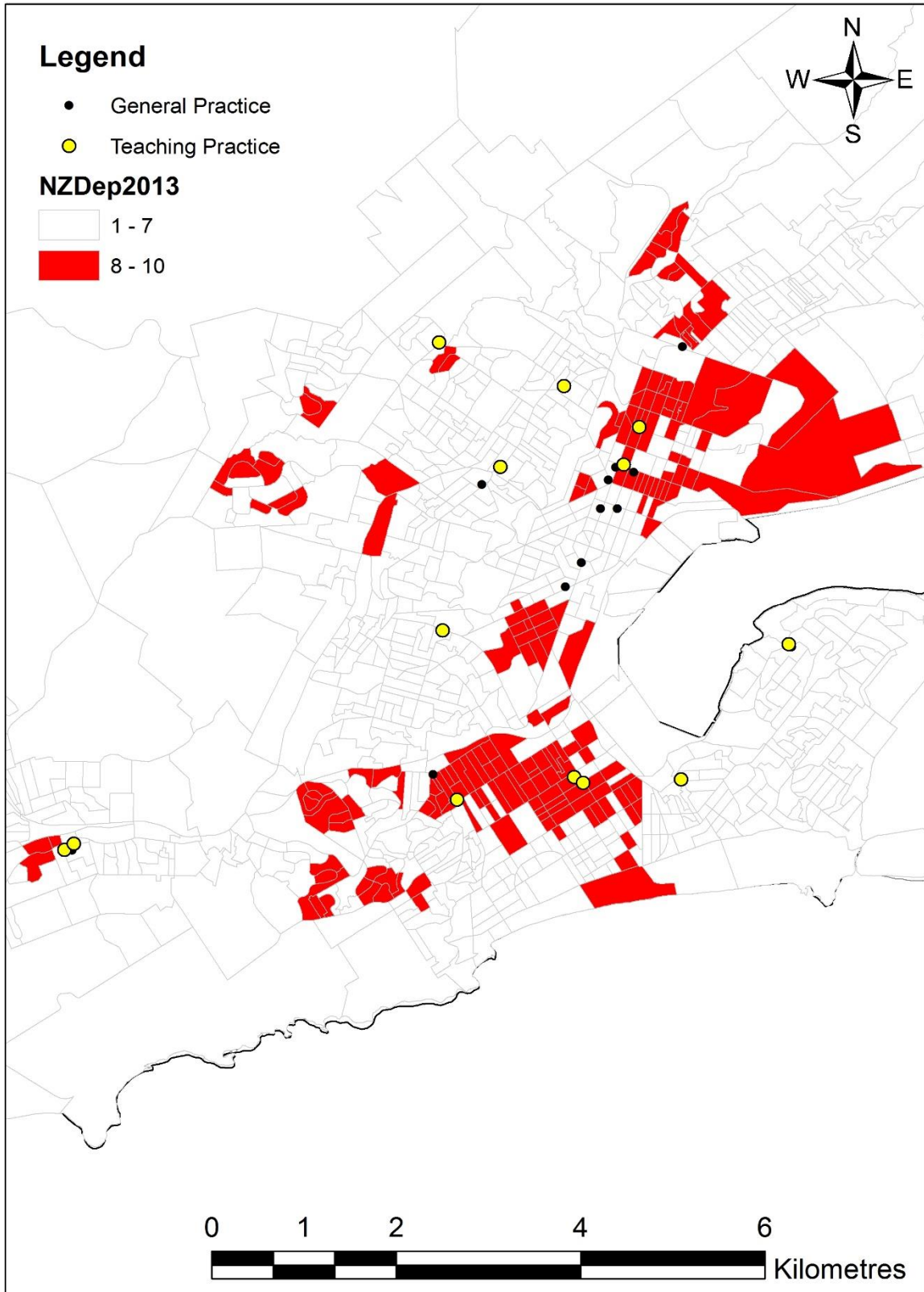


Figure 5.10: Teaching Practices in the Dunedin urban centre compared to high deprivation areas

