Patterns of care for diabetes: risk factors for vision-threatening retinopathy

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Thesis submitted in fulfilment of the requirements of the degree of doctor of philosophy

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2005

Declaration

I hereby declare that the research data presented in this thesis are the result of original research conducted by myself except where otherwise acknowledged. This thesis has not previously been submitted for a degree at this or any other university.

Neil John Orr (30/08/05)

Acknowledgements

I would like to acknowledge the great love and support of my wife Merrin Thompson during the conduct of the thesis. Also to Associate Professor Steven Boyages for his skilful supervision, and to the Orr and Thompson families for their encouragement throughout the process of researching and writing.

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Abstract

OBJECTIVES: In Australia, diabetes causes significant morbidity and mortality. Whilst the need to prevent diabetes and its complications has been widely recognised, the capacity of health care systems - which organise diabetes care - to facilitate prevention has not been fully established.

METHODS: A series of seven population-based case-control studies were used to examine the effectiveness of the Australian health care system and its capacity to manage diabetes. Six of the studies compared the patterns of care of patients who had developed advanced diabetes complications in 2000 (cases), to similar patients who remained free of the condition (controls) across Australia and for various risk groups. A secondary study investigated the role of treating GPs in the development of the outcome.

RESULTS: A strong relationship between the patterns of care and the development of advanced diabetes complications was found and is described in Chapter 4. In Chapter 5, this same relationship was investigated for each Australian state and territory, and similar findings were made. The study in Chapter 6 investigated whether late diagnosis or the patterns of care was the stronger risk factor for advanced diabetes complications, finding that the greatest risk was associated with the latter. In Chapter 7 the influence of medical care during the pre-diagnosis period was explored, and a strong relationship between care obtained in this period and the development of advanced complications was found. In Chapter 8, which investigated the role of socio-economic status in the development of advanced complications, found that the risk of advanced diabetes complications was higher in low socio-economic groups. Chapter 9 investigated geographic isolation and the development of advanced diabetes complications and found that the risk of advanced complications was higher in geographically isolated populations. Finally, Chapter 10, which utilised a provider database, found that some GP characteristics were associated with the development of advanced diabetes complications in patients.

CONCLUSION: A number of major risk factors for the development of advanced complications in Australia was found. These related to poorer diabetes management, later diagnosis, low socio-economic status and geographic isolation. Strategies must be devised to promote effective diabetes management and the early diagnosis of diabetes across the Australian population.

Chapter 1

The health problem

In Australia, diabetes causes significant morbidity and mortality and has been formally recognised as a National Health Priority.[1] Whilst the need to prevent diabetes and its complications has been widely recognised, the capacity of health care systems - which organise diabetes care - to facilitate prevention has not been fully established.[2]

In recent times there have been major improvements in diabetes care. For example, intensive insulin therapy,[3] new hypoglycaemic agents[4] and new treatments for hypertension[5] have been introduced. Improvements have been made in the organisation of diabetes care, such as through diabetes centres, patient registers and reminder and recall systems.[6] Yet, despite these developments, diabetes complications continue to occur and their prevalence may be increasing.[7]

A number of factors may be contributing to this trend. Firstly, the prevalence of diabetes has increased over recent decades leading to a much greater population at risk of complications.[7] Secondly, people with diabetes generally receive poor quality care in respect of their health needs, because the condition is difficult to manage.[8, 9] Thirdly, some of the most commonly used treatments may actually be ineffective, as only a small number have had their efficacy established in conventional health care settings.[10] In the face of the growing prevalence of diabetes and the factors that may be contributing to it, and in order to reduce the burden of diabetes, the capacity of the health care system to manage the disease needs to be established by robust epidemiological studies.

In pursuit of a greater understanding of diabetes management, this thesis takes a particular perspective. It begins from the principle that diabetes is a public health issue and not merely a clinical problem.[11] This is because of its substantial and growing prevalence, the great pervasiveness of its risk factors (such as impaired glucose tolerance, obesity and physical inactivity) among the population,[7] and also because the key metabolic disorders in diabetes are preventable through relatively inexpensive and potentially very accessible interventions.[12]

Diabetes represents a somewhat atypical challenge to the public health discipline as this field rarely concerns itself with diseased populations, focusing largely as it does on preserving or protecting health.[13] Yet, arguably the epidemiological and clinical characteristics of diabetes make the condition an appropriate public health concern. In a sense the disorder underlying diabetes – hyperglycaemia - is more akin to a risk factor for disease than a disease itself,[14] and the concerns associated with diabetes are in large part due to its complications, such as retinopathy and cardiovascular disease, which are eminently preventable.[15]

When a medical intervention is considered for use in clinical practice, ideally this is guided by whether it has been shown in clinical trials to be effective.[11] However, clinical effectiveness does not necessarily mean that the intervention will be effective in the community, or in routine settings of care.[11] Typically, when an intervention is shown to be clinically effective, its efficacy has only been demonstrated in ideal or research settings and with particular types of patient who

are suitable to be enrolled in clinical trials. This means that there is often doubt about whether clinically effective interventions will be similarly so in the broader population.[11]

Indeed, there are many examples of interventions that have been shown to be very effective in clinical trials that have made very little impact on population health.[11] There are a number of explanations for this inconsistency: the group in which the treatment was shown to be effective may not be typical of the broader group to whom the treatment is designed to be applied, or the treatment is not generally delivered to the standard at which its effectiveness has been demonstrated.[11, 16] However, only interventions effective at the population level reduce the burden of disease and are therefore of greater public health significance.[17] Such effectiveness has not been established for the management of diabetes in the Australian health care system.[11]

With regard to examining the effectiveness of current models of care, the thesis evaluates them across the Australian population using population-based case-control studies. Case-control studies start with the identification of persons with a condition of interest (cases), and suitable control groups of persons without the condition (controls).[18] The aim of these studies is to identify factors that differ between the groups and thus can help to explain the development of the condition in the cases. Population-based case-control studies are a special type of case-control study

distinguished by the fact that they source study subjects directly from the population of interest.

This is an important feature as other types of case-control study obtain subjects who are only indirectly connected to the population of interest. This means that there is often doubt as to whether such study subjects are truly part of the population of interest or whether they are from another group. That subjects of population-based case-control studies are directly sourced from the population of interest makes for more robust findings than those from studies where subjects are only indirectly linked.

In population-based case-control studies, study populations are defined geographically and temporally.[19] In the studies in the thesis, the population that they are concerned with consists of all people with diabetes in Australia who made Medicare claims between 1994 and 2000. The cases are all subjects within that population that were treated for the first time for vision-threatening retinopathy in 2000, and controls are subjects in the same population who had not been treated, nor developed the complication in 2000.

The thesis retrospectively compares the intensity and quality of diabetes management over seven years of cases and controls. The principal research question is: does a history of poor standards of diabetes management lead to the development of advanced diabetes complications. This question is examined from a number of

perspectives and for a number of high-risk groups. These comparisons are able to examine the effectiveness of diabetes management across Australia.

To conduct this investigation the Medicare database is used. The Medicare system funds most of the activities of GPs and specialists in Australia and is the major source of health care in the country.[20, 21] In each year approximately 90% of the population receive at least one Medicare service.[22] Thus, it has a greater likelihood of affecting the health of the population than perhaps any other health care institution or program.

The thesis uses a specific diabetes complication – vision-threatening retinopathy - as the outcome of the studies. Vision-threatening retinopathy is a relatively common advanced complication for which there are a number of very efficacious preventative interventions, in particular, glycaemic control[3] and screening for retinopathy.[23] The complication develops after many years of exposure to hyperglycaemia[24] and has been used as a sentinel indicator for poor diabetes management by other authors. [25]

Furthermore, the research questions addressed in the thesis may be relevant to other diabetes complications. This is because diabetes complications share a similar aetiology in that they are all associated with hyperglycaemia and the pathological processes that are related to it.[15] Hence, interventions that slow the progress of retinopathy by addressing hyperglycaemia are likely to improve other complications

as well.[3] Similarly, patterns of care associated with retinopathy that are investigated in the thesis, are likely to also reveal themselves in other diabetes outcomes.[26]

There is significant epidemiological evidence that particular groups within the diabetes population are at higher risk of developing complications.[27] These include low socio-economic groups,[28] geographically isolated populations[29] and Aboriginal and Torres Strait Islanders.[30] The relationship between socio-economic status and diabetes has been examined in a number of the studies.[31, 32] As diabetes complications occur more often in socio-economically disadvantaged populations,[32] it is important to understand the role of diabetes management in respect of this group. In addition, the relationship between geographic isolation and health has also been identified, with rural and isolated populations tending to have worse health status than those who live in metropolitan areas.[33]

Aboriginal and Torres Strait Islanders suffer a disproportionate burden of diabetes and also have poor access to health care services.[30] But as there is doubt about the identification of Aboriginal and Torres Strait Islanders in the Medicare database, a specific research question concerning this group was not able to be examined. However, the Northern Territory study in Chapter 5 was conducted in a jurisdiction with a relatively high population of Aboriginal and Torres Strait Islanders.[30] Hence this study may provide an indication of the relationship between health care utilisation and diabetes complications for Aboriginal and Torres Strait Islanders across the Australian population.

In population-based studies it has been found that only about 50% of people with diabetes have been diagnosed with the condition.[34] Diabetes complications, including vision-threatening retinopathy, have been shown to take many years to develop[35, 24] and during much of this time patients are often unaware that they are suffering from diabetes or hyperglycaemia.[24] In the pre-diagnosis period, people with diabetes do not attend practitioners for diabetes care, do not have access to hypoglycaemic medications and do not practise diabetes self-management. In hyperglycaemic patients, these circumstances may lead to poor metabolic control and the accelerated development of diabetes complications.[36] Hence the timing of diagnosis is a critical factor in determining the risk of developing advanced diabetes complications, such as vision-threatening retinopathy.

The significance of the timing of diagnosis is examined in two studies. In Chapter 6, a research question is examined to determine whether the timing of diagnosis or the pattern of care, is the more critical factor in the development of advanced complications. Differences in the patterns of care in an early-diagnosed group are used to establish which of the two is the most significant risk factor for the development of complications. In addition, in Chapter 7 whether patterns of care prior to the diagnosis of diabetes is a risk factor for advanced complications, using similar analyses is investigated. By using these studies the thesis is able to weigh up the relative merits of early diagnosis versus diabetes management as alternative population-based strategies for the prevention of complications.

There is also substantial evidence that the nature of GP treatment is a major factor that can determine the risk of complications.[37] It has been found that practitioners who take a long-term perspective in the management of diabetes achieve better diabetes outcomes than those that focus on remedying its symptoms.[38] Whilst much of the way in which GPs' practice is determined by systemic factors such as the relationships between various sectors of health care,[39, 40] some practices come down to practitioner attitudes, skills and knowledge. [41] In Chapter 10 the relationship between some of these personal attributes of practitioners and the development of advanced complications is examined.

The issues examined in the studies represent some of the major challenges associated with the management of diabetes in Australia.[42] Their findings have important implications for policy direction as they address issues such as whether diabetes management is adequate, whether the health care system should focus on the management of diabetes or on screening, whether efforts should be concentrated on primary or tertiary care, whether programs should be introduced to promote equity in how diabetes is addressed, and whether medical practitioners need to be better skilled in diabetes care. These are important issues to resolve if the management of diabetes is to be effective and equitable across the population in Australia.

ETHICAL APPROVAL FOR THE STUDIES

The study design and data elements were approved by the External Request Evaluation Committee (ECRC) of the Health Insurance Commission (HIC). The Medicare database was released to the authors in de-identified form by the HIC as it was deemed to be in the public interest.

Research questions

1. To determine whether patterns of primary and secondary health care utilisation are risk factors for the development of diabetes complications in the population with diabetes in Australia.

2. To determine whether state and territory health care systems play a role in the effectiveness of diabetes management in Australia.

3. To determine whether patterns of care or delayed diagnosis is the greater risk factor for the development of diabetes complications in the population with diabetes in Australia.

4. To determine whether health care utilisation prior to the diagnosis of diabetes is a risk factor for the development of diabetes complications in Australia.

5. To determine whether socio-economic status is a risk factor for diabetes complications in Australia.

6. To determine whether geographic isolation is a risk factor for diabetes complications in Australia.

7. To determine whether the characteristics of GPs are associated with the risk of diabetes complications in Australia.

Chapter 2

Literature review

The structure of the literature review

The literature review is in five parts and establishes the need for the research questions to be resolved. The review begins by identifying the major health issue that will be addressed in the thesis by providing an epidemiological and clinical overview of diabetes in Section 1. This is followed in Section 2 by a discussion of the health care system and the major interventions that can prevent the development of advanced diabetes complications. The focus then shifts to implementation, where Section 3 discusses the capacity of the health care system to support diabetes management. The issue of equity and its role in diabetes and its influence on health care utilisation is then considered in Section 4. Section 5 concludes the review by firstly summarising the major arguments in the review and then identifying the knowledge gaps that are addressed in the body of the thesis.

Section 1: Epidemiological and clinical overview of diabetes

This section provides an epidemiological and clinical overview of diabetes. It describes the major diabetes types, their distribution in the population and the contemporary trend of increasing diabetes prevalence.[7] Following the overview, a detailed clinical picture of diabetes is presented. This documents the clinical characteristics of diabetes, its major complications, most common treatments, and outlines the risk of each complication for people with diabetes in general and for particular risk groups.

This descriptive section establishes a basic understanding of the epidemiological and clinical features of diabetes and sets the scene for Section 2, which discusses the clinical guidelines for the management of diabetes through which many of these complications can be controlled or prevented.

Whilst diabetes imposes a large burden of disease globally,[7] this section argues that there is much in the way of prevention that can be used to address the condition. Indeed, in many ways because these interventions have been developed, the large burden of disease from diabetes is not something that we must resign ourselves to, but is something that can be addressed. This is a major theme of the literature review and a primary message of the thesis.

EPIDEMIOLOGICAL OVERVIEW

Diabetes is a chronic condition characterised by hyperglycaemia or high blood glucose.[43] In adults, diabetes is diagnosed when fasting plasma glucose ≥ 7.0 mmol and/or when 2-h plasma glucose is ≥ 11.1 mmol/l[a] and there are also symptoms of hyperglycaemia.[44] Diabetes is the seventh leading cause of death in Australia and contributes significantly to morbidity, disability and poor quality of life.[1] Its major impact is through complications, which include cardiovascular disease, retinopathy, renal disease and peripheral vascular disease (see Table 2.1 below).[15]

The prevalence of diabetes is increasing worldwide, with most of this increase accounted for by type 2.[b, 7] The International Diabetes Institute and the World Health Organisation estimate that by 2010 there will be approximately 221 million people with diabetes globally, which represents an almost doubling in the population affected from 124 million in 1997.[7] Trends such as the ageing of the population, the growth of sedentary lifestyles and increasing rates of obesity account for much of the increase in diabetes across the globe.[7] By contrast, in developed countries, whilst these trends have existed for years, they have increased steadily over the past 50 or so years. However, in developing countries they are a relatively recent phenomenon and are associated with the introduction of Western consumerism and sedentary

[a] Fasting Plasma Glucose (FPG): Blood glucose levels after overnight fasting.
2-h blood glucose: Blood glucose levels during a 2-hour 75-gram oral glucose tolerance test.
(World Health Organization. *Diabetes Mellitus: Report of a WHO Study Group*. WHO: 1985).

[b] The most common forms of diabetes are types 1 and 2 diabetes. Type 1 diabetes has an early onset and is related to an immunological disorder that impairs the functioning of the pancreas. Type 2 diabetes develops later and is associated with insulin resistance related to lifestyle and diet. Types 1 and 2 diabetes are discussed in detail below.

lifestyles.[30] In addition, the increase in diabetes in developing countries has been explosive, reaching 20-30% in some populations.[45]

Whilst the exact prevalence of diabetes in Australia is not known, when findings from health and diabetes surveys are extrapolated it is estimated that there may be up to one million people with the disorder.[30] However, because the vast majority of diabetes is type 2, it is estimated that only about half of this population has been diagnosed with diabetes.[34] This reflects the incipient nature of type 2 diabetes.[46]

Indigenous Australians and some ethnic populations suffer a disproportionate burden of diabetes (these are discussed in detail below).[30] This reflects the greater prevalence of behavioural risk factors,[27] poorer living conditions and in some cases genetic predisposition among these groups.[30] These etiological differences may explain some of the patterns of diabetes that have been observed among these populations, where type 2 develops at younger ages,[27] complications are more advanced when identified[47] and patients have poorer prognoses than populations of Anglo-European descent.[30] In a study of diabetes in the indigenous population of North Queensland, McCulloch et al. found the prevalence of diabetes to be 12.6%,[48] which is approximately 4 times greater than in the general Australian population.[48]

Diabetes care comprises a large and increasing component of the Australian health care budget. In 2003, Colagiuri et al. found that the annual cost of diabetes was approximately $3 billion per annum,[49] which represents a significant share of health

care resources. Thus, there are sound economic reasons, as well as health ones, to address diabetes.

CLINICAL CHARACTERISTICS

The most significant pathology in diabetes is a disturbance in the mechanisms of glucose transport, which results in hyperglycaemia.[50] The acute symptoms of hyperglycaemia such as ketoacidosis result from dysfunctional barrier and exchange mechanisms in the inter- and intra-cellular matrices that regulate the absorption of glucose.[51] The chronic complications of diabetes result from the persistence of hyperglycaemia and associated metabolic disorders that degrade cells, tissues and organs.[3, 5] The severity and persistence of hyperglycaemia, hypertension and dyslipidaemia determine the character and extent of this damage.[52]

There is strong evidence that hyperglycaemia and hypertension are the principal causes of diabetes complications.[3] In 1993, the Diabetes Complications and Control Trial (DCCT) published its seminal paper showing that intensive insulin therapy, with the aim of achieving near normoglycaemia, could significantly reduce the risk of advanced diabetes complications.[3] This study found that for people with diabetes who maintained levels of HbA1c at or below 7.2%, the risk of developing diabetic retinopathy was diminished by 50%. Similar findings were also made in respect of other complications such as nephropathy and neuropathy, pointing to the need for the widespread adoption of HbA1c <7.2 as a therapeutic target.[53]

Although the incidence of macrovascular complications such as cardiovascular disease was lower in the experimental group in the DCCT, it was found not to be statistically significant.[3] This confirmed that although related, microvascular and macrovascular complications were somewhat dissimilar and pointed to the importance of other factors such as hypertension[54] and dyslipidaemia[55] in the management of these conditions in diabetes.

Whilst the DCCT established the importance of aggressive glycaemic control for the prevention of complications, it only included people with type 1 diabetes in the study.[3] As there are a number of significant etiological and pathological differences in the two major diabetes types (see below), there was some doubt as to whether these findings, which related to type 1, would be relevant to type 2 when the study was first reported.[56] This was supported by the epidemiological evidence at that time, where studies of the relationship between hyperglycaemia and complications in type 2 had been somewhat equivocal.56 It was not until the findings of the United Kingdom Prospective Diabetes Study (UKPDS) were published that the significance of glycaemic control in type 2 was firmly established, where it was found to have a similar role in type 2 to its role in type 1.[57]

The UKPDS examined the role of hyperglycaemia and hypertension in the development of diabetes complications among people with type 2. In a number of important ways, the intervention examined in this study was similar to that of the DCCT in that it involved groups of newly diagnosed individuals who were given

intensive therapy with the aim of achieving low blood glucose targets. The study used metformin (an oral diabetes medication), blood pressure medication, and insulin as its major treatment modalities.5 In addition, by addressing hypertension, a greatly reduced risk of cardiovascular disease was found.5

These studies were both well constructed and executed randomised controlled trials with large sample sizes, which provided findings with a high level of validity. They provided very strong evidence of the need to control hyperglycaemia in the management of diabetes.

Classification of diabetes

Type 1 diabetes

Type 1 diabetes accounts for about 10-15% of diabetes in Australia. In this condition there is a total lack of, or a significant reduction in, the body's capacity to manufacture insulin because of the total or near total destruction (over 90%) of beta-cells in the pancreas.[58] It occurs as a result of an immunological disorder.[59]

Patients with type 1 diabetes usually present with symptomatic hyperglycaemia or diabetic ketoacidosis. Polyuria followed by polydipsia and weight loss occur when elevated plasma glucose levels lead to dehydration. In this condition, if insulin levels are not restored insulin deficiency can be fatal.[59] The average age of diagnosis is 15 years, although there is increasing evidence that the condition can develop at any age.[59]

The major therapy for type 1 diabetes involves the restoration of insulin levels.[59] As the pancreas can no longer produce insulin, this hormone (insulin) is supplied by artificial means such as by regular injections or insulin pump.[58] When insulin is well managed, people with type 1 diabetes can live a relatively normal life even though they have a potentially fatal condition.[59]

Type 2 diabetes

Type 2 diabetes accounts for about 85-90% of diabetes in Australia.[60] In this condition insulin deficiency is not absolute but relative.[61] Here, insulin deficiency results from insulin resistance (where insulin becomes less effective) and in the latter stages from beta-cell exhaustion. As a result of metabolic dysfunctions, glucose absorbing tissues become resistant to insulin and higher concentrations in the blood are required for glucose metabolism.[50]

Elevated blood glucose and insulin can have major pathological effects. Whilst hyperglycaemia causes diabetes complications, hyperinsulemia is associated with cardiovascular disease.[62] If insulin resistance persists, beta-cells become exhausted, leading to a condition similar to the non-functioning of beta cells that occurs in type 1, although absolute insulin deficiency does not eventuate.[63]

Whilst the foundation of the management of type 2 diabetes rests on lifestyle changes such as increased physical activity and carbohydrate modified diets,[64, 65] remedial therapy can take either of three approaches: insulin resistance can be

reduced by oral medications (insulin sensitising agents); insulin can be increased by injection or both types of therapy can be used.[66] Currently about one-third of type 2 patients receive insulin, with the majority of the remainder using oral medications.[66] The average age of diagnosis of type 2 is 50, but since it has become more prevalent in the population it is being diagnosed at earlier ages.[7]

There are three main risk factors for type 2 diabetes.[67] These are older age,[67] a family history of the condition,[68] and obesity,[61] which in turn is related to behavioural risk factors such as sedentary lifestyles[69] and inappropriate nutrition.[64] However, these risk factors rarely cause the condition independently as they are strongly correlated in people with diabetes.[70] Hence, it is common to find that people with type 2 possess a cluster of risk factors and require a range of treatments such as for hypertension,[71] dyslipidaemia[72] or hyperglycaemia during their diabetic lifetime.[73]

Whilst the aetiology and phenotypic characteristics of types 1 and 2 diabetes differ markedly, the dysfunction that underlies diabetes, hyperglycaemia, is very similar in both conditions.[61] Hence, many of the same treatment and management interventions are used for both.[74]

Pre-diabetes and other related conditions

Amongst the broad class of insulin deficiency syndromes of which types 1 and 2 diabetes are a part, there is a range of other clinical types including impaired glucose

tolerance (pre-diabetes) and gestational diabetes mellitus that are also significant causes of diabetes-related morbidity.[61]

Impaired glucose tolerance (IGT) is a condition of elevated blood glucose similar to that of type 2, but blood glucose is at levels below that which define diabetes (2-h blood glucose ≥ 7.8, but < 11.1).[50] It is a common condition in overweight and obese individuals,[7] a major risk factor for type 2 diabetes, and is associated with an increased risk of cardiovascular disease.[75]

Gestational diabetes mellitus is the elevation of blood glucose that occurs during pregnancy in otherwise non-diabetic women.[50] The condition can cause major obstetric and neonatal complications and hence is a major concern for pregnant women.[76] In non-diabetic women gestational diabetes mellitus resolves after pregnancy and does not generally result in advanced complications.[77] However, it can initiate symptoms of diabetes in people with impaired glucose tolerance and is often an indicator of incipient type 2.[78]

Diabetes complications

Table 2.1 below lists the most common forms of insulin deficiency syndromes (including diabetes) and their complications, which are discussed in the following pages. The greatest impact of diabetes results from its complications, which are primarily associated with damage to vascular systems.[51] Although the body's

vasculature is usually referred to as one system, the plural 'systems' is used here in order to differentiate the effects of diabetes on large and microscopic blood vessels.

Table 2.1: Common insulin deficiency syndromes and diabetes complications

Most common insulin deficiency syndromes
- Type 1 diabetes
- Type 2 diabetes
- Impaired glucose tolerance (pre-diabetes)
- Gestational diabetes

Complications

Microvascular
- Diabetic retinopathy
- Nephropathy
- Neuropathy

Macrovascular
- Coronary heart disease
- Stroke
- Peripheral vascular disease

Combined microvascular and macrovascular complications
- Diabetic foot disease

Whilst the precise mechanisms by which hyperglycaemia causes diabetes complications have not been fully described, there appears to be at least two distinct processes: in microscopic vessels such as those which supply the kidneys and eyes, disturbances in the barrier and exchange mechanisms at the microcellular level degrade cell walls (angiopathy), eventually resulting in microvascular complications such as diabetic retinopathy.[79]

In large (macrovascular) vessels such as the coronary and tibial arteries, damage to vessel walls result from the build up of atherosclerosis, that is thickening of the arterial walls by lipid deposits that obstruct and reduce blood flow, which in turn

stresses the cardiovascular system.[80] There are a number of factors that lead to atherosclerosis in diabetes: these include hypertension[81] and dyslipidaemia,[82] which often precede hyperglycaemia. While atherosclerosis is a common condition in the broad population, it is more aggressive in people with diabetes.[80] Hence the condition needs to be addressed assertively.

At the microcellular level, the pathological consequences of the exposure of tissues to hyperglycaemia include acute, insulin-reversible and chronic non-reversible abnormalities in cell functioning.[83] Amongst those abnormalities that are reversible are increased polyol pathway and protein kinase C activity, elevated hydrostatic pressure in microcirculation and the greater formation of early glycosylation products of matrix, cellular and plasma proteins.[84, 85, 86] These abnormalities are associated with increases in the vascular permeability and protein leakage that characterise early diabetes. The irreversible abnormalities, however, primarily involve changes to long-lived molecules such as extracellular matrix components and chromosomal DNA.[83] The cumulative effect of these pathologic processes is the narrowing of diabetic vascular lumina with inadequate perfusion in vulnerable organs that results in the vascular damage that characterises diabetes.

Microvascular complications

The most common microvascular complications of diabetes, as presented in Table 2.1 above, include retinopathy, nephropathy and neuropathy.[15] In addition, there are

also less well defined microvascular effects on the heart muscle, gastro-intestinal tract and erectile tissue,[15] which are also important but not discussed here.

Diabetic retinopathy

Diabetic retinopathy is the most common cause of blindness in people aged 30 – 69.[24] It has an estimated prevalence of 15.4% among people with diabetes in Australia.[60] The condition results from angiopathy of the retina, which can cause visual impairment and has the potential to lead to blindness.[24]

Although type 2 diabetics comprise the largest number of people who develop retinopathy, type 1 patients are at higher risk.[87, 88] This is because retinopathy is related to the length of exposure to hyperglycaemia and patients with type 1 generally suffer from diabetes for longer. The causes of blindness from diabetic retinopathy are retinal ischaemia and structural changes to the macula (maculopathy) that result from the reversible and non-reversible pathological mechanisms described above, when they affect the eye.[24]

In clinical studies diabetic retinopathy is classified into two broad types: non-proliferative retinopathy and proliferative retinopathy, with the latter following from and more severe than the first.[24] Non-proliferative retinopathy is characterised by the development of ischaemia and oedema on the retina.[89] Whilst proliferative retinopathy has many of the same symptoms as non-proliferative retinopathy, it is differentiated by the development of new vessels on the macula, which poses a

greater threat of visual impairment.[90] For most of its course diabetic retinopathy does not cause symptoms that patients are aware of as it is only when the retina has suffered significant damage that perceptible symptoms occur.[24]

After 3 to 4 years following the diagnosis of diabetes, about 19% of people with type 1 diabetes will have evidence of the condition.[60] In addition, retinopathy starts early in the progression of type 2. After 20 years nearly all type 1s and about 60% of type 2s will have retinopathy lesions. Further, after 20 years about 50% of type 1s and 10% of type 2s will have developed proliferative retinopathy, representing a large burden of visual impairment.[60]

The prevention and treatment of retinopathy is based on glycaemic control, ophthalmological screening and laser photocoagulation therapy (the outcome measure used in this study).[24] It is estimated that up to 90% of diabetic blindness might be prevented through existing screening, control and treatment modalities if they were appropriately applied and utilised.[91]

Diabetic nephropathy

Diabetic nephropathy is the major cause of end-stage renal disease (ESRD), a life-threatening condition that results in kidney failure.[15] The clinical definition of nephropathy is the presence of proteinuria (more than 0.5g per 24 hours) in a diabetic patient without cardiac insufficiency, urinary tract infection or other renal

disease.[15] It is estimated that 11.2% of people with diabetes have suffered or been treated for this condition in Australia.[60]

The development of ESRD is related to proteinuria, which is defined as abnormal concentrations of protein in the urine. Proteinuria is an indicator of the health of the kidney, specifically of damage to glomerular filtration.[92] In patients where proteinuria has been detected, 25% will go on to develop ESRD after about 6 years and 75% will develop the condition after 15 years, making it a very serious aspect of diabetes.[93]

Particular ethnic groups appear to be especially prone to developing nephropathy, pointing to the influence of behavioural, lifestyle and/or genetic factors in the aetiology of the condition.[94] For example, Indigenous Australians (see Section 4 below),[30] African Americans,[95] and Pima Indians all have higher rates of nephropathy than people of Anglo-European background with diabetes.[96] Proteinuria occurs in 15-40% of patients with type 1[97, 98] and between 5 to 20% of patients with type 2.[99, 100]

The prevention and control of nephropathy relies on glycaemic and blood pressure control, which is similar to other diabetes complications.[101, 102] This is achieved through dietary changes,[103, 104] insulin and oral diabetic[102] and blood pressure medications.[105] The need to treat nephropathy by controlling hypertension accounts for the high proportion of people with diabetes using blood pressure medications.[106]

There is also strong evidence of a link between nephropathy and retinopathy.[107] Most people have retinopathy when they are diagnosed with nephropathy and there are common pathological mechanisms involving hyperglycaemia and hypertension in both conditions.[108, 109]

Diabetic neuropathy

Diabetes is the most common cause of neuropathy (nerve damage) in developed countries, with 9.8% of people with diabetes in Australia reported to suffer from this condition.[60] Whilst the exact mechanism by which hyperglycaemia affects the nervous system is not well understood, it appears to result from damage to the vascular system at the micro-cellular level, as described above.[110]

Diabetic neuropathy encompasses a range of abnormalities affecting both the peripheral and autonomic nervous systems.[111] These include abnormalities in sensory tests and electrophysiology which may be accompanied by sensations of burning, numbness, tingling, fatigue, cramping and aching in the limbs.[111]

Nerve damage is generally symmetric and starts from distal nerves in the lower extremities such as toes and feet and progresses towards the upper extremities.[112] In its most severe manifestations, neuropathy can lead to ulceration, foot deformities and lower limb amputation.[113]

Diabetic neuropathy occurs at similar rates in both types 1 and 2 diabetes.[114, 115] In a population-based study, the Rochester Diabetic Neuropathy Study, it was estimated that 66% of type 1 diabetics have the condition, along with up to 59% of patients with type 2 diabetes, making it possibly the most common of all diabetes complications.[114]

Neuropathy can be prevented and managed by glycaemic control,[3] while sensory tests and foot inspections can identify foot pathologies.[116] Neuropathic pain can be treated by non-steroidal anti-inflammatory drugs (NSAIDS)[117] and anti-depressants.[118] Depending on symptoms, treatments may include infection care and in rare cases, lower limb amputation.[119]

Macrovascular complications

The second classification of complications identified in Table 2.1 is macrovascular complications, which occur at three sites in the vascular system: the coronary, cerebral and peripheral arteries.[120] These complications include cardiovascular disease and peripheral vascular disease.[15]

Cardiovascular disease

Cardiovascular disease is the main cause of death in people with diabetes, with an estimated 80% of diabetics dying from these conditions.[121] In Australia, people with diabetes are about four times more likely to suffer a heart attack and five times more likely to suffer a stroke than the general population.[60]

The most common form of cardiovascular disease is coronary heart disease,[122] which is caused by blockages from lipid deposits in the coronary arteries (atherosclerosis) that can lead to myocardial infarction (heart attack) or thrombosis.[123] Stroke results from a similar pathogenic mechanism but is due to blockages in the blood supply to the brain and can result in paralysis or death.[124, 125] In people with diabetes, cardiovascular disease can be addressed by lipid, [126] and blood pressure control,[127] which are facilitated by lifestyle changes such as improved diet, increased physical activity[128] and appropriate medications.[127, 126] There is some debate as to whether glycemic control is effective in this regard.[3, 102, 129]

There are a number of common treatments for cardiovascular disease in people with diabetes. These include biguanide metformin,[102] a medication primarily targeting hepatic tissue, which is involved in the regulation of blood glucose through glucose metabolism and storage. The UKPDS found that metformin reduced the incidence of fatal myocardial infarction by 50%, of stroke by 41% and of all cause mortality by 36%.[130] Metformin has become one of the mainstays of therapy in diabetes.