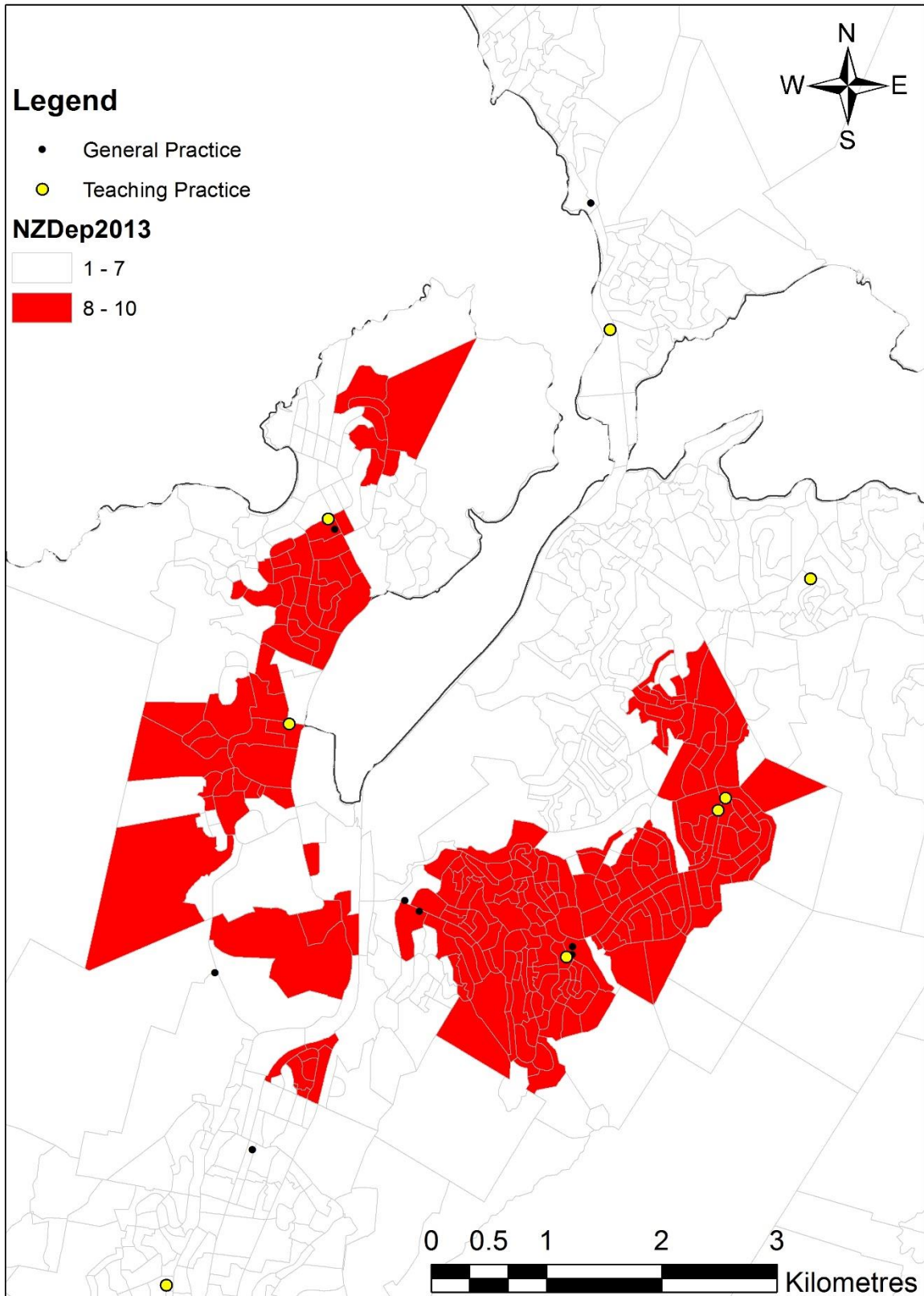


Figure 5.11: Teaching Practices in the Porirua region compared to high deprivation areas

Using GIS it is possible for medical schools to focus in on regions within their teaching catchment in order to visualise where students are being sent and to determine the potential teaching resources within the area. As a future research query it would be preferable to map service areas for teaching practices based on actual patient data as then it would be possible to determine the demographics of populations that students are being exposed to throughout their training.

### 5.1.3 Medical Student Origin

The home address origin of 495 2<sup>nd</sup> year medical students was located and geocoded in ArcMap. The data layers were merged to create one dataset. Fifteen students had nominated P.O Boxes as their contact home address. They were excluded from the dataset as P.O Boxes are unable to be geocoded. One address was not able to have an NZDep Score allocated due to the score being withheld from the index file.

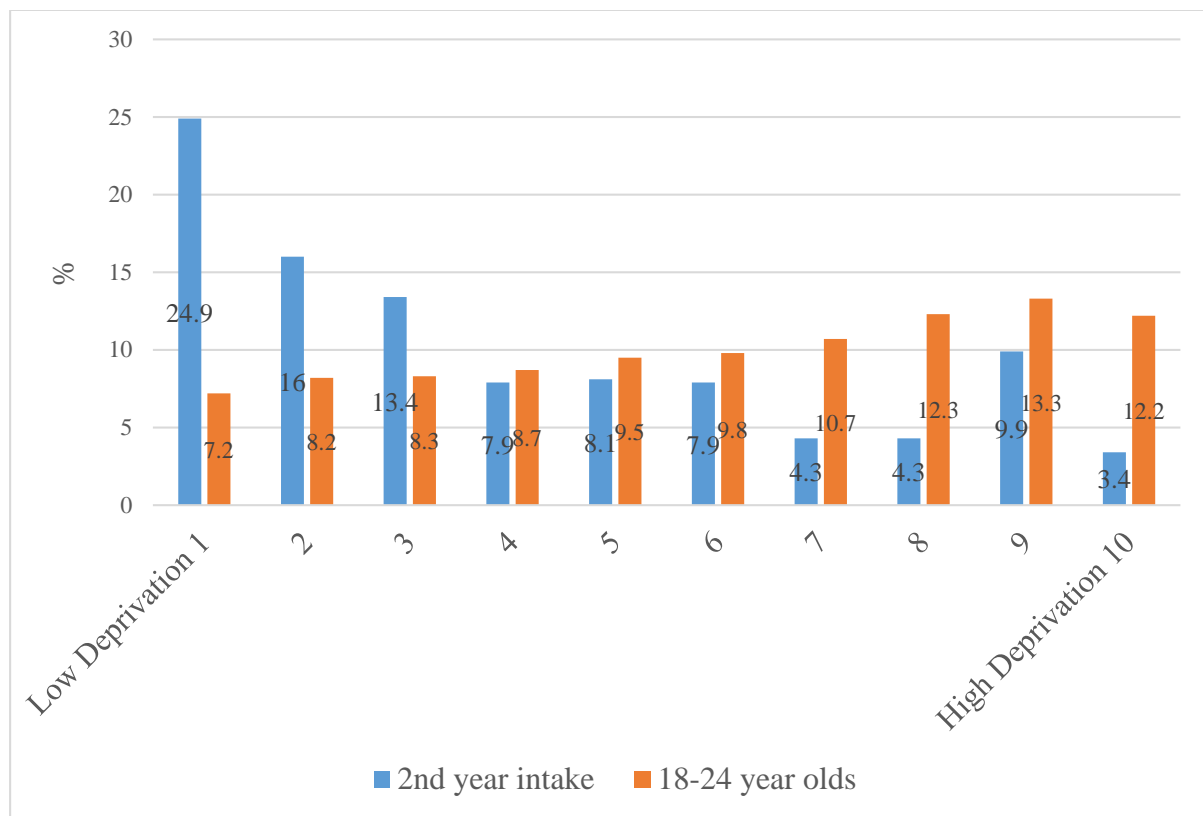


Figure 5.12: Percentage of 2nd year medical students from NZDep Scored areas compared to NZ 18-24 year olds

The majority, 40.9% (202/494), of students came from the least deprived quintiles (NZDep scores 1-2) compared to 13.4% (66/494) from the most deprived. It is likely that the peak of

students in scores 9 and 10 is largely due to the North Dunedin student quarter being listed as a high deprivation area.