In addition, statins, which reduce LDL cholesterol, are also used. These medications have been shown to reduce the risk of a first and recurrent cardiovascular event in people with type 2 diabetes. The Cholesterol and Recurrent Events (CARE) trial investigated pravastatin (40mg daily) in 586 subjects with impaired fasting glucose who were at high-risk of developing diabetes. It was found that those who took the medication had a 25% lower risk of recurrent coronary events.[131] In addition, in a

combined analysis of the CARE trial and the Long-term Interventions with pravastatin in the Ischaemic Disease (LIPID) study (which was conducted in Australia), pravastatin (40 mg daily) reduced the cumulative risk of coronary events by 44%, which points to this agent being very effective in preventing acute cardiovascular conditions.[132]

As well, the Diabetes Atherosclerosis Intervention Study (DAIS) investigated the effects of fenofibrate (200 mg/day), a treatment for dyslipidaemia in people with diabetes. It was found that after three years of taking this medication, the progression of localised coronary stenosis was reduced, resulting in fewer cardiovascular events.[133]

With regard to hypercholesterolemia, the Scandinavian Simvastatin Survival Study (4-S) investigated whether another statin drug, simvastatin, was effective in reducing this aspect of dyslipidaemia. It was found that simvastatin reduced hypercholesterolemia in men who had had a previous myocardial infarction or coronary heart disease and significantly reduced the risk of a subsequent cardiovascular event.[134]

Studies have also been conducted into hypertension therapy in diabetes. In the Heart Outcomes Prevention Evaluation study (HOPE), 3577 normotensive diabetes patients were given ramipril (10mg daily) and they experienced a 37% reduction in cardiovascular mortality.[135]

Studies have also shown that thiazolidinediones (troglitazone and rosiglitazone), which are used to treat insulin resistance, favourably alter fat distribution and dyslipidaemia in people with diabetes.[136,137] In addition, among patients who are at an imminent risk of cardiovascular events heart or vessel surgery, such as coronary angioplasty may be appropriate interventions.[138]

Peripheral vascular disease

Peripheral vascular disease reduces the circulation of blood in the lower limbs, which can lead to a disease process that results in the need for amputation.[116] The National Health Survey conducted in 2001 by the Australian Bureau of Statistics found that 2.1% of people with diabetes reported having had an amputation. This amounts to a four times greater risk than in the general population.[60]

Peripheral vascular disease results from blockages in the tibial and peroneal arteries that serve the legs and feet by lipid deposits that can be detected by weakened pulse in these arteries.[139] Although peripheral vascular disease is an infrequent cause of ulcers (which are more commonly associated with neuropathy),[140] it plays a major role in wound healing and gangrene and is a common contributing factor to amputations.[141]

Peripheral vascular disease can be prevented by glycaemic control,[3] identified through foot screening.[116] Topical wound and infection care may be required for treatment.[141] However, normalising lipids or reducing blood pressure has not been

shown to improve the condition.[116] In many cases, neuropathy and peripheral artery disease co-exist, resulting in legs or feet that have nerve damage as well as depleted circulation.[141] This condition is termed diabetic foot disease and is discussed below.[116]

Combined microvascular and macrovascular complications

In addition to complications due to discrete microvascular or macrovascular pathologies, there are also complications that result from both of these pathological processes combined.[116] The major complication of this type is diabetic foot disease.

Diabetic foot disease

Diabetic foot ulcers and lower-extremity amputations are common and can affect up to 15% of people with diabetes.[116] They have a profound effect on the functionality and integrity of the foot.[141] Ulcers, which are breaks in the skin that allow infections to penetrate, are the primary lesions of diabetic foot disease.[141] If ulcers or infections develop, necrosis can occur leading to a need for foot or lower limb amputation.[142] In addition, there are other effects on the structure of the foot leading to deformities. These are termed Charcot foot.[142]

There are two types of diabetes-related foot pathologies. These are neuropathic feet,[143] in which nerve damage predominates and neuro-ischaemic feet, where both nerve damage and peripheral vascular disease occurs.[144] In a review of the evidence, Gavin estimated that 60% of ulcers were due to a neurological cause and the

remaining 40% to peripheral vascular disease or both mechanisms combined.[145] The neuro-ischaemic complication is the more severe of the two.

Conclusion

Section 1 of the literature review has provided an overview of the epidemiology and clinical characteristics of diabetes. It has shown that diabetes affects a broad range of tissues, organs and systems and makes a significant contribution to the overall burden of disease. However, there is a large body of evidence showing that with appropriate lifestyle changes and medical care, diabetes complications can be prevented,[3, 5, 67, 146] as discussed in Section 2 below. This is because of the central role that hyperglycaemia, hypertension and dyslipidaemia play in complications.[15] In most cases these metabolic conditions can be managed,[3, 5] which is the principal concern of the research questions investigated in this thesis.

As most interventions used to prevent complications can be readily provided through primary and secondary care,[74] it has become possible in recent decades for the health care system to focus on the prevention of complications rather than on their remediation (see Section 2 below).[147] Nevertheless, the epidemiological evidence suggests that the prevalence of advanced diabetes complications is high and may actually be increasing.[7] This is the case even for complications that are well understood and easily prevented, such as diabetic retinopathy.[146] This suggests that many health care systems have continued to focus on remediating the symptoms of diabetes rather than on preventing them. Thus non-clinical factors such as access to

primary health care on an ongoing basis may be one of the most significant factors determining morbidity from diabetes.[147]

The section that follows reviews the preventive interventions as represented by clinical management guidelines for diabetes and explores the evidence concerning utilisation of the guidelines in Australia. The descriptive information in respect of the guidelines is provided in order to establish an understanding of codified standards of care aimed at preventing diabetes complications, the use of which is examined in the body of this thesis. The thesis uses indicators of health care utilisation that can approximate the use of the guidelines. The evidence in respect of the use of the guidelines, which is generally found to be inadequate, sets the scene for the subsequent section on a more effective model of chronic disease care.

Section 2: Clinical management guidelines for the prevention of diabetes complications.

Having described the epidemiology and clinical features of diabetes in the previous section, this next section presents a discussion of the clinical management guidelines for diabetes. The clinical management guidelines are significant in that they embody evidence-based interventions for the prevention of complications and as such are intended to form the basis of a health care system that can systematically address diabetes.[12]

The clinical and public health evidence suggests that the combination of effective self-management, matched with regular monitoring and screening of complications can significantly reduce the risk of diabetes complications.[148, 149] The disposition of diabetes to be controlled is determined by its maturity,[150] the proficiency of patients in self-management and their ability to obtain regular medical care.[151, 152] The evidence shows that even patients with established diabetes and advanced complications benefit when their condition is managed in such a way as to achieve appropriate blood glucose targets.[150]

After discussing the role of self-management in diabetes care, this section explores the importance of the structure and organisation of care for reducing the prevalence of complications. The major modalities of diabetes care are outlined and their functions discussed. The second half of the section focuses on clinical management

guidelines as a vehicle through which care can be organised. It summarises an example of such guidelines and then reports the evidence concerning aspects of management reflected in them. The broad finding that evidence-based clinical management guidelines are not well complied with is taken up in Section 3, which explores the potential to improve diabetes outcomes by reorganising the health care system towards the greater provision of appropriate chronic disease care.

SELF-MANAGEMENT

There is strong evidence that increasing the participation of patients in their own medical care by encouraging self-management, leads to better clinical outcomes.[151, 152] This has been found for diabetes[153] and other chronic diseases such as asthma.[154] With regard to diabetes, the major self-management tasks in diabetes include: (1) engaging in activities that promote health and build physiological reserve such as exercise, proper nutrition, social activities and sleep; (2) utilising health care providers and systems and adhering to recommended treatment protocols; (3) monitoring physical and emotional status and making appropriate management decisions on the basis of symptoms and signs; and (4) managing the impact of diabetes on one's ability to function in important roles, on emotions and self-esteem and on relations with others.[155]

However, from the practitioner's perspective, getting patients to effectively manage their diabetes can be a difficult undertaking.[156, 157] This is not only because the

competencies required of the patient are numerous and demanding, but also because each competency needs to be tackled individually. It appears that competencies do not reinforce one another, such that patients can be very competent in some aspects of self-management but may fail to perform well in others.[154] For example, it is common to find that patients who take their medication diligently are not sufficiently physically active.[148]

The factors found to be related to competency in self-management include the personal characteristics of the patient such as self-efficacy,[158] the strength of their motivation to protect their health and their understanding of the illness.[159] In addition, social circumstances play a role, with patients who have adequate social support faring better.[160]

Perhaps surprisingly, studies have found that there is no relationship between socio-demographic characteristics and competence in self-management.[149] This is despite the strong relationship between these characteristics and other aspects of diabetes such as the development of vision-threatening retinopathy[161] and obesity. [162]

Studies have also found no consistent relationship between competence in self-management and gender, [163,] education, income,[164] intelligence, general health knowledge, personality type or level of compliance to medical regimens, [149, 165] despite all of these factors being related to health behaviour in other conditions.[149] Thus competence in diabetes self-management appears not to be determined by

factors that are generally related to self-care practices but rather seems to be problematic for most people with diabetes regardless of their social or psychological status.[154]

THE ORGANISATION OF CARE

When individuals are considered, the major determinants of the risk of complications include health status,[150] lifestyle,[166, 167] competence in self-management,[149] the appropriateness of the treatments they receive,[168] whether they have a regular source of medical care[169] and the competence and approach of their practitioners.[170] By contrast, when populations are considered, a major determinant of the risk of complications is the organisation of the health care system. [171] This is because at the macro level, the health care system influences the individual determinants identified above, governs access to medical care and determines the nature of the care that is provided.[172]

In Australia, health care is the responsibility of both the Commonwealth and state and territory governments.[173] Whilst the Commonwealth government funds general practice and some specialist care through the Medicare system, the states administer public hospitals.[173] Because people with diabetes generally suffer from both acute and long-term conditions,[15] they are generally users of both the Medicare and hospital systems.[147] The influence of state and territory health care systems on the risk of complications is examined in Chapter 5 of the thesis.

The significance of the funding source stems from the administrative arrangements that underpin it, as different funding sources point to federal and state bureaucracies being responsible for specific parts of the health care system.[174] However, it also points to the potential for the fragmentation of care as patients move between levels of care.[175, 176]

Reflecting the broad range of health care received by people with diabetes, there are a number of modalities of care involved in the treatment of this condition.[175] The modalities generally address different aspects of diabetes and have a varying capacity for involvement in day-to-day management of the disease. The major modalities of care include that provided by GPs, medical specialists, specialist outreach programs, ambulatory care (or diabetes centres), acute care hospitals and shared care.[42] An overview of these modalities is provided here to illustrate the nature of health care systems that are involved in diabetes.

Modalities of care

Care by GP alone

Between 80 and 90% of people with type 2 diabetes may be managed by their GP alone, and this care is primarily funded by Medicare.[177] This common arrangement equates to a conventional doctor-patient relationship and is the most accessible form of health care for the population.[178] In this modality, a GP provides generalist care and co-ordinates care from all sources. When specialist or allied health services are

required, patients are referred to them, but the GP retains overall responsibility for the patient's care.[179]

Ideally, patients will have only one GP. However, in Australia there is no mechanism by which attendance at GPs can be restricted,[178] as occurs through patient registration in the National Health Service in the United Kingdom[180] and in Norway and Denmark.[181] In the absence of such a mechanism, patients are free to move between doctors.[178] Whilst this may enable greater freedom of choice on the patient's behalf, it can also result in the fragmentation of care if the patient has frequent changes of GP. Because of the danger of patients receiving incompatible treatments, frequent changes can have serious consequences for the effectiveness of the management of diabetes.[169] Similarly, a patient without strong ties to one practice is less able to engage in ongoing, high quality diabetes care.[169]

As diabetes management is primarily provided by GPs,[177] it is likely that the majority of care represented in the Australian epidemiological evidence reported below refers to this modality. The role of GPs in the management of diabetes is examined in Chapters 4 to 10 of this thesis.

Care by medical specialists and consultant physicians

It is uncommon for medical specialists or consultant physicians, such as endocrinologists, to be the principal providers of care for people with diabetes.[182] However, they play a significant role in the management of diabetes. Indeed,

Overland estimated that during the 1990s up to 38.5% of diabetes patients in Australia were treated at some stage by consultant physicians.[183] Generally, medical specialists focus on applying their specialist knowledge and skills in their medical practice and tend to see patients on a sessional basis.[175]

When they do take a principal role in the management of diabetes, this may be an indication of a greater need for intensive therapy as a result of a more symptomatic condition.[177] As this care is provided in the community and in public hospitals, it is funded by both Commonwealth and state and territory health care systems.[173] The role that medical specialists and consultant physicians play in the management of diabetes is investigated in Chapters 4 to 9 of this thesis.

Specialist outreach services

In communities where medical specialists and GPs are scarce, specialist outreach services have been established.[42] These services often include ophthalmology, endocrinology, cardiovascular specialists and diabetes nurse educators, enabling geographically isolated populations access to diabetes care. Such services often represent the only access remote and regional populations have to these types of treatment.[33] This care is funded by both Medicare and state and territory health care systems.[173]

Ambulatory care

In Australia, diabetes centres are the principal providers of ambulatory care (or out-patient hospital care) for people with diabetes.[184,] These centres offer a broad range of diabetes health care services, including complications monitoring and screening, as well as diabetes education and social support.[184]

Patients often attend these centres for screening, to remedy crises, or when the treatment required is beyond the capacity of their regular GP (for example, retinopathy screening).[184] Diabetes centres are usually based in or strongly linked to public hospitals, which provide them with a steady stream of newly diagnosed patients as well as patients whose diabetes is advanced and difficult to manage.[42, 184]

In order to meet demand for the type of care that diabetes centres provide, some centres ration their services by avoiding taking formal clinical responsibility for patients (the co-ordination of care role). They do this by restricting the length of time over which most patients can attend centres, thus coercing patients to return to their GP for the long-term management of diabetes.[185] As most diabetes centres are based in public hospitals, they are primarily funded by state and territory health care systems, although Medicare funds some of the services depending on how particular practitioners are reimbursed.[173] The role of ambulatory care in the management of diabetes could not be specifically examined in the thesis.

Diabetes care in public hospitals (acute care)

Even though public hospitals operate separately from general practice in Australia, they provide a large range of medical care to people with diabetes.[186] This mainly relates to tertiary, acute and emergency care and hospitals are rarely involved in the day-to-day management of diabetes. This care is primarily funded by states and territory health care systems.[173] Whilst public hospitals could not be directly examined in this thesis, their influence can be inferred from the state and territory study (Chapter 5), as how hospitals are organised is the primary difference between the states and territory health care systems.[173]

Shared care arrangements

The most effective modality of diabetes care is shared care, which refers to co-operative arrangements between GPs, medical specialists and allied health practitioners such as diabetes educators.[42] Studies have shown that when diabetes management is provided in a comprehensive and co-operative manner, diabetes outcomes improve significantly.[38]

The National Diabetes Strategy summarised the aims of shared care as:

> to provide the person with diabetes integrated and better quality care by: (1) improving communication between primary and specialist services; (2) improving co-ordination in the planning and delivery of diabetes care; (3) increasing the involvement and skills of GPs in caring for people with

diabetes; (4) promoting consistent standards of care; (5) avoiding duplication of services.[42]

Each of these aims has been shown to improve the quality of diabetes care (see section 3 below).[38]

Despite the evidence in support of shared care, most people with diabetes do not receive this type of management, as it requires a significant profession and skills base that is rare, as well as formal agreements between practitioners.[187] This care is funded by both Medicare and state and territory health care systems.[173] Similar to the modalities of care above, the role of shared care in the management of diabetes could not be examined in the thesis.

Adequacy of modalities for chronic disease management

In general, the effectiveness of modalities of care in managing diabetes is determined by their ability to provide ongoing and appropriate diabetes care.[38] For some modalities such as GP care, this is more able to be achieved than for others, such as public hospitals.[179] However, in many cases, people with diabetes are required to rely on modalities of care that are not appropriate to provide diabetes management. This may lead to poor management and a higher risk of complications even though practitioners may be highly skilled in treating diabetes.[175]

Even in modalities that are appropriate for ongoing chronic disease management, other factors may lead to poor quality care, particularly where treatment involves a short-term focus and where medical care is disease rather than patient focused.[188] Hence, it is not just important that patients gain access to the appropriate modality, they must also be provided with care that is of an appropriate nature and standard.[189]

The preceding overview has shown that there are a number of institutions and modalities involved in the care of people with diabetes. Whilst there is a range of systems and practitioners involved in diabetes care, GPs provide the majority of care for diabetes in Australia. This reflects the nature of the medical care required by people with diabetes, as well as the structure of the health care system through which this care is provided.[179]

Recently, however, it has been recognised that GPs, both in Australia and internationally, have not been very proficient in managing diabetes.[190, 191] This is evident in the rate of risk factors among regular GP attendees,[192] in addition to the often inadequate level of screening and monitoring reported in epidemiological studies (see Chapter 4 below).[190, 193]

In some countries this has led to a shift back to acute care hospitals as the major providers of diabetes management,[38] although this has not occurred in Australia.[42] At the same time, a large number of policy makers and practitioners have also recognised the importance of keeping diabetes care largely in the primary health care

system.[194, 195, 196] This is because of the need to make diabetes care widely accessible and community-based, rather than reverting to a more specialised and intensive mode of treatment.[196, 197, 198] These authors have argued for a greater orientation of the primary health care system towards chronic diseases.[6, 194]

Before exploring how the health care system could be oriented to more effectively manage chronic disease, the literature review sets out the evidence-based clinical guidelines for the management of diabetes. The guidelines can serve as a vehicle through which diabetes care is organised and which has the potential to significantly improve the quality of management.[199] The section then reports on the findings from a number of studies that have examined the extent to which the guidelines have been implemented in Australia. Together these findings point to delivery of sub-optimal care by the primary care sector to people with diabetes during the 1990s. This evidence sets the scene for the analyses of current care models comprising Chapters 4 to 10 of this thesis.

CLINICAL GUIDELINES FOR THE MANAGEMENT OF DIABETES

Much like other individuals, diabetes patients seek medical care for a wide range of purposes and in addition, obtain a large amount of care in respect of their diabetes.[193] In Australia, most care for diabetes is provided by GPs, supplemented by occasional visits to acute care hospitals, diabetes centres, medical specialists and allied health professionals,[42] as discussed above.

Reflecting the major role played by GPs in diabetes care, in the past few decades there has been a concentrated effort to improve the capacity of GPs to manage diabetes.[42, 74, 200] This has been driven by factors such as the development of inexpensive and effective prevention interventions,[74] the prohibitive cost of hospital care, and the need to make care for diabetes more widely available.[194]

Australian health departments have sought to consolidate GPs as the major providers of diabetes care by codifying primary care-based screening and monitoring interventions into clinical management guidelines as the basis for the management of diabetes (see Table 2.2 below).[74, 200] The guidelines are based on both established and contemporary clinical evidence which shows that by following the prescribed interventions, most diabetes patients should minimise the risk of developing advanced complications.[12]

The guidelines recommend complications screening and monitoring at identified intervals that should be achievable in primary care. From the perspective of facilitating diabetes management, the guidelines can be used in two ways: either as a method of planning clinical practice, or for evaluating the quality of care.[199] Health care utilisation that approximates the level of adherence to the guidelines, forms the basis of the main research question testing chapters in the thesis (Chapters 4 to 9).

The guidelines published by the New South Wales Department of Health in 1996, replicated in Table 2.2 below, are typical of those developed in other states and

territories of Australia. They also reflect contemporary international standards of diabetes care.[201]

Table 2.2: The Principles of Care and Guidelines for the Clinical Management of Diabetes Mellitus (The New South Wales Department of Health, 1996)

(1) Assess diabetes control by measuring HbA1c Every 6 months for insulin treated patients. Every 6 to 12 months for non-insulin treated patients.
(2) Ensure that a comprehensive ophthalmological examination is carried out At diagnosis and then every 1 to 2 years for patients whose diabetes onset was at age 30 years or more. Within five years of diagnosis and then every 1 to 2 years for patients whose diabetes onset was at age less than 30 years.
(3) Measure weight and height and calculate BMI On initial visit, then measuring weight every 3 months. Measure weight more frequently if the patient is on a weight reduction program.
(4) Measure blood pressure
(5) Examine feet Every six months or at every visit if high-risk foot or active foot problem. Refer to specialist experienced in the care of the diabetic foot if infection or ulceration is present. Ensure that patients with high-risk foot or active foot problem receive appropriate care from specialists and podiatrists expert in the treatment of diabetic foot problems.
(6) Measure total cholesterol, triglycerides and HDL cholesterol Every 1 to 2 years (if normal). Every 3 to 6 months (if abnormal or on treatment).
(7) Test for microalbuminuria At diagnosis and then every 12 months for patients with type 2 diabetes. 5 years post diagnosis and then every 12 months for patients with type 1 diabetes.
(8) Encourage healthy lifestyle Healthy food choices. Appropriate physical activity. No smoking.

The purpose of the guidelines

Both Australian and international studies show that the quality of diabetes care varies significantly between practitioners and across jurisdictions.[202, 203, 204] This often means that some patients receive high quality care, whilst others are treated very inadequately. Thus an important goal of health care policy has been to standardise the quality of diabetes care,[199] and this is promoted through the use of clinical management guidelines such as those presented above.

The interventions that are recommended are those required by patients from the time of diagnosis and throughout their diabetic lifetime in order to achieve diabetes control.[12] Whilst the medical care individuals obtain will vary due to differences in the character of diabetes (for example, some patients may need to focus on specific co-morbidities such as hypertension), the guidelines represent a minimum inventory of care that is required by all patients for the management of diabetes.[12]

In Australia, the guidelines have been introduced with education and skills-based programs for GPs and medical specialists,[200] and in recent times they have been formalised by being incorporated into the funding schedules of Medicare.[205]

Structure of the guidelines

The guidelines are comprehensive in their scope and address two levels of risk relevant to diabetes. These are proximal risk factors (Guidelines 1,2,4,5,6 and 7 in Table 2.2) and underlying risk factors (Guidelines 3 and 8), where the hierarchy

represents the closeness of the risk factor to the principal pathology implicated in the complication.

Proximal risk factors can be distinguished as those that are monitored using pathology, diagnostic and sensory tests for hyperglycaemia, hypertension and dyslipidaemia, or that represent actual morbidities such as foot disease and retinopathy. By contrast, underlying risk factors are states or behaviours that attenuate proximal risk factors, for example obesity, smoking, physical inactivity and poor diet and are not specific to diabetes.

At the time that many of the studies reported in this section were conducted, the clinical management guidelines were promoted through state and Commonwealth based education and training programs for GPs and medical specialists,[200] but specific Medicare funding for diabetes management had not yet been introduced (this was not established until 1999). However, the pathology tests prescribed in the guidelines were able to be claimed as individual items (such as HbA1c tests) from the time of the establishment of the Medicare system in February 1984 and all medical attendances were funded.[206]

What the guidelines measure

Assess diabetes control by measuring HbA1c (Glycosylated haemoglobin) every 6-12 months

Glycosylated haemoglobin (HbA1c) is a measure of glycaemic control.[207] The advantage of HbA1c over other indicators is that it is not affected by short-term

fluctuations in blood glucose, which commonly occur, as its value depends on the concentration of glucose in the blood over a 120 day period.[207] As has been established in Section 1, glycaemic control is essential for the management of diabetes.[208] The use of HbA1c testing in the management of diabetes in Australia is examined in Chapters 4 to 9 of this thesis.

Ensure that a comprehensive ophthalmological examination is carried out every 1 to 2 years

Annual or biannual ophthalmological examinations are recommended for the prevention of diabetic blindness. During examinations, the condition of the retina is observed in order to identify retinopathy.[144, 209]

There are two methods of examination used in Australia: ophthalmological examination using ophthalmoscope or retinal photography.[210] In both methods, practitioners look for the signs of retinopathy, which include haemorrhages, distinctive textures and spots, the density and characteristics of which can be graded and related to the risk of blindness.[211, 212] The use of ophthalmological screening can be inferred from the specialist and optometrist data in the studies in Chapters 4 to 9. In addition, these studies include a retinal photography indicator.

Measure weight and height and calculate body mass index (BMI) every 3 months

Body Mass Index is an important indicator of overweight and obesity (BMI $\geq$ 25), which as noted in Section 1 above, is a major risk factor for coronary heart disease and stroke in people with diabetes.[213]

Measure blood pressure

High blood pressure is a symptom of cardiovascular disease and nephropathy. Whilst it has many of the same consequences in both diabetic and non-diabetic individuals, in diabetes, morbidity occurs at blood pressures below that of the non-diabetic population. Thus there is a need for aggressive treatment for this condition.[214]

Examine feet every 6 months

Foot examinations include a range of checks including visual inspection for skin discolouration, oedema, ulcer, callus and deformities. In addition, foot temperature, vibration perception and tactile sensation are tested. [215] To assess the vascular status of feet, vascular claudication, rest pain and pedal pulses are also examined by practitioners.[140]

Measure total cholesterol, triglycerides and HDL cholesterol every 1 to 2 years

Hyperglycaemia results in a particular type of dyslipidaemia, where people with diabetes tend to have high levels of LDL-cholesterol and triglycerides and low levels of HDL-cholesterol. There are also changes in the nature of LDL-cholesterol, such that the cholesterol particles become more dense, which may increase the deposition of atherosclerosis on vessel walls.[216] The role of HDL-cholesterol testing in the management of diabetes is examined in Chapters 4 to 9 of this thesis.

Test for microalbuminuria every 12 months

Elevated microalbuminuria is the earliest reliable and clinically detectable sign of nephropathy and is an indicator of the integrity of glomerular filtration.[101] Changes in the structure and function of the kidney in diabetes can lead to ESRD.[15] Only limited data on the role of microalbumin testing and the management of diabetes were available for the present study (1998-99 only). This is presented in the multivariate models in Chapters 4 to 9 of this thesis.

Encourage a healthy lifestyle

As was discussed above, the largest component of diabetes is provided by diabetes patients themselves through self-management.[149] Reducing the risk of complications requires that patients obtain sufficient physical activity, eat healthy diets, participate in social activities and get enough sleep.[155] The principal means by which self-management is promoted in the medical setting is by diabetes education.[217] Compliance with this aspect of the clinical management guidelines was not examined in the thesis, although it can be inferred as being a component of the medical attendances in the studies reviewed below, as well as the GP data used in Chapters 4 to 9.

EVIDENCE ON THE EXTENT OF SCREENING AND MONITORING DIABETES COMPLICATIONS IN AUSTRALIA

A number of Australian studies have reported on aspects of diabetes management reflected in the clinical management guidelines. These studies are reviewed in order to provide a picture of diabetes care in recent times in Australia.

Methodology for selecting studies

The aim of the following review is to represent diabetes management practices in Australia for the general diabetic population as they occurred in the 1990s, according to the best epidemiological evidence. To achieve this, the literature included in this review was selected according to three criteria. Firstly, the findings included information on the use of interventions identified in the clinical management guidelines. Secondly, the studies were population-based so that the findings were generalisable to the broader population. This resulted in the exclusion of studies solely concerned with type 1,[182, 218] as well as those utilising diabetes register populations.[219] Finally, the studies were required to be relevant to contemporary diabetes care, such that studies that used data collected before 1990 were excluded.[186] From the application of these criteria to the Australian diabetes literature, six studies emerged.

Each of the studies was ranked according to these criteria, with the ranks then summed to give an overall score of validity and relevance. The studies are reported

for each of the guidelines with the highest ranked study first, followed by studies that were ranked successively lower. The studies show widely varying estimates of diabetes screening and monitoring, reflecting different practices, populations and methods of data collection. The studies provide robust estimates of the levels of adherence to some of the guidelines (such as ophthalmological screening) but for others, the data are much less reliable (for example, weight measuring). In addition, there is an absence of longitudinal studies, as most are cross-sectional.

HbA1c testing

Two studies reported on levels of HbA1c testing in Australia, using data from New South Wales[190] and Western Australia.[193] In a study of the Medicare records of the diabetes patients of GPs in South Western Sydney, Harris et al.[190] found that 12.7% of 3828 diabetes patients had been tested for HbA1c between January and June 1996. This rose slightly to 13.6% of 5481 diabetes patients in July and December 1998 in the same locality. Kamien et al. conducted an audit of the diabetes care received by 467 type 2 diabetes patients selected from the patients of a random sample of 204 GPs in Perth, Western Australia in 1991 to 1992.[193] They found that 52% of patients in this sample had received an HbA1c test within 12 months. The overall impression is that the level of HbA1c testing was well below the recommendation in the clinical management guidelines that patients obtain this test every 6 to 12 months.[12]

Ophthalmological examinations

Using the AusDiab study, a population-based study of 11,067 diabetes patients across Australia conducted in 1999 to 2000, Tapp et al. reported that 77% of diabetes patients had received an eye examination in the 2 years prior to the study being conducted.[203] The New South Wales Health Survey, which was at that time, a biannual survey of the health of the population of New South Wales,[204] suggested higher levels of screening, with 54.7% of 726 people identified with diabetes having received an eye check within the 12 months prior to the survey. Additionally, the study by Kamien et al. of general practice patients found that 50.1% of diabetes patients had received an eye examination or been referred to an ophthalmologist over a 12 month period,[193] which is close to the findings of the New South Wales Health Survey.

When compared, the studies show varying levels of ophthalmological screening and visits to eye care specialists. Whilst the most robust study, AusDiab, suggests that about 35% of people with diabetes obtained screening in the 1990s, this was well below the findings in New South Wales.[204] This suggests that either the level of ophthalmological screening was higher in New South Wales than in the other states and territories, or that studies measured screening differently. Despite the major differences between the studies, the overall impression is that the level of ophthalmological screening in Australia during the 1990s was well below the clinical management guideline that patients obtain an ophthalmological examination every 1 to 2 years.[12]

Weight and height measuring (to calculate BMI)

Only one study reported on weight measurement. However, because it may be an unremarkable aspect of a medical consultation there may be significant under-reporting against this guideline. In the only study that reported it, Kamien et al.,[193] found that 55.9% of diabetes patients had been weighed by their GP over a 12 month period. Whilst it is not possible to generalise this finding to the Australian diabetes population, it suggests that a significant proportion of patients may not have had their weight monitored according to the clinical management guideline, which recommends that patients be weighed every 3 months.[12]

Blood pressure checking

The New South Wales Health Survey of 1997 found that 86.8% of diabetes patients had their blood pressure checked in the previous 3 months.[204] Kamien et al. found that 94% of patients had received a blood pressure check in 12 months.[193] These findings suggest that the level of blood pressure testing was high during the 1990s.

Foot examinations

Tapp et al. found that 50% of diabetes patients in Australia were examined for foot pathologies in a year.[203] However, the New South Wales Health Survey found that foot examinations may have been about half this level (25.6%).[204] This may reflect differences between the Australian and New South Wales populations, or indicate that alternative methods of measuring of foot examinations were used.[220] However, overall the findings suggest that the level of foot examination was well below the

clinical management guideline that patients obtain foot examinations every six months.

Cholesterol and triglyceride testing

The New South Wales Health Survey of 1997, found that 80% of diabetes patients had their cholesterol checked in the previous 12 months.[204] However, Harris et al. found very low levels of lipid testing with 3.9% of diabetes patients being tested in the six months between January to June 1996, which increased to 4.6% in July to December 1998.[190] In addition, Kamien et al. found that 56.1% of diabetes patients had received a cholesterol test and 48.8% a triglyceride test over a three-year period.[193] The large variation in the level of cholesterol, triglyceride and lipid testing between the studies suggests that there may be major differences in testing or that this testing was measured differently in each study. If the New South Wales Health Survey data is most representative, the level of testing in Australia may be close to the level recommended in the clinical management guideline. However, if Harris et al. or Kamien et al.'s studies are most representative, there were significant deficits in the levels of testing during the 1990s, which is recommended to occur every 1 to 2 years.[12]

Microalbumin tests

The guidelines recommend that patients be tested for microalbumin every 12 months. Harris et al. found that the level of microalbumin testing was very low, with

6.9% of diabetes patients tested between January and June 1996, which increased to 10.2% in July to December 1998.[190]

Encourage healthy lifestyle (diabetes education)

In their general practice study, Kamien et al.[193] found that 66.2% of patients had been given dietary advice, 35.8% advice on exercise and 36.2% advice on smoking. In a 1996 population-based survey of 191 people with type 2 diabetes in South Australia, Phillips et al. found that most patients had received some education or advice about diabetes from their GP, but the nature of the advice was not comprehensive.[191] While 90% of patients had received advice on blood pressure and 84% on cholesterol control, only 38% had been advised on physical activity and 40% on body weight. In addition, only 60% of smokers had been advised to quit. The studies suggest that diabetes education is commonly provided during general practice consultations but that doctors are more likely to provide information that is disease rather than lifestyle oriented, making it difficult for patients to take responsibility for their diabetes.[221] Diabetes education is seen as an ongoing responsibility for doctors and appears to be a common component of GP consultations.

Conclusion

This section has documented evidence relating to the prevention of complications and the utilisation of prevention interventions in Australia in the 1990s. By comparing actual rates to the standards set by the clinical management guidelines a

number of conclusions about the potential of screening and monitoring practices in Australia to prevent diabetes complications in recent times can be drawn.

First, the studies suggest that the practice of diabetes care did not match what was recommended in 1990s. This is despite the introduction of significant programs to promote the guidelines during that decade.[74, 183]

Looking across the studies, compliance with recommended guidelines was low in relation to every guideline except blood pressure testing, which almost certainly would have taken place as a routine part of any medical attendance and may not reflect diabetes-specific care.[222] Compliance was particularly poor for HbA1c testing, weight monitoring, foot testing and microalbumin testing. In addition, ophthalmological examination was moderately low.

Whilst the levels of diabetes education appeared to be high,[191] the effectiveness of this education must be questioned. This is signalled by Phillips et al.'s study which found that whilst many patients recalled receiving diabetes education from their GPs, the nature of this education was limited. In particular, GPs provided many patients with information about diseases and their medical control, such as hypertension and related medications, but little information about aspects of diabetes over which patients themselves could exercise control, such as physical activity.[191] This suggests that despite the high level of diabetes education reported above, patients may have been poorly advised about how to manage their diabetes.