### 5.1.3.1 Ethnicity

The medical student ethnic groups were analysed using ‘total response’ records (325) as both the University of Otago and the University of Auckland allow students to self-select up to three ethnic groups that they self-identify with. The total response method allows for all these responses to be recorded so that the total number of results exceeds the total number of students. Only the ethnicity of domestic students was included in the analysis as international student data was not received by the researcher. There were a total of 646 responses for ethnicity from 495 students. These were grouped into four categories: Māori, Pacific, MELAA (Middle East/Latin America/Africa) and European/Other. Students of Māori ethnicity comprised 12.2% (79/646); Pacific peoples 6.7% (43/646); Asian 25.9% (167/646); MELAA 2.5% (16/646); and European/Other 52.8% (341/646).

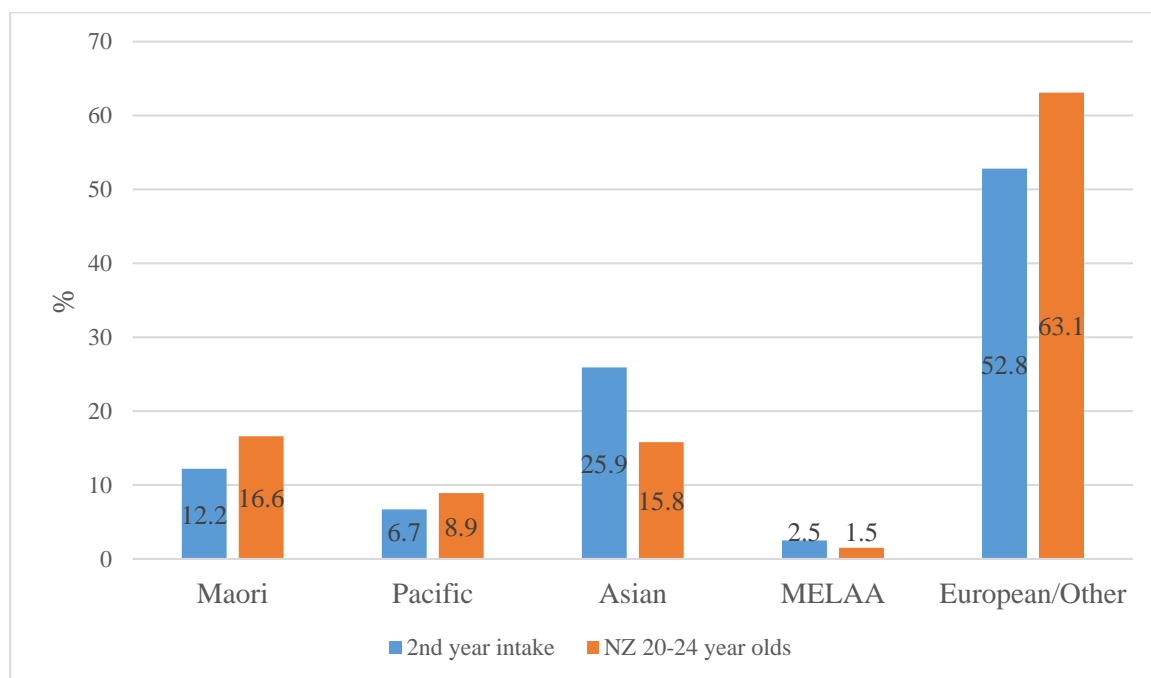


Figure 5.13: Ethnic Origin of 2nd Year Medical Students

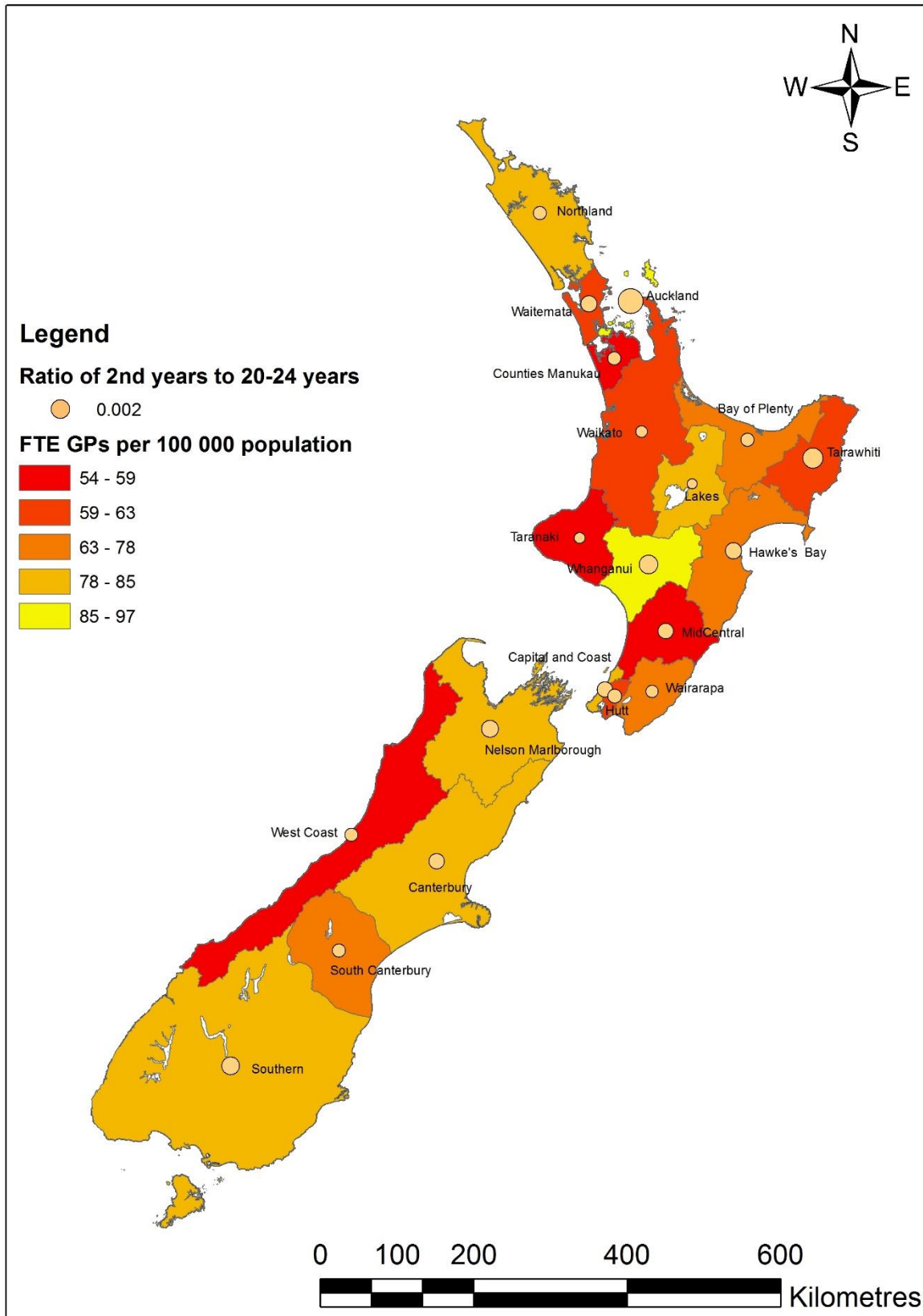


Figure 5.14: Ratio of Medical Students Admitted compared to the 18-24 year old population resident within the DHB boundary with the DHB FTE GP ratio

Figure 5.14 aggregates the student data to present it as a ratio of students admitted compared to the DHB age-matched population. This can be used to display regions of lower student recruitment such as the Waikato, Lakes, Wairarapa and Taranaki, and compare them to areas with the highest intake (Auckland, Tairāwhiti and Whanganui DHBs). It would be valuable to map data from successive intakes to determine whether regions were chronically under-represented. This map has the FTE GP per 100,000 ratio as the background to show which DHBs have particularly severe GP shortages and where it may be particularly important to focus secondary school student recruitment efforts such as Taranaki, West Coast and Counties Manukau.

## 5.2 Qualitative results

Three main themes emerged from the research journal as they were repeated throughout the data collection and input phases of the study. These themes were: the difficulties of adapting American software, tutorials and online forum advice to the NZ context; the challenges of formatting and inputting data into the GIS database; and concerns from data providers over issues of anonymity and privacy of data. Because the first two themes are related I will address these together before considering the final theme of anonymity and data privacy. These difficulties and challenges led to changes in my research processes following the principles of Action Research where challenges lead to reflection before action.

### 5.2.1 Difficulties with context, language and inputting data

ARCGIS software originates from Redlands, California in the USA, therefore its software support, online tutorials and the data used for them are based on American examples. This often made it difficult to transfer the information into the New Zealand context. Quite a considerable amount of time was spent trying to apply examples of recommended practices from the tutorials to the NZ data files downloaded to be used in the database. In addition, the software support relied upon the user having a strong background in computer programming terminology.