The medical care examined in this review occurred at a time when the health care system in Australia was relatively stable,[173] and it is unlikely to represent a temporary state of affairs in a system that was otherwise well functioning and effective in its approach to diabetes management: Medicare had been introduced at least seven years prior to the earliest data reported in the studies and the organisational infrastructure supporting the system was well established.[173]

The difference between the general diabetes population (as documented above), insulin-users and other diabetes register patients, may provide an indication as to how the health care system needed to improve with regard to diabetes care in the 1990s. Studies by McCarty D et al.[218] and Sale et al.[182] of insulin using patients on the Tasmanian Diabetes Register during the 1990s, along with Bonney et al.'s study of the National Divisions of General Practice Diabetes Project,[219] showed higher levels of screening and monitoring, as well as of GP, specialist and allied health attendances, than did the studies of Tapp et al.,[203] the New South Wales Health Survey,[204] Harris et al.,[190] McCarty DJ et al.[223] and Kamien et al.,[193] which concerned the general diabetes population. For example, Sale found that in 2000, 69% of patients on the Tasmania Diabetes Register had obtained an ophthalmological examination, 93.5% had their blood pressure checked and 47.3% had their feet examined.[182] In addition, Bonney et al., who examined patients enrolled on diabetes registers, found that between 1999-2000, 48% of patients had received an HbA1c test, 43% had been weighed, 56% had their blood pressure checked and 35% had their feet checked over a six-month period. Also, 60% of these

patients had received a lipid test and 36% a microalbumin test in a 12 month period, while 51% had received an ophthalmological examination within two years.[219] This indicates somewhat higher quality of diabetes care among register patients than in the general diabetes population (although there was still considerable room for improvement in the latter).[197]

In addition to diabetes registers, the epidemiological evidence provides other pointers towards improving diabetes care. Some of the interventions that have been found to be effective in this regard include improving the skills of GPs in diabetes management,[224] and increasing the role of diabetes nurses in the provision of diabetes care.[225, 226] Whilst there is no data on the effectiveness of these interventions in the Australian context, many of the improvements in diabetes care internationally have been traced to these interventions.[227, 228]

In sum, Section 2 has presented the clinical management guidelines for diabetes and has examined the evidence concerning the utilisation of the guidelines in Australia. The clinical evidence upon which the guidelines are based would suggest that the levels of utilisation documented here would result in a significant burden of diabetes complications.[12] However, because the relationship between the level of utilisation of the guidelines and the incidence of diabetes complications has not been evaluated in Australia, it is not known whether these two factors are related. This is despite the strong clinical evidence for most of the interventions included in the guidelines.[12]

In light of this knowledge gap, this thesis sets out to explore the relationship between diabetes management and the development of diabetes complications in Australia through a series of population-based case-control studies. This investigation will enable a determination of whether the poor levels of diabetes management documented here may have resulted in the greater prevalence of diabetes complications during the 1990s and the contemporary period.

Before proceeding to examine this issue in a series of studies (see Chapters 4 to 10), the nature of the health care system through which diabetes management is provided needs to be considered. It is possible that the primary reason that advanced complications occur at the present time is that the health care system does not provide the organisational support for effective diabetes management,[16] as this would result in low levels of screening and monitoring. Without an understanding of the health care system and how it manages chronic diseases, it will not be possible to determine whether the guidelines are ineffective because they are based on limited clinical evidence and may not be appropriate for a population-based approach to the management of diabetes, or whether their ineffectiveness stems from not being implemented well in population health settings.

Section 3: Enhancing diabetes management through the primary health care system

As has been shown, diabetes results in a significant health burden as a consequence of a range of potentially disabling complications.[15] However, the previous section showed that improving self-management practices and increasing compliance with clinical management guidelines could avoid much of this morbidity.[12] Nevertheless, it has been shown that the standard of care in Australia was poor during the 1990s, and this could have led to a significant burden of complications.

This section explores why the standard of care was poor in this period. In particular, the nature of the health care system is examined, as it is the major institution involved in the provision of health care.[6] The section presents a best practice model of chronic disease care: the Chronic Care Model developed by Wagner et al.[38] and reports the findings of studies of the utilisation of the health care system by people with diabetes in Australia, in order to build a picture of the system of Australian diabetes care. In this regard, a number of conclusions about the capacity of the system to manage diabetes are drawn. This discussion sets the scene for Section 4 of the literature review, which focuses on other factors that can have a major influence on the capacity of the system to manage diabetes, in particular structural factors such as the socio-economic status of patients and their relative geographic isolation.

HEALTH CARE SYSTEM MODEL BASED ON CHRONIC DISEASE CARE

Both Australian and international evidence suggest that the level of screening, monitoring and diabetes education that occurs in a population is a function of the structure of the health care system.[38] Where systems have a greater focus on chronic disease, such as by providing a diabetes register, recall and reminder systems,[197] the standard of diabetes management is much improved (as measured by the interventions discussed in Section 2).[23] By contrast, in health care systems where a chronic disease focus does not prevail, the standard of care is low.[176] For example, in disadvantaged populations in the United States, where patients have poor access to health care, screening for retinopathy, as well as foot screening and HbA1c testing is very low.[229] Key studies point to the need for the health care system to be purposefully designed for the management of chronic diseases.[194]

In recent times, the need to establish systems for the long-term management of diabetes has been widely recognised.[230] At the same time, as the clinical and pathological characteristics of diabetes has become better understood, it has become possible to manage most diabetes by relatively simple interventions delivered through primary care (as exemplified by the clinical management guidelines discussed above in Section 2).[12]

Whilst by the 1990s GPs played the major role in the management of diabetes internationally, it became clear that they were not performing well in this regard and

that improvements in the standard of care were required.[23] The inadequate level of screening and monitoring such as HbA1c testing, lipid testing and retinopathy screening in Australia reported above was typical of the standard of diabetes management at that time.[193, 203]

In response, there was recognition that if diabetes care were to be improved major reforms to general practice would be required.[197] For example, in 1989 the St Vincent Declaration on Diabetes Care in the 1990s,[231] identified the need to improve the standard of diabetes management in primary care and in 1999 in Australia, the Commonwealth Department of Health in Australia established incentives for GPs to manage chronic disease through its Enhanced Primary Care Initiative in 1999, which particularly focused on diabetes.[205] This indicated a tacit recognition of the need to improve the standard of care.

In the process of designing a health care system that could respond effectively to chronic disease, important lessons have been learned from the practices of hospital diabetes clinics.[232, 233] Studies had shown, for example, that when high quality diabetes care was provided, this was not just due to the superior competence that is part of a hospital clinic's expertise, but was also because of the way in which clinics arranged care for their patients.[6] Features that were found to be most important in this regard included the ability to focus on a narrow range of pathologies and the provision of a more planned and structured approach to medical care.[232, 234]

Since this realisation, there have been major efforts to incorporate these features into general practice by establishing diabetes clinics in primary care,[235, 23] as well as registers and recall and reminder systems.[6] However, despite the sound evidence of the effectiveness of these features with regard to improving the standard of diabetes management, their incorporation into general practice has proven to be problematic in Australia as such infrastructure and clinics have remained relatively rare.[219, 236]

Many of the problems associated with the implementation of these interventions stem from how general practice has developed historically, in particular that it evolved when infectious diseases were the major concern for population health.[237] This led to the development of a system that was focused on the cure of diseases rather than their management, where medical care involved short term and episodic engagements between doctors and patients which were modelled on the sick role.[238] However, both the Australian and international experiences have shown that this approach to medical care is inappropriate for diabetes, as it leaves many of the most important aspects of chronic disease management unaddressed.[193, 237] The evidence for this contention is very strong. For example, in a meta-analysis of randomised controlled trials concerning the management of diabetes, Griffin found that the evidence supported a need for highly structured and long-term medical care in order to address diabetes.[197]

In response to evidence such as that described above, a large literature on the structural and organisational requirements of chronic disease management has

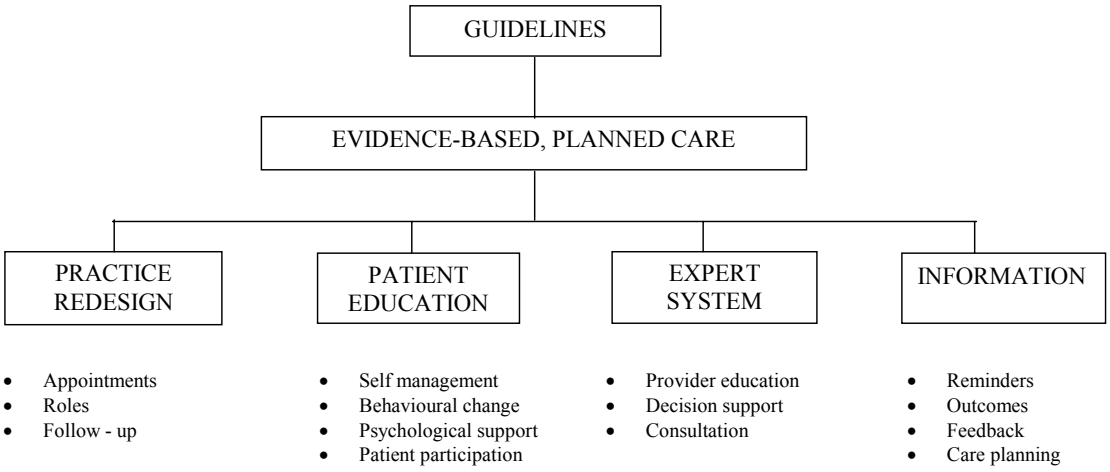
developed. Wagner et al. from the United States published the most influential model of chronic disease management in 1996, and this is captured in Figure 2.1 below.[38]

Following a thorough review of literature concerning the management of chronic disease, the authors developed a model consisting of elements of care for which there was clinical or public health evidence of efficacy. In a statement of principle, Wagner et al. argued that the best outcomes had resulted from health care systems that were patient-centred, proactive and anticipatory, with assessments, health education and follow up delivered at pre-determined intervals, and with the active support of patients taking responsibility for the management of their diabetes.[38] This represents a major contrast with the conventional model of health care that expects patient passivity, employs a narrow therapeutic focus, encourages limited engagement with the health care system and whose purpose is for a doctor to cure a disease.[239]

Chronic Care Model

Wagner et al.'s Chronic Care Model seeks to improve the quality of care by re-orienting the health care system so that it is more in tune with the management of chronic disease. Wagner et al. proposed that the effectiveness of such a system would be demonstrated by greater participation in preventive health care, as represented by high levels of adherence to clinical management guidelines and improved self-management, in addition to better health outcomes.[38]

Figure 2.1: Chronic Care Model for improving outcomes in chronic illness



From: Wagner E, Austin T, Von Korff M. Organizing Care for Patients with Chronic Illness, *Milbank Quarterly* 1996, p. 519 [38]

The model has four strata that represent a hierarchy of influence over the quality of chronic disease management. At the uppermost stratum (Level 4) are clinical guidelines which ensure that the health care provided is evidence based and hence of proven clinical effectiveness. The guidelines provide an explicit statement of what needs to be done, at what intervals and by whom.[199]

Below this level, the philosophy of the system is defined. This is termed evidence-based planned care (Level 3) and is founded on the need to reorganise the health care system to facilitate effective chronic disease management. In the implementation of evidence-based planned care (Level 2), Wagner et al. argue there are at least four major elements for achieving this objective: practice redesign; a focus on patient education; the establishment of health care infrastructure, such as

expert systems for increasing the knowledge and skills of GPs; and the easy flow of information between practitioners and patients.[38] The elements are described below.

Practice redesign

The authors argue that the introduction of systems of care that anticipate patient needs and follow them up through regular medical appointments are required in the management of chronic disease, as without such systems chronic disease patients are likely to miss out on significant amounts of medical care and are thus at risk of developing advanced complications.[240]

In addition, Wagner et al. argue for a shift in the nature of the doctor-patient relationship. The authors believe that some of the functions of this relationship need to be transferred from an individual doctor to a multidisciplinary team dedicated to managing diabetes.[241, 242] The ideal team, they suggest, would consist of a GP, a diabetes nurse, medical specialists and allied health practitioners who would be jointly responsible for a patient's management.[38] Advantages of the team approach are that it increases the accessibility of specialist expertise, provides a vehicle for the co-ordination of care and facilitates shared responsibility for the patient.[242]

As optimal diabetes care involves a range of health practitioners and the active participation of patients, the co-ordination of care is centrally important. When care is well co-ordinated, patients receive a broad range of management interventions at appropriate intervals in keeping with the optimum standard of care.[243] This leads to

more effective treatment, less duplication and better compliance with clinical management guidelines.[243] Because diabetes management is demanding, the authors argue for a dedicated professional such as a nurse to co-ordinate care for diabetes caseloads in general practice. The co-ordinator of care would facilitate optimal access to practitioners, as well as provide diabetes education and counselling.[243]

Patient education to improve self-management and behavioural change

The second organisational element of evidence-based planned care in Wagner et al.'s model is patient education.[38] This has the important goals of improving and supporting self-management and promoting positive behaviour change in patients. In diabetes care, health education is not just an adjunct to medical care, but is the major mode of intervention.[151, 152]

With regard to effective diabetes education, two types of intervention have been shown to be efficacious: cognitive behavioural therapy and greater involvement by patients in decision making about their medical care. Interventions that use these methodologies have been found to improve knowledge about diabetes, dietary habits and physical activity.[244, 245, 246]

Currently GPs are the major providers of diabetes education in Australia.[191] However, evidence suggests that they may not be the most appropriate practitioners for providing diabetes advice. For example, Phillips et al. showed that although most GPs provided information about diabetes to their patients, it was often of a highly

selective nature which left many patients ill-informed about important aspects of diabetes.[191] To address this problem Wagner et al. suggest that a diabetes educator be a major provider of education to people with diabetes.[38]

Expert systems

Identifying a third element of evidence-based planned care, Wagner et al. argue that the management of chronic disease requires the establishment of systems to facilitate access to expert advice.[247] The authors argue that the typical approach of referring patients to specialists has the disadvantage of potentially leading to the fragmentation of care. Some of the interventions that have been proposed to address this problem generally involve greater collaboration between primary health care practitioners and specialist or other practitioners.[224]

Wagner et al. point out that the dissemination of information technology (IT) has significantly improved the nature and availability of specialist expertise, through computerised decision support systems.[248] For example, IT is the basis of most diabetes register, recall and reminder systems.[197] In the past two decades, IT has facilitated changes that have the potential to significantly increase the capacity of the health care system as well as make it more efficient.[249]

Information

Wagner et al.'s fourth major organisational element concerns information and communication, and is closely linked to the previous element. The Chronic Care

Model is built upon the ready flow of information within diabetes teams and from teams to patients.[249] This is most effective when communications systems are attached to diabetes registers where patients can be prompted to attend for screening monitoring and checkups.[250] The implementation of diabetes registers has been shown to significantly improve the standard of care.

At a basic level, communication between doctors and patients can be conducted via telephone, which can be a cost-effective method of communicating with patients. [251] At a more sophisticated level, automated diabetes register, recall and reminder systems can be used as the basis of communication in diabetes care.[249]

The fragmentation of care

In their review, Wagner et al. acknowledged the potential for fragmentation of care to occur with the introduction of the Chronic Care Model.[38] This danger arises when the specific requirements of diabetes separate diabetes care from the rest of the health care system, such that patients use one health care system for the management of diabetes and the primary health care system for other health care needs. Whilst the evidence points to the need for chronic disease focused care systems, Wagner et al. warn of the implications of such specialisation on the need for primary care.[38]

How the Chronic Care Model is implemented in health care systems will show considerable variation. For example, in some health care systems the role of a team approach to the management of diabetes has been well legitimated,[242] while in others

it does not fit well with current financial or organisational arrangements.[252] Hence, whilst the epidemiological evidence provides support for the Chronic Care Model, there is no one recipe for its implementation.

THE PRIMARY HEALTH CARE SYSTEM AND DIABETES IN AUSTRALIA

Having outlined the 'ideal' model of a health care system for addressing chronic disease this section reviews the structure of the primary health care system in Australia and compares it to this ideal. Whilst an earlier section examined the utilisation of clinical management guidelines in Australia, this section evaluates the capacity of the Australian health care system to manage chronic diseases. It examines the structure of the diabetes care system by investigating the patterns of attendance at primary and secondary care, as documented by studies that have sought to examine the utilisation of health care by people with diabetes. In this review, the structure of the health care system is roughly defined by the health care utilisation of people with diabetes.

Methodology for the selection of studies

The aim of the review below is to analyse the structural characteristics of the health care system through which diabetes care was provided in the 1990s, according to the best epidemiological evidence available. To achieve this, the literature used was selected according to three criteria. The first criterion was that the findings of the studies included information on the use of the primary and secondary health care

systems, which form the basis of diabetes care. The elements considered to be relevant included general practice care, specialist care, allied health care and chronic disease management infrastructure (based on the Chronic Care Model presented in Figure 2.1 above). The second criterion was that the studies needed to be population-based so that they could be generalised to the broader population. Thirdly, the studies needed to report recent findings in order to make the analysis relevant to the contemporary health care system. On the basis of these criteria, six studies emerged.

Each of the studies was ranked according to the three criteria with the ranks then summed to give an overall score of validity and relevance. The studies are reported for each of the aspects of health care, with the highest ranked study first and the others in subsequent rank order. Overall, the studies show widely varying estimates of health care utilisation, which reflect different populations and methods of data collection, as well as differences in study instruments. While the studies provide robust estimates on some aspects of health care utilisation such as the number of patients who visited ophthalmologists (McCarty CA. et al.),[253] for other aspects of health care utilisation the data are much less reliable (for example, shared care). Notwithstanding their limitations, these studies offer the best evidence for evaluating the role of the health care system in the management of diabetes. Most studies included in this section were utilised in the review of compliance with clinical management guidelines provided in Section 2.

General practice care

As diabetes care is centred in primary care, facilitating access to GPs is perhaps the single most important function of the health care system. The Australian evidence shows that people with diabetes generally have good access to GPs and confirms that the primary health care system provides a large component of care to these patients. In a study using Medicare data, Harris et al. found that the proportion of diabetes patients from South Western Sydney who attended a GP in the six months of January to June 1996 was 74%, which increased to 87% between July to December 1998.[190] This high level of utilisation was reflected in the study of Kamien et al., who found that diabetes patients attended a GP 12.3 times in a 12-month period, of which 7.1 visits were specifically for diabetes.[193] This compares to 6.5 times on average for the Australian population during 1997-1998, suggesting that people with diabetes were high users of GP services.[254] The role of GP care in the management of diabetes is evaluated in chapters 4 to 10 of the thesis.

Specialist care

Whilst the locus of diabetes care has shifted to general practice in recent decades, medical specialists still play an important role in the management of diabetes, such as in diabetic retinopathy screening. Some of the specialists involved in diabetes care include endocrinologists, ophthalmologists and paediatricians. The New South Wales Health Survey of 1997 found that of 726 people who had been diagnosed with diabetes, 58.2% had consulted an eye care specialist in the previous year.[204] Lower levels of eye screening were suggested in the Melbourne Visual Impairment Project,

a study of eye disease in a representative sample of the Melbourne population aged 40 years and older conducted between 1996 and 1997. Of the 162 people with diabetes identified in this study, 52.6% had visited an ophthalmologist in the two years prior to the survey.[253] Overall, people with diabetes were intensive users of medical specialists and secondary care. The role of specialists in diabetes management is evaluated in chapters 4 to 9 of the thesis.

Allied health practitioners

The third type of practitioner involved in the management of diabetes was allied health practitioners, which included diabetes educators, nurses, optometrists, opticians, podiatrists and psychologists. Their involvement in diabetes care is similar in many ways to the role of medical specialists, in that they operate primarily on a sessional basis and do not take overall control of diabetes care. In the New South Wales Health Survey 1997, 34.5% of diabetes patients had consulted a diabetes educator in the previous 12 months. In addition, 30.9% had consulted a dietician and 25.3% a podiatrist over a 12-month period.[204] In their general practice study, Kamien et al. found that people with diabetes were very high users of allied health practitioners, with 95% having attended at least one of these practitioners over twelve months. These authors found the most frequented allied health practitioners were opticians, whom 33% of patients reported having attended, followed by podiatrists, who had been attended by 21%. A further 16% had attended a dietician. In addition, Kamien et al. found that 15% of patients had attended a diabetes nurse, perhaps reflecting the significant role nurses play in diabetes education and the co-

ordination of care.[193] Of the 162 people with diabetes identified across the Melbourne metropolitan area, 49.4% had visited an optometrist in the two years prior to the survey. [253] These findings suggest that people with diabetes are high users of allied health care. However, the only allied health practitioners included in the data collection of the present study were optometrists. Their role in the management of diabetes is examined in Chapters 4 to 9 of this thesis.

Practice systems

Turning to the extent to which elements of Wagner et al.'s Chronic Care Model had been built into the Australian diabetes care system, the literature indicates that in Australia, diabetes registers, recall and reminder systems were not widely available in general practice during the 1990s. Kamien et al. found that only 9% of general practices had a diabetes register, while 6% had reminder and recall systems.[193] Beilby et al. found similarly low levels of diabetes infrastructure, with only 8% of surgeries having at risk recall and reminder systems.[255]

In addition, Beilby et al.'s findings indicated an apparent reluctance on the part of GPs to prompt their patients to attend for diabetes care, with only 37% reporting that they sometimes contacted their patients about medical care - which may have significantly limited the potential of diabetes recall and reminder systems to work effectively. With regard to the use of clinical management guidelines, Beilby et al. found 24% of GPs reported that they used written prompts (flow sheets operationalising the guidelines that are designed to trigger recommended aspects of

care) when they managed diabetes, indicating a low level of acceptance of tools, despite the major focus that Australian health authorities have placed on guidelines for improving diabetes care.[255]

Summary

In summary, the epidemiological evidence suggests that the system of diabetes care in Australia is comprised primarily of community based GPs, medical specialists and allied health practitioners. The literature suggests that there has been a poor level of implementation of diabetes management infrastructure as many of the systems that are used internationally were not evident in Australia during the period of the studies cited here. While diabetes patients were intensive users of health care during the 1990s,[193] the apparent lack of chronic disease infrastructure suggests that most diabetes patients relied on conventional systems of care for the management of diabetes. This may explain the low level of screening and monitoring reported in Section 2.[255] The coinciding of conventional systems of care with low levels of compliance with recommended diabetes management guidelines suggests a strong relationship between the organisation of care and the standard of diabetes management during this period.

Whilst the studies did not report on the use of diabetes team based management, the New South Wales Health Survey 1997 indicated that over a third of diabetes patients had consulted a diabetes educator in a 12 month period.[204] These educators are often

involved in diabetes team-based care.[241] However, whether this was part of an ongoing or co-operative arrangement could not be determined.

There were no reliable data available on the use of expert systems in diabetes management. There were also few studies reporting on the utilisation of communication systems in the management of diabetes. However, as noted above, Beilby et al. found a general reluctance on the part of GPs to contact their patients with regard to their medical care, which indicates that there may be substantial barriers to the implementations of diabetes registers reminder and recall systems.[236] On the other hand, it also points to the potential gains that more formal, automated systems offer GPs by circumventing the need for them to rely on their own initiative when managing patients.[6]

Conclusion

This section has argued that the structure of the health care system is a major factor determining the quality of diabetes care at the population level. The studies cited here provide only limited evidence on the organisation of diabetes care across the population, both because the implementation of the Chronic Care Model was not specifically evaluated and because the nature of the organisation of care was sketched from limited information on the utilisation of health care practitioners and diabetes care infrastructure. Nevertheless, the evidence suggests that few of the elements of Wagner et al.'s Chronic Care Model were present in the Australian

health care system over the period of the studies cited, and thus that it was ill-equipped to provide high quality diabetes care.

However, since the studies reported in this section were conducted, some important aspects of the Chronic Care Model have been introduced into the Australian health care system, perhaps indicating a recognition that the standard of care needed to be improved. These include new Medicare schedules that directly pay GPs to manage chronic diseases,[205] and the introduction of Medicare payments for nurse practitioners who can co-ordinate care and provide diabetes education.[20]

Whilst it appears that the new Medicare schedules have been well accepted amongst GPs,[256] it is too early to determine whether they have had a significant impact on the standards of care. Nevertheless the clinical evidence points to their potential to improve diabetes management as it is now directly funded.[257] Similarly, the role of nurse practitioners in improving the standards of care has not been evaluated, but if the international experience is repeated in Australia, the greater use of nurses should lead to more comprehensive diabetes education and improved co-ordination of care.[6, 243]

Still many important aspects of the Chronic Care Model are yet to be implemented in Australia. For example a strong movement towards diabetes team-based care has not emerged, with many GPs still reluctant to become involved in formal co-operative arrangements for patient care.[252] Also, where diabetes registers do exist

they tend to be for insulin users, and do not generally serve most people with type 2.[182, 190, 236]

It appears that we are currently in a transition phase with regard to the management of diabetes and many of the elements identified in the Chronic Care Model such as population wide diabetes registers may yet be introduced into Australia. However, there may be significant limitations to the extent of changes achievable in the Australian health care system given the nature of how it is structured and run.

Whilst no particular aspect of the Chronic Care Model appears to be antagonistic to the Australian health care system, the scope of the reform it implies may be a major barrier. One of the key goals of the Chronic Care Model is to raise the standard of diabetes care across the population. However, this will require the implementation of the Model by all or most GPs. Whilst many GPs may welcome this as an opportunity to improve care for patients with chronic disease, others GPs may resist, seeing it as an extension of government demands and control.[258]

Historically, the private health care sector in Australia, which includes the majority of GPs and specialists, has resisted the imposition of government regulation over health care even though most practitioners are dependent on government finance.[258] This has meant that programs have often been limited in their ability to engage doctors in systemic changes to medical care. Typically in Australia, changes to the health care system are achieved by providing financial incentives to doctors rather

than through structural reforms.[205] Thus the basic structure of the health care system, from which many of the problems with medical care flow, is rarely altered. Section 2 of the literature review noted that the relationship between diabetes management and the development of complications had not been evaluated in a population-based study in Australia. As diabetes management is provided by the health care system, this can also be said of the health care system. However, the population-based case-control studies that evaluate the effectiveness of diabetes management in this thesis can, by extension, also be considered to be an evaluation of the effectiveness of the health care system in managing diabetes.

Before this evaluation is conducted, it is important to consider factors other than the structure of the health care system that also impact upon the nature of diabetes care as well including the risk of complications. While understanding the effectiveness of the health care system in managing diabetes is an essential step in improving diabetes management, so too is understanding the nature of inequalities in respect of diabetes. This is significant as inequalities in health and access to services determine to an important degree the management of diabetes across the population.[164] There is a danger that if diabetes management programs are introduced without equity being considered, they will not address a significant burden of the disease and may actually attenuate existing health inequalities. The nature of equity and diabetes is discussed in the section that follows (Section 4).

Section 4: Equity and the management of diabetes

Having described the epidemiology and clinical characteristics of diabetes in Section 1, discussed the clinical management guidelines in Section 2 and examined the role of the health care system in Section 3, the literature review now turns to the issue of equity in diabetes. Equity is significant because diabetes, its complications and risk factors are unequally distributed across the population and because more broadly, social inequalities influence health care utilisation. There is evidence that if a health care system is to deal with diabetes effectively it must not only provide adequate standards of diabetes management, it must also address social inequalities.[32, 33, 164]

This section begins by reporting key international evidence on the impact of socio-economic status on diabetes. Most of the literature cited is from Europe, in particular the United Kingdom, where there have been a number of population-based studies examining the relationship between socio-economic status and diabetes, which offer reliable population estimates of diabetes, complications, risk factors and health care utilisation for socio-economic groups.[32] Following this discussion, evidence on socio-economic status and geographic isolation in respect of diabetes is presented, with an examination of how these inequalities are associated with diabetes and health care utilisation in the Australian context. The literature concerning the relationship between geographic isolation and diabetes is then reported. Next, the evidence concerning diabetes and the Aboriginal and Torres Strait Islander population is examined, showing that this group is very badly affected by diabetes,

while also experiencing socio-economic and geographic inequalities.[30] Finally, evidence from the Australian and international literature is presented which examines how health care systems address health inequalities and the factors that need to be considered when improving the management of diabetes.[259] In this discussion a number of implications of health inequalities for the Chronic Care Model are identified: these include the need to provide greater diabetes infrastructure in disadvantaged populations. This section sets the scene for the final section of the review (Section 5 below) which identifies the major gaps in knowledge in the operation of the health care system in the management of diabetes in Australia. These are further addressed in the epidemiological studies in the thesis (Chapter 4 to 10).

SOCIO-ECONOMIC INEQUALITIES AND DIABETES

Socio-economic status is an indicator of an individual's, a community's, or a population's material resources, and is determined by factors such as level of income, occupation or workforce status.[260] There is a large body of evidence showing that socio-economic disadvantage has a major influence on health, including in relation to diabetes.[261] Socio-economic inequalities are instrumental to our understanding of diabetes management and prevention as they can have a major impact in determining the risk and severity of complications.[32]

A detailed overview of the international literature on the relationship between socio-economic status and diabetes is presented below, including in relation to the prevalence of diabetes, mortality rates, the incidence of complications and the utilisation of health care services among people with diabetes. Next, the Australian evidence on the association between diabetes and socio-economic status is summarised using similar themes. By highlighting different levels of health needs among different population groups, as well as poorer access to health care services by certain groups, this section points to the need for a focus on equity in the health care system that addresses diabetes.

International evidence on the relationship between socio-economic status and diabetes

The prevalence of diabetes and socio-economic status

There is strong evidence that low socio-economic status significantly increases the risk of type 2 diabetes, but not type 1.[262] This has been reported from developed countries including Australia,[263] the United Kingdom, [262, 264] the United States, [265, 266] and Canada.[267, 268] For example, in an analysis of a diabetes register with coverage of all patients with known diabetes in the South Tees Region of the United Kingdom in 1994, Connolly et al. found that the prevalence of type 2 diabetes was 1.4 times greater in the lowest socio-economic areas, as compared to the highest.[269] In addition, in the US, Everson reported that in the baseline survey of the Alameda County Study, which began in 1965, low socio-economic status respondents were 2.8 times more likely to report that they suffered from type 2 diabetes than their high status counterparts.[266] Finally, in an analysis of the 1996-1997 Canadian National

Population Health Survey, Tang et al. found that low income respondents were 2.16 times more likely to report that they suffered from type 2 diabetes than those who had high incomes. This points to a need for preventive health care systems to focus on low socio-economic groups.[268]

Mortality and socio-economic status in people with diabetes

Secondly, as well as being at greater risk of diabetes, there is sound evidence that people of low socio-economic status are at a greater risk of premature death than the more affluent. For example, in an analysis of the diabetes register mentioned above, Roper et al. found that in the South Tees Region of the United Kingdom, diabetes patients from the most deprived areas had a 1.8 times greater standardised mortality rate (death from all causes) than those from the most affluent areas. [270] Similarly, in a report from the Whitehall II study of British civil servants in 1995, Chaturvedi et al. found that of 218 civil servants with diabetes, those from the lowest occupational groups were 1.7 times more likely to have died since the study began than those employed in professional or executive occupations.[32] The authors also analysed data from the London component of the 1995 WHO multinational study of vascular disease in diabetes. In this study of 300 people with diabetes, the probability of dying was 2.1 times greater in the lowest social class when compared to the highest (when assigned by occupation).[32]

Interestingly, a study from Finland conducted by Koshkinen et al. found no difference in mortality by socio-economic status in people with diabetes. This study

investigated 11,215 deaths of people who were registered as suffering from diabetes between 1981 and 1985 and followed up in 1990. The authors reported that in contrast to the studies citied above, people with diabetes of lower social class in Finland did not have a higher all cause mortality rate than those of higher social class.[271] They suggested that the difference between their findings and other studies was that health inequalities may have been ameliorated through the Finnish health care system which has a great concern for equity.[271]

Diabetes complications and socio-economic status

In relation to the need for screening and prevention interventions, a third dimension of the relationship between socio-economic status and diabetes is that the incidence of complications is higher among those who are socially disadvantaged. With regard to macrovascular complications, Chaturvedi et al. reported that among people with diabetes in the Whitehall study, low status civil servants were twice as likely to suffer from ischaemic heart disease than were high status civil servants.[32] Similarly, in the WHO multinational study of vascular disease in diabetes, Chaturvedi et al. reported that people with diabetes of lower social class were 2.27 times more likely to die from cardiovascular disease than those of higher social class.[32]

With regard to microvascular complications, Chaturvedi et al. also found that people with diabetes of lower social class were 1.8 times more likely to suffer from proteinuria (an indicator of kidney disease) than those of higher social class.[32] In addition, the same study found that people with diabetes of lower social class might

have been at higher risk of developing retinopathy than those of higher social class, although this relationship was not statistically significant.[32]

Finally, Klein et al. reported on a number of findings concerning socio-economic status and risk of eye disease in a population-based study of 2990 people with diabetes in Wisconsin in the United States. The sample was stratified into younger onset diabetes patients (aged less than 30) and older onset diabetes patients (aged 30 or older) to provide an approximate division of types 1 and 2 diabetes. The authors found that in the younger onset group, doubling of the visual angle, an indicator of visual impairment, was 1.6 times less likely to develop in employed men compared to those who were unemployed. In addition, the risk of proliferative retinopathy was found to be related to educational status among women (an indicator of socio-economic status), where for every five or more years of formal education, the risk of this complication decreased significantly.[161] Further, for older onset subjects, men with less education or of lower socio-economic status were more likely to have a doubling of the visual angle than those with more education or of higher socio-economic status. A similar relationship was also found between level of education and clinically significant macular oedema, common symptoms of diabetic retinopathy.[161] The differential rates of diabetes complications point to more persistent and severe diabetes in lower socio-economic groups and accord with the findings on metabolic risk factors below.

Risk factors for diabetes and its complications and socio-economic status

In relation to the development of new cases of diabetes, the literature indicates that the greater prevalence of diabetes, higher mortality rates and greater risk of complications among people of lower socio-economic status documented above is reflected in the higher prevalence of risk factors among this group. For example, with regard to metabolic risk factors for diabetes, Chaturvedi et al. found that systolic blood pressure and blood glucose may have been higher in lower status civil servants compared to higher status employees, although these relationships were not statistically significant.[32] Similarly, in a case control study of 192 matched diabetes patients enrolled on a population diabetes register in the district of Kristianstad, Sweden, Larsson et al. found that those with poorly controlled diabetes had lower education levels that those with good metabolic control.[272] Finally, in study of 1549 subjects in Newcastle-upon-Tyne in the United Kingdom, Bhopal et al. investigated both socio-economic and ethnic differences in risk of cardiovascular disease and diabetes. The study compared 840 European subjects with 709 subjects of South Asian background who were resident in the same area between 1993 and 1997. Differences in metabolic risk factors were found mainly in the European subjects, and men of lower socio-economic status were found to have higher levels of 2-h glucose and systolic blood pressure than those of higher socio-economic status. In addition, higher levels of 2-h glucose were found in low socio-economic status women.[262]

In relation to obesity, in the WHO study noted above, Chaturvedi et al. reported that in people with diabetes, body mass index (BMI) was 1.8 points higher for those of lower social class, than those of higher social class.[32] In addition, in an analysis of the 6266 people enrolled on a diabetes register in the district of Tayside in Scotland, of whom 792 had type 1 and 5474 type 2 diabetes, Evans et al. found a strong relationship between obesity and socio-economic status, although this was only evident in type 2 patients.[262]

In an extensive review of the evidence from 144 published studies of the relationship between socio-economic status and obesity, Sobel and Stunkard found a strong inverse relationship in developing countries. However, in developed countries, a consistent inverse relationship was only found among women.[162]

In addition to biological risk factors for diabetes, there is strong evidence of a higher prevalence of behavioural risk factors such as sedentary lifestyles and poor nutrition among diabetes patients of lower socio-economic status. For example, in an analysis of 770 people with diabetes recruited from 40 GPs in Avon and Somerset in the United Kingdom, Bachman et al. found that those of low socio-economic status were 10.8 times more likely not to obtain sufficient physical activity than high status patients.[273] Further, in an analysis of the 1989-1984 baseline survey of a random sample of 2682 men who participated in the Kuopio Ischaemic Heart Disease Risk Factor Study, Lynch et al. found that less educated men were more than twice as likely to lead sedentary lifestyles than those with higher levels of education. Similar

patterns were also found according to income and employment status and physical activity.[164] Finally, in an analysis of 6980 subjects who took part in the Whitehall II Study, Brunner et al. reported that lower social class civil servants with diabetes were 1.4 times more likely to be physically inactive than those of higher social class.[274]

Reporting on diet and nutrition in the Kuopio Ischaemic Heart Disease Risk Factor Study, Lynch et al. found that people with diabetes with less education consumed poorer diets.[164] Bartley et al. made this same finding with regard to the wives of British civil servants.[275]

In addition to obesity related risk factors, smoking is a major risk factor for cardiovascular disease which is also related to socio-economic status. In the WHO study Chaturvedi et al. found that people with diabetes of lower social class were 1.8 times more likely to be smokers than those of higher social class. Whilst this same relationship was evident in the Whitehall II study, the differences between the civil servants were not statistically significant.[32] However, in the Kuopio Ischaemic Heart Disease Risk Factor Study, Lynch et al. reported that subjects with poor education were 1.4 times less likely to be non-smokers and were also found to have smoked for an average of 1.8 times longer than those with higher education.[164] Both the prevalence of diabetes and complications are strongly related to the risk factors discussed above. The higher rate of these risk factors in low socio-economic groups

points to the need for targeted interventions to address these causes of diabetes and complications.