Wang has stated (326) that these complex “human-defined formal languages” have strict grammar rules which are difficult for non-technical GIS end-users to understand, learn and use. This reduces the ease of accessibility of GIS to those without the necessary training background or without the work infrastructure to support the learning process. Wang believes that the range of fields that GIS have been applied to, indicate that users are either prepared to persevere through this phase to reach a level of competence or have an expert in the GIS software to assist them.

Traynor stated (269) that software applications such as ARCGIS are developed with certain assumptions. These assumptions are that the end-user has prior knowledge of the technical field and “software architecture”. Because end-users often do not fulfil these assumptions but still require the software capability to answer research questions this frequently leads to end-users becoming dependent upon experts acting as “intermediaries between them and the software”. Traynor believes that GIS software are particularly prone to non-technical end-user difficulty as they combine geography, cartography and database management: all requiring computer-literacy and the time to learn the software architecture.

Fortunately, as I discovered, once competence in a specific task such as geocoding has been reached it is typically straightforward to repeat. However, sometimes tasks that should be straightforward become riddled with error messages that do not indicate the true reason behind the error. Sometimes in such situations, online forums were useful to explain what the error was, but it was not always possible to overcome the problem. This could have been due to limitations of the computer to process the datasets as they became larger. For example, the 2013 census meshblock dataset had 46,637 entries which were unioned with the 1064 GP service area polygons in order to extract information on supply of GPs in high versus low need areas as defined by the census variables. The personal computer I had for the project was unable to cope with this process and regularly ‘crashed’ in just the preliminary steps. I was fortunate enough to have the support of the GIS specialist, Dr Tony Moore in the Surveying Department who offered to complete this union procedure on his office computer. Unfortunately the ARCGIS method of carrying out this procedure would not work either so other web-based techniques were used instead.

This emphasised to me the importance of having specialist support with this software as it was particularly invaluable in the analysis phases of the datasets. Technical support in the analysis phase is important because specialists are able to understand how to extract the necessary information out from the data in a time-efficient manner. Without this specialist input I am unsure whether I would have known best how to visualise the solutions to the research questions. The analytical phase is in contrast to the data input phase which was relatively straightforward and was characterised more by repetition of key tasks until the data was successfully housed in the database. But the data analysis was where a specialist understanding of what the data could be used to show was crucial.