The utilisation of health care and socio-economic status of people with diabetes

However, despite the greater burden of disease and potential for new cases of diabetes among socio-economically disadvantaged groups, there is evidence that the same groups have poorer access to diabetes care. For example, in a study of 620 diabetes patients registered with seven randomly selected general practices in Leicestershire in the United Kingdom diagnosed prior to 1990, Goyder et al. found major socio-economic differences in access to diabetes care, as reflected in patterns of health care utilisation between 1990 and 1995.[276] Patients with access to a car (an indicator of greater economic resources) were 1.35 times more likely to have attended a hospital diabetes clinic (an indicator of greater structure in diabetes care) over the study period than patients without; patients who owned their own home were 1.36 times more likely to have attended a hospital diabetes clinic than patients who did not; and patients employed in non-manual occupations were 1.32 times more likely to have attended a hospital diabetes clinic than those who worked in manual occupations. In addition, the authors found that patients of low socio-economic status, as measured by the Townsend score (a measure of relative disadvantage often used in the United Kingdom), were less likely to have attended a general practice for a diabetes review over the study period.[276] Further, in a study of patients on a diabetes register in the Salford district in the United Kingdom between 1993/94 and 2000/01 (where 4034 patients were included on the register in 1993 and

5671 in 2001), Edwards et al. reported that diabetes patients from more deprived areas were 1.27 times less likely to have shared care arrangements for their diabetes.[277] As this is the most effective arrangement for the management of diabetes, this may be an indicator of unequal access to high quality care.

The study by Bachman et al. noted above also examined the relationship between socio-economic inequalities and the utilisation of health care among people with diabetes. The authors reported that in the Avon and Somerset regions of the United Kingdom, diabetes patients with lower levels of education were less likely to attend hospital diabetes clinics than those with higher educational status. Low socio-economic groups appear to be specifically disadvantaged with regard to the utilisation of health care. This may help to explain the lower levels of diabetes complications screening and monitoring that are often found in lower socio-economic groups.[273]

Discussion

The international evidence of a link between diabetes and socio-economic status is compelling and shows a greater risk of diabetes, its complications and of premature death among socio-economically disadvantaged groups. This appears to be associated with higher levels of metabolic risk factors such as obesity and with behavioural risk factors such as smoking.

However, the evidence concerning the relationship between socio-economic differences and the utilisation of health care is more equivocal.[277] Whilst the level of diabetes care appears to be poorer in socio-economically disadvantaged populations in some localities,[276] this is not the case for all.[277] The literature indicates that the relationship between health care utilisation and social class is complex. Typically, attendance at GPs is higher among lower socio-economic groups, perhaps as a result of poorer health status. However, socio-economic inequalities are often found in the quality of the health care that is provided, such that disadvantaged groups are less likely to attend specialists or to obtain structured care or shared care for their diabetes.[273]

The chain of causation in the relationship between low socio-economic status and health inequalities has been explored by a number of authors.[261] In general, these studies have shown that health inequalities result from poor living standards associated with fewer material resources. The relationship between low socio-economic status and health care utilisation has been shown to derive from both the greater burden of ill health in low socio-economic groups and from institutional discrimination in the functioning of health care systems, where poorer people obtain higher levels of general practice care, but receive lower levels of prevention, specialist care and diabetes education.[276] As these factors are instrumental in the management of diabetes they may explain the greater prevalence of diabetes and complications in disadvantaged populations.

In relation to addressing socio-economic disadvantage and health, the evidence supports a broader public policy approach aimed at improving living standards and not just the introduction of medical interventions to reduce the burden of disease. This is not to discount the importance of improving access to appropriate medical care, which has also been shown to lead to better health, as demonstrated by evidence from Finland[271] and Salford in the United Kingdom.[277] However, as the genesis of most diabetes lies in poorer social conditions, these must be addressed if the disorder is to be properly prevented.

Having presented key international studies on the association between socio-economic status and diabetes, Australian evidence regarding this relationship will now be presented. Where there is an absence of studies specifically examining diabetes, reference is made to diabetes-related morbidity, mortality and risk factors such as cardiovascular disease, from which inferences about diabetes can be made. These findings paint a picture of a similar relationship between socio-economic status and diabetes as that evident in the international literature.

Socio-economic status and diabetes in Australia

The prevalence of diabetes, mortality, complications and socio-economic status in Australia

The socio-economic inequalities in diabetes documented in the international literature are to a large extent reflected in Australia. Firstly, the prevalence of diabetes is about twice as high among low socio-economic groups as it is among more affluent populations.[278] In addition, similar to the picture in the United

Kingdom, all cause mortality rates from diabetes are higher among disadvantaged groups, with poor women with diabetes about twice as likely to die than their better off counterparts.[60]

Whilst Australian data on the relationship between socio-economic status and diabetes complications are limited, there is evidence of a relationship between socio-economic status and cardiovascular disease that may reflect morbidity from diabetes. For example, in a study of the association between coronary heart disease and socio-economic status in New South Wales which used hospital in-patient data, Taylor et al. found that when adjusted for age, country of birth and region, the lowest socio-economic groups were 1.4 times more likely to suffer from an acute myocardial infarction than the more affluent.[279] In addition, in a study of the relationship between socio-economic status and causes of death in Australia using mortality records, Turrell and Mathers found that in 1995-1997 people of low socio-economic status were 1.94 times more likely to die of a disease of the circulatory system (including coronary heart disease and stroke) than the population on average,[263] again a similar relationship to that found overseas.

Risk factors for diabetes, complications and socio-economic status in Australia

Reflecting the international picture above, Australian studies have found socio-economic inequalities in relation to metabolic risk factors. For example, in an analysis of the 1989 National Heart Foundation Risk Factor Prevalence Survey, Bennett found that men of low educational status were 1.65 times more likely to

suffer from hypertension than those with higher levels of education.[280] Women of low educational status were 3.3 times more likely to have high systolic blood pressure and 1.8 times more likely to suffer from hypertension than their high status counterparts.[280]

As in the international evidence, associations between socio-economic status and risk factors for diabetes and its complications have been documented in Australia. In the 1999-2000 AusDiab study, a population-based cross-sectional survey of people with diabetes aged over 25, it was found that of 4996 men, those with lowest education status were 2.4 times more likely to be obese than those with high education status.[31] A similar differential was found among 6071 women subjects, where those of low educational status were 2.1 times more likely to be obese than those with higher levels of education.[31]

Also, in a recent analysis of the National Health Foundation Risk Factor Prevalence Survey 1989, Salmon et al. found that of 9309 subjects, those from low status occupational groups were 1.4 times less likely to participate in any leisure time physical activity and 1.8 times more likely to smoke.[281] These risk factors may be particularly important with regard to preventing morbidity from diabetes.

The utilisation of health care and socio-economic status for people with diabetes in Australia

Again, the Australian patterns of socio-economic inequalities and utilisation of health care among people with diabetes have similarities to the international

findings. In a study of the relationship between medical attendances and socio-economic status for 177,280 people with diabetes in New South Wales, Overland et al. found that those of lowest socio-economic status were 2.5 times less likely to be under the care of a GP than those of highest socio-economic status. In addition, people with diabetes of lowest socio-economic status were 2 times less likely to have attended consultant physicians and 1.4 times less likely to have attended medical specialists than those of high socio-economic status, and this points to major inequalities in care.[22]

Discussion

The Australian evidence on the relationship between diabetes and socio-economic status reported here points to a greater risk of diabetes and its complications for socio-economically disadvantaged groups, similar to that found in international studies. This relationship appears to be associated with higher levels of metabolic risk factors such as obesity and with behavioural risk factors such as diet and physical activity, each of which are more prevalent among low socio-economic groups.

A noteworthy point of departure from the weight of international research is Overland et al.'s finding that suggests that people with diabetes of low socio-economic status use GPs less in Australia.[22] This is at odds with the usual evidence with regard to socio-economic status and GPs and perhaps points to differences associated with people with diabetes and perhaps other chronic diseases, when

compared to the general population. The finding may explain the overall lower level of health care utilisation among low socio-economic groups, which might result in under testing and under-referral for diabetes care. The relationship between socio-economic status, health care utilisation and diabetes complications is investigated in Chapters 6 to 8 of the thesis.

GEOGRAPHIC ISOLATION AND DIABETES

In addition to socio-economic status, there are also significant geographic inequalities in respect of diabetes (see Chapter 9). While there have only been limited investigations of the relationship between geographic isolation and health in developed countries, there is growing recognition that geographical isolation is a major source of health inequality. It is especially significant in Australia, in that just over a third of the population live outside of metropolitan areas.[33]

There are methodological issues affecting research into geographic isolation and health. Whilst many populations at high risk of diabetes and its complications are often geographically isolated, such as indigenous groups, they also tend to have lower living standards than metropolitan populations. Thus, it is often difficult to separate out the effects of relative poverty from geographic isolation. Nevertheless, there is strong evidence that relatively isolated populations, both in Australia and internationally, have higher levels of diabetes complications and risk factors than the urban populations, even when income level or other measures of socio-economic status are controlled.[282]

With regard to the international evidence, in a 1998 Canadian study of 9,042 patients of 241 randomly selected primary care physicians, Leiter et al. found that the prevalence of impaired glucose tolerance was 1.6 times greater among those from rural as compared to urban populations.[29] In addition, in an analysis of 16

jurisdictions in the United States as part of the National Health Interview Survey conducted in 1991, which compared 4391 women of rural, urban and suburban residence aged between 40 and 64, Ramsay et al. reported that rural women were 1.3 times more likely to be obese than their urban counterparts, which increased their risk of diabetes.[283]

Further, in the pooled results of two population-wide health surveys in Finland conducted in 1991 and 1998, which together included 26,014 adults, Laaksonen et al. found that respondents who lived in rural areas were 1.02 times more likely to be physically inactive than those who lived in cities and 1.4 times more likely to eat an unhealthy diet.[284]

There is also some evidence concerning geographical isolation and mortality among people with diabetes. Using the National Mortality Database compiled from Births, Deaths and Marriages registered in Australia, the Australian Institute of Health and Welfare (AIHW) estimated death rates from diabetes for metropolitan, rural and remote populations and found that between 1992 and 1996, people who lived in remote locations were almost 2.5 times more likely to die from diabetes than those who lived in cities.[33] When this is compared to the data on socio-economic status, it appears that geographically isolated individuals may be at a higher risk of dying from diabetes than those who are socio-economically disadvantaged.

In a study using the National Hospital Morbidity Database compiled from hospital separations in most Australian states and territories, the AIHW found that between 1995 and 1996, people who lived in remote areas were hospitalised for diabetes more than twice as often as metropolitan residents. [33] In addition, the population in remote localities who lived outside of remote centres were 1.6 times more likely to be hospitalised for stroke than those who lived in cities.[33] However, in an analysis of death rates no difference between metropolitan, rural or remote locations was found.[33]

Analysing coronary heart disease and geographic isolation between 1995 and 1996, the AIHW found that populations who lived in small regional centres were 1.1 times more likely to be hospitalised for this condition than metropolitan residents.[33] Further, between 1992 and 1996, populations from large rural centres were 1.13 times more likely to die from coronary heart disease than those who lived in metropolitan centres.[33]

However, caution must be exercised when interpreting levels of hospitalisation in isolated settings in Australia. In many geographically isolated areas, acute care hospitals play a greater role in the provision of general practice care as a result of the scarcity of private medical practitioners. In these settings, levels of hospitalisation are likely to be indicators of the availability of health services as well as of morbidity.

There is some evidence concerning the relationship between geographical isolation and the risk factors of overweight and obesity, again from Australia. The ABS National Health Survey 1995 reported that the prevalence of these conditions was 1.15 times higher in rural women that in women from metropolitan areas. However, no similar differential was found in men.[285] In addition, people who lived outside of remote population centres were found to be 1.2 times less likely to walk for exercise and 1.2 times more likely to smoke.[285] This is a similar excess in smoking to that found in lower socio-economic groups in the Kuopio study.[164]

There are a number of factors that may explain the relationship between geographic remoteness and disease. These relate to the nature of remote populations, which tend to be poorer and less healthy than those who live in urban areas.[33] In addition, many rural populations are older, which increases the risk of chronic disease. In addition, there is a shortage of GPs and specialists in rural areas in Australia which affects access to health care,[286] and which may mean that people with diabetes in these areas are less likely to be diagnosed or appropriately treated.

In conclusion, there is evidence of a relationship between geographical isolation and diabetes.[33] Many of the factors that make diabetes a more common and severe disease in low socio-economic groups also occur in geographically isolated populations. This commonality potentially points to similar influences on health in isolated localities as occur in socio-economically disadvantaged populations. This

may mean that many of the interventions aimed at improving diabetes management in low socio-economic groups could also benefit isolated populations.

Ensuring equity of access to health care for the management of chronic disease in isolated communities poses a particular challenge. There are very few models of care that have been shown to provide adequate levels of care for chronic diseases in rural and remote settings (the role of outreach care for people with diabetes was discussed in Section 2). In these areas access to services appears to be a particularly difficult problem to solve as isolated populations suffer from a lack of medical practitioners and there are diseconomies of scale that preclude the introduction of specialist or tertiary health care services.[286] This means that many patients are required to travel to population centres in order to receive the medical care they require. These factors may seriously confound efforts to improve the management of chronic disease. The association between relative isolation, health care utilisation and the risk of diabetes complications is explored in Chapter 9 of this thesis.

DIABETES AND THE INDIGENOUS POPULATION

Having examined the influence of socio-economic status and geographic isolation on diabetes more generally, the impact of diabetes on the indigenous population is now considered. As noted above, the disproportionate prevalence of diabetes and its complications among indigenous people gives this population special purchase in a study evaluating the effectiveness of the health care system in managing diabetes.[30]

The evidence regarding diabetes in the indigenous population shows that they are at a greater risk of diabetes than the rest of the population and appear to suffer disproportionately from mortality and complications.[30] However, our knowledge is limited with regard to risk factors and the impact of specific complications. This is partly the result of the quality of indigenous health data and the problem of correctly identifying Aboriginal and Torres Strait Islanders.[287]

With regard to identifying the indigenous population in health and other data sets, the Australian Bureau of Statistics has identified four factors that significantly impact on the quality of information on indigenous health. These include the problem of implementing standard methods and procedures for identifying indigenous people, which vary between locality and setting; the completeness by which indigenous data are recorded in health surveys and administrative databases, which also applies to the Medicare database; and the validity and reliability of self-report data also affects knowledge of health status in the general population.[287]

These impediments mean that there is generally limited information on diabetes and health status in the indigenous population. However, a number of studies have been conducted which estimate factors associated with diabetes in Aboriginal and Torres Strait Islander populations and these can be used to build a picture of diabetes. Some of the findings are discussed below.