### 5.2.2 Concerns over anonymity and information privacy in geotechnologies

This study faced some reluctance to provide data due to concerns about whether it was appropriate to do so. Interestingly this concern was not from the ethical committee who gave approval for data gathering but from departments requested to provide data. Unfortunately the missing data reduced the strength of the research outcome for one of the study questions. International studies have also found that concerns over spatial data confidentiality and privacy of individual information have been found to limit the use of GIS (271).

Most legal issues related to applications of GIS are concerned with the collection, ownership, access, retention, use and distribution of geographic data at either the individual or collective levels (267). This is primarily due to concern around individual privacy and data accessibility issues. Westin's (327) 1967 definition of privacy states that "privacy is the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others".

A key concept in new American legislation is that of locational privacy. This entails an individuals' right to decide how much locational information about them should be conveyed to others (328). According to Sui (267) location is an integral part of somebody's identity "as where we are often reflects and defines who we are". Maintaining locational privacy and the spatial confidentiality of individuals is increasingly under threat from geographic mapping technologies. But as Boulos et al., (329) assert, there will always be some level of trade-off between maintaining data privacy and getting the most accurate geographical analyses of a particular dataset. Techniques like spatial generalisation through aggregating and anonymising individual detail are important methods to protect an individuals' location privacy with GIS technologies (267, 330).

Information privacy in NZ is regulated through the Privacy Act 1993 and the Privacy Commissioner whereas patient privacy is dealt with through the Health and Disability Commissioner Act 1994. The Health and Disability Commissioner has argued that complaints over breaches in patient information privacy should be dealt with by both commissioners through a Memorandum of Understanding (331).

The NZ Privacy Act resulted from the increased use of technology changing how privacy operates and how access to personal information could occur (332). This Act embraces Moor's theory of "control restricted access" (333), meaning that access to personal information should be restricted once it has been collected by an external agency. This recognises that current



technologies make it virtually impossible for an individual to maintain complete control over their personal information but that agencies should act in the individuals' best interests by protecting and managing their data (334).

Boulos et al., (329) argue that "self-policing" of maps for publication is still the most important issue for researchers to be aware of. In particular, they believe that researchers should question whether it is necessary for a map to display individuals at a 'point-level', from which a person's identity could be traced back. This study had individual address data for medical students that could potentially have been displayed at the point-level, however the final results produced aggregated these students into the NZDep Score and DHB levels in order to preserve their locational privacy. To further preserve their privacy, access to the database was restricted to the researcher and two supervisors for the duration of the project.

## 6 Discussion

In this section I discuss the results, describe the limitations and the implications of the research

The emphasis of this project was upon the demonstration of feasibility of using GIS as a research and planning tool rather than on the interpretation of the results that the tool produces. The accessibility of general practice services, the location of teaching practices and the origin of medical students in New Zealand may be useful for planning and policy purposes at some point but all would need greater expansion and more in-depth research to produce conclusive, generalisable results.

### 6.1 General Practices

The network analysis has produced the most current and up-to-date picture of general practice accessibility in New Zealand. The data resulting from these analysis comprises of 1064 general practices or 'points of supply', linked to service area polygons containing 2013 census demographic information including the NZDep Score. This method has shown that physical accessibility to general practices varies considerably throughout New Zealand but that the presence of clinics in rural areas is reducing the shortage of medical services and increasing the access of these populations to health professionals such as Rural Nurse Specialists and Nurse Practitioners.

The maps of NZ with the density of GPs overlaid made it possible to visualise the effects of urbanisation upon services such as health care. While regional and rural areas had low to moderate levels of GPs due to the low population density in these regions, main urban areas such as Auckland had a high density of GPs. NZ Statistics predicts that main urban centres, satellite urban and rural areas with high and moderate urban influence will experience the greatest increase in population over the years 2001-2021 (335). The better availability of services and amenities in urban and peri-urban areas drives greater urbanisation of the population as cities then become more attractive to young professionals, the growing middle class and immigrants (324). Services such as GPs, pharmacies (102) and hospitals (305, 336) then follow the urbanisation of the population and become concentrated in urban areas. This then affects regional and rural areas as it becomes uneconomic to effectively provide health care services to small, dispersed populations (337).

This is reflected in the results for the average number of General Practices per NZDep Score over the South Island. There was a low number of practices in the middle deprivation scores

(NZDep4-7). These scores covered many of the regional and rural towns such as Lawrence, Rakaia, Geraldine, Golden Bay and the West Coast that would have been negatively affected by the consolidation of population and health care services into urban areas. Their access to both GPs and hospital care is likely to be reliant on travel times greater than thirty minutes duration.

It would have been of interest to expand this dataset linking the general practice service areas with the NZDep score to the North Island to see if a similar picture was apparent there. Unfortunately this analysis was hindered by the capacity of the computer to handle the large dataset from the North Island. Interestingly, in the South Island the average GP service provision covered by the thirty minute service area boundary was equal in the areas with the least deprived and the most deprived NZDep Scores. This suggests that at least in the South Island, communities in low and high deprivation areas have good service supply, perhaps because they are located in urban regions and that poor service supply is more related to rurality than socio-economic deprivation.

#### 6.1.1 Limitations

Because the service area catchments in this study are not based upon actual patient utilisation data but upon where the practice is located geographically, the catchment is unlikely to accurately reflect the true practice catchment. This is particularly important in the main urban areas such as Auckland where a patient's daily activity space may be more centred on their place of employment than their home so an individual's access to a GP is not necessarily constrained by their place of residence. This service area model assumes that patients would travel to their closest GP when this has been proven through research to not be the case. Ideally the service area catchment model would utilise actual data on patient choice, access and utilisation of GP services as this would be a more realistic representation of the geographical extent of health services and patients' 'realised access'. But this data was not sought by the researcher as it was beyond the scope of the study and would potentially be difficult to access (277). In spite of this, the service area method was selected through consultation with a GIS specialist because the technical process would be within the skill level of the researcher as a novice GIS user. In addition it was thought that the results could be used to provide evidence of the potential feasibility of using GIS software in NZ primary care research.

The service area boundaries also carry the risk of the "tyranny of zonation". This is where artificially fixed boundaries create a false binary relationship between access and non-

accessibility (338). A further problem then arises because this study related the catchment of the practice to area deprivation and need measures. The problem then becomes that health care or practitioner catchments do not follow census area boundaries as the practice draws patients from many small areas. The risk then is that the census based data assigned to the practice is not accurate so few, if any, generalisations can be made about the catchment characteristics (339). The remedy for this would be a survey of the actual patients utilising the practice so that the demographic data is accurate and the catchments can be re-drawn based upon this.

Research based on this method may help to explain the ongoing high level of reported unmet need for primary care in NZ. Because it could suggest that the availability and potential accessibility to services does not guarantee their utilisation (68). This is because measures of potential accessibility may neglect to include individual preference so it is important to include actual utilisation as an indicator of accessibility. This highlights the need to include qualitative aspects to studies to determine why patients choose a particular clinic over another and their reasons for not using the closest facility. The problem of accessibility is not just the location or number of clinics but also other factors.

Additionally, because census units of measurement such as area units or meshblocks unnaturally aggregate individuals in geographic space to enable individual data confidentiality this can lead to an overestimation of the strength of the relationship between the individual and the area. This is called the ‘modifiable areal units problem’ (322). In particular, the accuracy of NZ census data is affected by the withholding of data in spatial units with very small populations. In this project, the suppression of data led to some general practices and medical students missing data on NZDep Scores and other measures of need.

Accuracy is also affected by the five-yearly interval between censuses in NZ. Fortunately this project had access to the most recent census data available and the analysis is focused on the period around the date of the census. But the database will become less accurate with time until the next census is collected and the database is updated with this. Additionally, the Christchurch earthquake delayed the latest census by two years affecting some comparisons between this census and those previous. This region has undergone considerable migration and urban redevelopment since the earthquakes which could affect the accuracy of research linking geography with population health and its needs (340).

The dataset upon which the 30 minute service areas was calculated has some limitations around the speed attribute allocated to roads. The speed limit attribute is not the legal speed limits but

the actual speed a car may travel at on a particular road e.g., most residential streets are specified as 40km/h as they allow for this speed more than 50km/h. The validity of the data also depends upon the file having been very recently updated, especially for Christchurch whose travel times may have increased considerably after the 2010-2011 earthquakes affecting roads. The file does not go into the high level of detail for particular regions so the service areas in Christchurch may be smaller than depicted due to longer travel times to a GP.

### 6.1.2 Research Implications

To expand the dataset on general practices, it would be valuable to include the numbers of FTE GPs per practice and what level of nursing services are available e.g. whether there are nurse practitioners who are able to dispense medications as these factors could increase or decrease the service provision to these communities. In addition, with the advent of e-health or telemedicine services for GP consultations in rural areas such as the West Coast and the Eastern Bay of Plenty, a future line of research would be to map the geographical areas using these digital methods and to interview residents on their perspectives of these services as to whether they are as accessible as face-to-face consultations. Qualitative perceptions of accessibility could be explored from a number of perspectives and then compared with the physical accessibility results derived from this study. E-health methods may lead to changes in peoples' activity patterns so that inferences about individuals by combining areal units and socioeconomic data in a GIS may become more problematic unless a qualitative perspective is incorporated.

## 6.2 Teaching Practices

The teaching practice data showed an encouraging range of communities that practices were located in and students were potentially exposed to with 72% of practices located in the middle to highest deprivation areas (NZDep scores 5-10). The map of South Island practices shows that there are a high number involved in teaching suggesting that some DHBs may be reaching saturation point. This is especially evident in the high-scale map of Dunedin where most of the inner-city practices are teaching practices. Data on whether the other practices were teaching PGYs or GP registrars was not available, however this may explain why they do not participate in teaching undergraduates. Also because this dataset is only from one year of practices used by medical schools it may change yearly with some practices opting to teach or not to teach in particular years for various reasons.

### 6.2.1 Limitations

The teaching practice data is not a complete census of practices as only the University of Otago's data was accessible due to concerns about privacy of data. The data spread of practices for the Otago schools reached as far north as Taranaki and the East Cape of the North Island so there is a considerable part of the national picture missing. It would be incredibly useful for future planning to have the complete dataset to map a nationwide census of teaching practices. This complete dataset could include data related to whether a practice teaches other years including PGYs and GP registrars as this may explain why some general practices do not participate in teaching undergraduates. This could then be related to their capacity for students as it would be very important to know which practices have the ability to host more students due to the increasing student numbers.

Unfortunately this study was not able to extract the service area and NZDep score data related to the teaching practices as was done for the South Island general practices. This would have been a more valid method of describing the demographics of the communities surrounding a teaching practice than using the individual meshblock score for the practice as this score only applies to the area containing the 100-200 individuals resident there. Therefore it is especially important than the interpretation of the NZDep Score as applied to the teaching practice is done with caution.

### 6.2.2 Research Implications

Because of the pressure upon teaching resources it may be necessary to form a nationwide body that coordinates general practice placements for undergraduate and postgraduate students. This could increase the pool of available practices to each school and make sure that potential teaching resources are not wasted as there may be practices willing to train students but that are not used by the school within whose boundary they fall. It could also benefit students as they may be exposed to different regions and styles of practice in the different PHO and DHB boundaries. This could increase the potential for positive learning experiences and provide further opportunities to persuade students to specialise in general practice. This nationwide body could maintain a regularly updated dataset of available practices to which students were allocated to. This would ensure that each school had a sufficient diversity of practices to send their students to.

## 6.3 Medical Student Origin

### 6.3.1 Ethnicity

Encouragingly, it appears that across the Auckland and Otago medical school intakes the ethnic background of students is approaching the NZ picture. Students of Māori ethnicity comprised 12.2% (79/646); Pacific peoples 6.7% (43/646); Asian 25.9% (167/646); MELAA 2.5% (16/646); and European/Other 52.8% (341/646). This compared to NZ Statistics 2013 census total group response results for 20-24 year olds where: 16.6% identified as Māori; 8.9% Pacific peoples; 15.8% Asian; 1.5% MELAA; and 63.1% European/Other (341). So while the Asian intake is significantly higher than the NZ population, the Māori and Pacific intakes are almost equivalent to their proportion in the population. This may reflect the increasing impact of multiple programmes at both the secondary and tertiary levels and through health workforce development initiatives.

The University of Otago now has four main programme areas working to increase Māori representation in the health workforce. These programmes start at secondary school level, follow students through both the Foundation year and Health Sciences First Year (HSFY) and then act to support those students who are in the health professional programmes. As a result of this, in 2014 there was a 40% increase in the number of Māori students studying in the Health Sciences First Year programme (342). Research on Auckland medical students showed that Māori students were more likely to intend working in regional and rural settings and have a strong interest in general practice as a speciality while Asian students were the most likely to opt for urban-based careers (248). Therefore the increase in Māori students could have positive repercussions for the GP shortages in regional and rural areas in the future.

### 6.3.2 NZDep Scores

However it is somewhat discouraging to note that as has been reported in previous studies on medical students this study showed that the vast majority originate from the less deprived regions of NZ. This is in marked contrast to the distribution of NZDep Scores that NZ 18-24 year olds reside in, with a higher percentage being resident in high deprivation areas than in the low deprivation areas. Medical school cohorts for some time now have been reported as being relatively more affluent (104, 157) than the general age-matched population. Because the demographic characteristics of medical students are correlated with their future area of practice, for example students with a rural origin are more likely to return to practice in rural areas (171, 343), it is crucially important that medical schools ensure they train doctors who

are willing and able to practice in high need areas. This could be achieved by an increased demographic range in the student intake, specifically including students from underserved backgrounds.

### 6.3.3 Research Implications

This raises the question of why the programmes and affirmative action policies that seem to have been effective at increasing Māori and Pacific representation are not enabling students of low socio-economic background to gain entry to medical school. If it is a matter of social justice and in the public good for a diverse intake then it is crucial that these students, regardless of their ethnicity, are targeted for similar programmes and policies. UK research has shown that low socio-economic students tend to underestimate their chances of entering medical school even if they are academically able. They can feel alienated from it due to cultural, academic and financial differences and inequalities (259). These factors could be apparent within the intensely competitive and expensive tertiary first year for the health professional programmes and act to filter out students who have succeeded thus far.

In the UK some medical schools have introduced an alternative entry test, the UK clinical aptitude test (UKCAT), aimed to increase the intake of low socio-economic students. This test bypasses the student's performance at secondary school as an entry criterion because previous academic achievement can be affected by the type of school the student attends and is not then the most perfect predictor of success at medical school (344). In 2001 (157) there was the suggestion that affirmative action policies targeting low socio-economic students may be needed in NZ medical schools but little has been done to advance this idea.

Possibly it would be too challenging to implement, as in the NZ context it could be difficult to accurately define the requirements a student would have to fulfil to gain entry under such a pathway. Similarly to the rural entry pathway, it may require a certain amount of time experience living within a high deprivation area or attending a low decile secondary school. Or it could allow for students from low decile schools having their academic score from their tertiary first year programme being weighed higher than students who have attended high decile schools. Kings College in London has developed an extended medical degree programme that admits students from a list of approximately 100 state schools or colleges that are located in "educationally deprived" areas of inner London. Their admissions process also includes a cognitive assessment, an interview and the requirement that the student achieves a requisite grade in their final school examinations (345).



Because medical school entry is a high-stakes endeavour, if the requirements were not adequately defined the entry pathway could be open to manipulation and not act to increase representation from these low socio-economic populations. In addition, there is the financial costs to the educational institution as UK research into ‘widening participation students’ show that they require considerable extra academic and pastoral support to succeed in graduating from medical school. These students also have a higher rate of attrition (345). Interestingly, the retention rate of disadvantaged students is higher when they are financially better supported. Since the mid-2000s most Australian universities have implemented ‘equity scholarships’ targeted to students from low socio-economic backgrounds in recognition of the drop in participation of students from these backgrounds in any form of higher education (346). Since retention of medical students is important due to the large financial investment made by the tertiary institution and government into their education, targeted scholarships could be a valuable supplement to an affirmative action policy.

#### 6.3.4 Limitations

However there are limitations in the interpretation of this data. Students may nominate their study address as their home address, particularly if they are graduate or mature medical school entrants as they have spent longer away from their parent’s home and may have been exposed to more formative environments since leaving secondary school. International research suggests that graduate entrants can act to widen academic and socio-demographic diversity in medical school intakes (347). This study did not receive data to identify the graduate entrants so it could not stratify the results to determine whether this finding applied to the cohort. Because of this, this could skew the results and interpretation of place of origin as, for example, the North Dunedin student quarter is biased toward the NZDep scores of high deprivation (9-10) so a higher prevalence of these scores may be due to this.

Inaccuracies with the address file for both students and general practices can also cause errors in the geocoding process leading to spatial mismatches and the prevention of matching addresses to their correct location. This can occur from the use of post office box addresses and the address file having missing fields or misspellings. Various studies have evaluated the extent of geocoding error and positional accuracy with health address data. Cayo and Talbot found that positional error was more of an issue in rural than urban areas (348). Concerningly, this type of error can lead to the misallocation of census demographic variables to the address, and so by association, to the individual. This study had 15 students who specified post office box addresses and it could be that some of these were located in rural regions. Because these cannot

be geocoded there is the risk that the true geographic and demographic origin of these students is missing which could lead to bias in the results.

The medical student sample was limited to one nationwide 2<sup>nd</sup> year cohort which although it has the benefit of including data from both the Otago and Auckland schools of medicine, it is difficult to draw strong conclusions from, and provides limited generalizability. However as a demonstration of the utility of GIS to enable the ongoing monitoring of the impact of affirmative action policies and educational initiatives upon medical class diversity, the sample sizes could be argued to have been sufficient.

This is demonstrated in the map showing 2<sup>nd</sup> year medical student origin compared to their age-matched population in NZ DHBs. A map such as this, could be used over successive cohorts to determine whether some DHB regions are particularly poorly represented in medical school intakes and could potentially benefit from targeted recruitment and secondary school pipeline programmes. This data could be linked to the FTE GP numbers per population for each DHB as was demonstrated in the results, as some DHBs suffer from especially low GP service supply and may wish to initiate ‘grow our own workforce’ programmes similar to Counties Manukau.

#### 6.4 Feasibility of GIS in Primary Care Research

This overriding aim of this project has been to discover whether utilising GIS technology in primary care research is possible. As a non-specialist end-user there have been some difficulties in developing the database, from learning the software architecture and how to use the necessary tools, to learning the methods of data analysis from a GIS specialist, however none of these have been unsurmountable. This project has shown that it is indeed possible to learn and use the software to visualise, store and analyse data from mixed sources. Visualisation is the real power of a GIS, as it enables patterns that may not be evident to be seen (271). But the key remaining obstacle to an increased use of GIS is whether institutions are willing to invest the time, finances and human capital into the technology.

An important note is the need to maintain the database that results from this study as without maintenance and updating it will quickly lose track of the trends in general practice provision over New Zealand as it is a “snapshot” of time. Maintenance would enable multiple uses to be made of the data and would lead to improvement of the quality of the data contained within the database. Multiple uses of the data would enable the real benefit of any investment made into GIS technology to be realised (271). In addition, it would be valuable to use this database to

monitor the trends in teaching practices and student intakes over a number of years for any patterns in both to become evident.

It has been argued that a national 'spatial information' database of geo-referenced health service locations should be maintained to allow "informed debate on the accessibility of health services in New Zealand" without researchers having to re-collect the necessary data (349). Recently there have been calls for more regular and formalised methods of assessing the performance of the NZ healthcare system and to objectively measure the level of unmet need, including the accessibility, timeliness and quality of care received by patients (350). Having an up-to-date geocoded dataset of general practice and hospital locations would be crucial for this to be a possibility.

Research using an interdisciplinary team and cooperative data sharing would be essential in order to further advance the use of GIS in primary health care research. The biggest obstacles to this goal are the lack of awareness of the potential of GIS within primary care planning for population analysis and modelling at both the medical educational and DHB levels. This lack of awareness may need to be addressed so that subsequent research outcomes and conclusions are seriously considered.

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# Appendix A



14/049

Academic Services  
Manager, Academic Committees, Mr Gary Witte

14 April 2014

Dr M Williamson  
Department of General Practice & Rural Health  
Dunedin School of Medicine

Dear Dr Williamson,

I am again writing to you concerning your proposal entitled "**Geographic description and analysis of factors affecting the demand for, and supply of, General Practice services in New Zealand**", Ethics Committee reference number 14/049.

Thank you for the email from Ursula Poole on 13 April 2014, advising that your survey will be amended to include an explanation of the aim of the study, and therefore a consent form will not need to be included.

In addition, the medical student participants will now be one 2nd year cohort from both the University of Auckland and University of Otago.

On the basis of this response, I am pleased to confirm that the proposal now has full ethical approval to proceed.

Please provide copies of the finalised documentation in due course to update the record of your application.

Approval is for up to three years from the date of this letter. If this project has not been completed within three years from the date of this letter, re-approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

Yours sincerely,

A handwritten signature in cursive script that reads 'Gary Witte'.

Mr Gary Witte  
**Manager, Academic Committees**  
Tel: 479 8256  
Email: gary.witte@otago.ac.nz

c.c. Assoc. Prof. C Jaye Head of Department Department of General Practice & Rural Health

## Appendix B

### NGĀI TAHU RESEARCH CONSULTATION COMMITTEE *TE KOMITI RAKAHAU KI KAI TAHU*

Tuesday, 18 March 2014.

Dr Martyn Williamson,  
Dunedin School of Medicine - General Practice and Rural Health,  
DUNEDIN.

Tēnā Koe Dr Martyn Williamson,

#### **Geographic description and analysis of factors affecting the demand for, and supply of, General Practice services in New Zealand**

The Ngāi Tahu Research Consultation Committee (The Committee) met on Tuesday, 18 March 2014 to discuss your research proposition.

By way of introduction, this response from The Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states "Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago". As such, this response is not "approval" or "mandate" for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

*"Consultation does not mean negotiation or agreement. It means: setting out a proposal not fully decided upon; adequately informing a party about relevant information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a decision that may or may not alter the original proposal."*

The Committee considers the research to be of interest and importance.

The Committee suggests including in the research team a researcher with expertise in analysing and interpreting data by ethnicity.

The Committee suggests dissemination of the research findings to Māori health organisations including the Māori Doctors Association regarding this study.

We wish you every success in your research and the Committee also requests a copy of the research findings.

This letter of suggestion, recommendation and advice is current for an 18 month period from Tuesday, 18 March 2014 to 5 September 2015.

The Ngāi Tahu Research Consultation Committee has membership from:

*Te Rūnanga o Ōtākou Incorporated  
Kāti Huirapa Rūnaka ki Puketeraki  
Te Rūnanga o Moeraki*



NGĀI TAHU RESEARCH CONSULTATION COMMITTEE  
*TE KOMITI RAKAHAU KI KAI TAHU*

Nāhaku noa, nā



PR NTRCC

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