Prevalence estimates for diabetes have found high and increasing rates of type 2 diabetes in the indigenous population. When early studies are compared with more recent investigations, it has been found that Aboriginal and Torres Strait Islanders originally had very low (or non-existent) levels of diabetes, while in recent times they have recorded some of the highest rates in the world.[30]

The contrast between the early and late studies is thought to partly reflect the impact of social change and epidemiological transition on the Aboriginal and Torres Strait Islander population. With regard to recent estimates, a North Queensland study conducted in 2003 found that 12.6% of Aboriginal and Torres Strait Islander adults had been diagnosed with diabetes,[48] which was approximately four times greater than in the Australian population in general.[288]

With regard to mortality, the evidence suggests that diabetes may account for a larger proportion of mortality among indigenous groups than among the non-indigenous population. For example in the Northern Territory, it has been estimated that diabetes contributed 3% to 5% of excess deaths in the indigenous population.[289]

As has been noted, Aboriginal people have a much greater incidence (4 times) of end-stage renal disease.[290] For example, in the Northern Territory it was found that the age-adjusted risk of ESRD in the indigenous population was 17.4 times greater than for the rest of the Australian population.[291] Phillips et al. found that renal disease was the most common cause of death in Central Australia.[292] It is estimated

that between 20 and 30% of ESRD in Aboriginal and Torres Strait Islander communities is attributable to diabetes.[291, 293]

Whilst there are some data available on renal disease, there is little information on other microvascular complications. However, it is believed that sensory neuropathy may be more common among Aboriginal and Torres Strait Islanders, although they may suffer from similar levels of retinopathy to the rest of the population.[294, 295] There is no information on the prevalence of diabetic foot disease among indigenous people.[30]

One of the major reasons that diabetes is a major concern for indigenous health is that it is related to cardiovascular disease, which is among the major causes of death in Aboriginal and Torres Strait Islanders.[296] For example, in a study from the Kimberley, the prevalence of "Probable and suspect coronary heart disease" was found to be 1.5 times greater among Aboriginal and Torres Strait Islander men compared to non-Aboriginal men. For women, this difference was 2.4 times greater.[297] In addition, it is estimated that Aboriginal people suffer 2-3 times more from ischaemic heart disease[298] and 6.9 times more from stroke[299] than the general Australian population.

The higher level of diabetes and its complications in the Aboriginal population could be explained by the greater prevalence of risk factors such as obesity. For example, The National Aboriginal and Torres Strait Islander Health Survey in 1994 found that

57% of Aboriginal women and 60% of Aboriginal men were overweight or obese, compared to 38% of the general population.[287] In addition, the Kimberley study mentioned above found that Aboriginal women might experience twice the risk of hypertension than among non-Aboriginal women.[297]

Reflecting the higher risk of renal disease, a Northern Territory study found that the frequency of proteinuria was 6 times greater in the Aboriginal and Torres Strait Islander population.[300] Moreover, they may also have a high risk of macroalbuminuria. Rowley et al., in a survey of Aborigines of Northern Australia, found that 22.2% of men and 26.9% of women suffered from this condition.[301]

Whilst there is an established epidemiological relationship between diet and diabetes, the evidence regarding these risk factors in the Aboriginal and Torres Strait Islander population is equivocal. A number of studies have found higher levels of fat and refined sugar in Aboriginal and Torres Strait Islander diets, however, others have found no such relationship.[302, 303, 304] In addition, there is also scant evidence about physical activity. However, in a study of risk factors for diabetes in Northern Queensland, McCulloch found that Aborigines in this area had inadequate levels of physical activity.[48]

Indigenous populations in Australia not only have much worse health status; they are also disadvantaged with regard to the utilisation of health care services.[292] Whilst

this is partly a function of geographical remoteness, there are also factors related to social exclusion that impact on the accessibility of medical care.[305]

Conclusion

The Australian evidence on diabetes in the Aboriginal and Torres Strait Islander population is roughly in accord with the evidence on indigenous populations internationally, which shows comparatively high levels of diabetes and complications.[306, 307, 308] This greater prevalence appears to be related to the recent erosion of traditional lifestyles through dispossession, and with the poverty associated with this.[309] The high level of diabetes, risk factors and complications appear to be associated with the transition from traditional lifestyles to modern Western ones.[310] In addition, the trends that initiated the epidemic of diabetes in indigenous populations appear to be far from ending.

However, in comparison to other similar groups, Aboriginal and Torres Strait Islanders appear to be particularly disadvantaged. Whilst in many indigenous populations, living standards and health status have improved in recent decades, these improvements have largely bypassed Aboriginal and Torres Strait Islanders.[287] This has occurred as a result of the continuation of poverty, low social status and poor living conditions that typify this population.

However, the fact that the health and socio-economic status of indigenous groups in other countries have improved, points to the potential of a similar improvement in

Aboriginal and Torres Strait Islanders.[311, 312] In countries that have achieved the greatest gains, this has come about by major social changes where indigenous populations have been able to assert their identity and improve their socio-economic status.[313] This suggests that were such changes to occur in Australia similar improvements in health would be forthcoming.

ACHIEVING EQUITY IN HEALTH CARE

The previous discussion documented the Australian and international literature on the relationship between socio-economic status, geographic isolation and diabetes. A discussion on diabetes in the indigenous population ensued as arguably this group has the most to gain from the development of a health care system that can effectively manage diabetes.

The proven association between equity and health, as discussed above, has been a strong motivator for the development of health care policy, both in Australia and overseas. For example, health care systems such as the National Health Service in the United Kingdom have been introduced with the aim of raising the health status of the poorest groups by providing them with access to health care.[314] Similarly, Australia's Medicare was introduced with an explicit goal of ensuring access to health care for all members of the community.[315]

In both countries however, the goal of equal access to health care has not been achieved[22] nor has that of eliminating socio-economic or geographic differentials in health.[33, 277] This is evidenced by continuing socio-economic differentials in access to medical care, especially access to medical specialists, and also by hospital separation rates which exhibit significant inequalities in relation to diabetes care.[22] Not only have health inequalities persisted despite the introduction of these systems; in some cases they have widened as a result of the increasingly wider socio-economic inequalities over the last 20 years or so. [316] This is particularly true for the Aboriginal and Torres Strait Islander population.[287]

Some researchers and policy makers have argued that the reason for the limited success of these health care systems in addressing inequalities has been that causes of disease lie in broader social conditions and it is the failure to address these factors that socio-economic inequalities persist.[316] According to this argument, government responses to health inequalities that have relied solely on the health care system to deliver better health outcomes have been of limited success as they do not address the root causes of poverty and inequality.[316] The authors point to the historical record, which has shown that when health improvements occurred, this has most often been the result of factors such as the remediation of over-crowding and poor sanitation which represent improvements in social conditions.[316]

When confronted by the fact that health care systems can only have a limited influence on health status, policy makers have had to be very cautious in how they

approach health inequalities. Typically they have adopted an approach that seeks to improve equity in how the health care system operates rather than focusing on health outcomes. Mooney, for example, argues that the only rational objective for policy makers in this context is equal access to health care for people of equal need. This, the author argues, is an appropriate objective as access to health care is more able to be achieved by health policy changes and is also to the broader population's benefit.[259] The principle forms the basis of Medicare in Australia[315] and the National Health Service in the United Kingdom.[180]

There are a number of ways in which the principle of equal access for equal need can be promoted. However, they all share a common methodology: that of uncoupling a person's capacity to pay from their access to health care.[259] In some cases medical care is provided free as of a right to all attendees, such as in public hospitals in Australia,[258] and in respect of general practice in the United Kingdom.[180] In other systems, individuals are provided with taxpayer funded health insurance, as occurs in Medicare.[258]

Conclusion

The section has drawn on a range of evidence that shows diabetes to be a greater burden on disadvantaged groups than on more advantaged populations. This burden includes greater rates of diabetes, higher morbidity and mortality, and poorer levels of metabolic control. In addition, socially disadvantaged groups tend to perform comparatively poorly in obtaining preventive care, notwithstanding the findings of

the literature review in Section 2 above, which suggested that diabetes self-management may be problematic for all people with diabetes. Similarly, there is evidence that geographically isolated individuals are disadvantaged in access to health care in a number of significant ways. Further, the section has reported on the evidence concerning the profound disadvantage experienced by indigenous Australians in respect of diabetes.

The breadth of the impact of social disadvantage, both internationally and in Australia, strongly suggests that there is a need for greater equity in diabetes care and that care needs to be organised with the goal of equity in mind. Whilst the overall level of access to care among disadvantaged groups, apart from Aboriginal and Torres Strait Islanders, appears to be good in Australia, as reflected in high rates of utilisation of GPs,[286] there is evidence that once people acquire a chronic disease, major socio-economic inequalities develop. This is suggested by Overland et al., who found lower levels of general practice and secondary care utilisation among socio-economically disadvantaged groups with diabetes.[22] In addition, in the international literature there was evidence of significant inequalities in diabetes clinic attendances, shared care and specialist and consultant physician attendances as found by Goyder et al.,[276] Edwards et al.[277] and Bachman et al.[273] from the United Kingdom. This evidence suggests that the quality of diabetes management is significantly poorer among disadvantaged populations.

However, when equal access to the Chronic Care Model, which has the potential to remediate many of the problems with diabetes care is considered, the Model may pose its own problems with regard to inequalities. For example, the emphasis on prevention may be problematic because of the lower propensity of disadvantaged populations to participate in preventive care interventions.[317, 318, 319] As well, poor patients are less likely to play an active role in their treatment and are more likely to rely on a traditional doctor-patient arrangement for their medical care.[305, 319]

In addition, other aspects of the model raise the issue of medical practitioner supply which may be a particularly acute problem in socio-economically disadvantaged or isolated regions. For example, the practice redesign element of the Chronic Care Model requires medical care to be arranged by a multidisciplinary diabetes team. However, in many places the personnel that are required to staff these teams might not be available.[320] Whilst this is most likely to relate to medical specialists and allied health practitioners, in some areas there are also chronic shortages of GPs.[320]

However, there is less evidence of socio-economic inequalities in self-management, as was discussed in Section 2, which appears to be similarly poor in advantaged and disadvantaged populations,[154] although it may differ in qualitative terms. This is the case even though it includes actions and interventions that have traditionally been found to be problematic for disadvantaged groups in other contexts.[321]

Whilst the equity-related problems discussed above may be difficult to rectify, there could be considerable scope for the broad implementation of diabetes registers to improve the management of diabetes across socio-economic groups.[6] Diabetes registers could be used to prompt GPs and patients to make the best use of the medical care that is available, even though this may be below that which could be achieved in well-served affluent metropolitan areas.

Another practitioner supply issue which is perhaps able to address supply-based inequalities relates to the third element of the Chronic Care Model, expert systems. There has been a vast dissemination of information technology through the health care system in recent decades and these technologies have reached many disadvantaged and remote communities.[322, 323] This has allowed the expertise and support they offer to penetrate into hard to reach disadvantaged and isolated areas. Hence, IT may serve to address some aspects of health inequality and counter some of the impediments to the management of chronic disease.

Thus while some elements of the Chronic Care Model may fit into the current arrangements for medical care in disadvantaged populations, there are other barriers that need to be addressed if the management of chronic disease is to be improved across the population. There is a danger that unless the barriers are addressed, the promises of the model will not be shared by disadvantaged populations.

Whilst there appears to be good sense in the introduction of the Chronic Care Model within disadvantaged populations, as was the case in Sections 2 and 3 above, we do not know whether it is the quality of care offered in disadvantaged populations in Australia that increases the risk of complications. This is because to date there have been no population-based studies examining health care utilisation and its relationship to the risk of diabetes outcomes in disadvantaged populations. It is important that this relationship be investigated as a large proportion of the burden of diabetes lies in these populations and this needs to be better understood if complications are to be prevented. This challenge is taken up by this thesis in Chapters 6, 7, 8, 9 and 10, which investigate whether health care utilisation associated with socio-economic status and geographic isolation is related to the development of diabetes complications.

In conclusion, whilst the Australian health care system provides a solid foundation for pursuing equal access to health care for equal need through the Medicare system and free hospital care,[173, 258, 286] it appears that chronic diseases present their own problems for service delivery. Perhaps it is because chronic diseases rely so much on the competence and capacity of patients, as well as preventive care and the long-term commitment of practitioners, both of which are supported by a complex system of health care arrangements, that achieving equity in diabetes poses particular challenges for the health care system. However, before going on to evaluate the role of social disadvantage in the health care system, which is explored in Chapters 8 and

9, Section 5 below presents a summary of the arguments covered in the review and documents the evidence gaps that will be addressed in the thesis.

Section 5: Summary of the literature review and the evidence gaps addressed in the thesis

The key argument informing the literature review is that whilst a lot is known about diabetes, there are key knowledge gaps that hold back the development of health care systems to prevent complications. These relate primarily to the effectiveness of current care models for the management of diabetes. This was established by firstly describing the epidemiological and clinical characteristics of diabetes, which were presented in Section 1. This section argued that diabetes was a major public health problem because of its complications and its increasing prevalence across the globe. It was also noted that it is of particular concern for high-risk groups such as Aboriginal and Torres Strait Islanders, where there was urgency for diabetes to be addressed.

Following this description a clinical overview of diabetes was presented, which considered the major pathologies, aetiologies and risk factors for types 1 and 2 diabetes. A detailed description of microvascular and macrovascular complications then followed. For each complication, its clinical manifestations, risk factors, distribution in the population, and most common interventions were presented. Section 1 concluded by arguing that despite the clinical complexity of diabetes, the burden of diabetes could be addressed as there were many prevention and management interventions available.

Having described the health impact of diabetes, Section 2 sought to explore the nature of diabetes management. The section began by exploring self-management, and argued that this was the most important component of diabetes management as the development of complications is largely dependent on the capacity of people with diabetes to manage their own condition.

This was followed by a wide-ranging discussion on the nature of diabetes management, which included consideration of the major modalities involved in providing diabetes care. Each modality was evaluated in terms of its capacity to manage diabetes. The Clinical Management Guidelines for Diabetes in Adults[74] were then presented as a means by which diabetes could be effectively managed across the population. A description of each guideline and its usefulness was then presented. This was followed by a review of the evidence regarding the use of the guidelines in Australia during the 1990s. Section 2 concluded by arguing that the epidemiological evidence suggested that the use of the guidelines was poor in Australia. However, it was argued that it was not known whether this had led to a greater burden of diabetes.

Having established that diabetes management was inadequate during the 1990s, Section 3 sought to explore why this could have occurred. It was noted in this section, that the evidence, both from Australia and internationally, pointed to the importance of the structure of the health care system in determining the quality of diabetes management. It was argued that major problems existed in conventional

health care systems with regard to the management of chronic disease and these related to the purpose of medical care, which was of curing disease; to the method of care, which was largely practitioner driven; and to the nature of engagement, that relied on short-term and intermittent contact to deliver medical care. The review observed that these characteristics pervaded the Australian health care system and may have been responsible for the poor standard of diabetes care that was observed in Section 2.

Following these observations, Wagner et al.'s Chronic Care Model[38] was presented as a means by which diabetes management could be improved. The model represents the ideal design of a health care system that could provide optimum care for diabetes. To illustrate the deficiencies of the Australian health care system, it was compared to Wagner et al.'s model in regard to the major elements used in the management of diabetes. In this analysis, the health care system was found to lack significant infrastructure such as diabetes registers, reminder and recall systems and that it appeared to promote conventional models of care. It was hypothesised that the inadequate level of screening and monitoring was a direct result of its lack of capability to manage chronic disease.

Having argued in Section 3 that there was a need for the Australian health care system to develop greater capabilities in the management of chronic disease, Section 4 identified equity as another major concern with regard to diabetes. Studies had found that major inequalities existed with regard to the risk of type 2 diabetes,

diabetes related mortality, morbidity and risk factors in addition to access to health care. Of particular concern was low socio-economic status, geographic isolation and indigenous status, which were all investigated in relation to diabetes.

Having identified major equity issues, the section proceeded to explore health care systems and how many of them had developed in order to address social inequalities. Of particular note was Medicare and the state and territory public hospital systems in Australia, which both provided free or inexpensive access to health care.

A discussion then ensued regarding the challenge of introducing the Chronic Care Model into disadvantaged populations. It was found that there were a number of significant impediments that could compromise the quality of care. It was concluded, that although desirable, the improvements in chronic disease management in disadvantaged groups may be harder to achieve than for the rest of the population.

Throughout the literature review it has been argued that despite the nature of diabetes and its management in Australia being reasonably well understood, it is not known whether the diabetes management practices that have prevailed have resulted in a greater burden of complications. Thus because there have been no longitudinal population based evaluations of the health care system which have focused on the management of diabetes, this has left a number of very significant evidence gaps regarding diabetes management and the health care system that need to be

addressed. The studies that follow address a number of these gaps using population-based longitudinal studies.

EVIDENCE GAPS ADDRESSED IN THE THESIS

The evidence gaps identified in this section form the basis of the research questions in Chapter 1. In the previous discussion it has been argued that there was a need to evaluate the Australian health care system and its capacity to manage diabetes if diabetes management was to be improved. Whilst there have been a number of population-based studies of diabetes management, most studies have used a process of care, such as the frequency of retinopathy screening or metabolic risk factor, such as HbA1c value as a measure of its effectiveness.[277, 324] However, these study outcomes represent risk factors for complications rather than complications themselves, hence doubt has remained as to whether the interventions have been truly tested as to their capacity to manage diabetes.

Whilst a diabetes complication could not be used as the study outcome in the thesis, a process of care that is highly correlated with an advanced diabetes complication was used as the outcome in these studies.[24] This has meant that the health care system was measured against the risk of developing an advanced complication, in particular vision-threatening retinopathy, in these studies. This provides a more direct link between health care utilisation and the development of complications than

most other studies. This is a characteristic of all of the current studies (Chapters 4 to 10).

Much of the discussion in Sections 2 and 3 of the literature review concerned the effectiveness of different models of care. This related to the observation that the current Australian health care system was not well designed for chronic disease.[187] However, a study that was able to compare *actual* health care systems was not identified. In this thesis the capacity of eight (albeit related) health care systems could be compared. These were the state and territory samples. By comparing the patterns of care and the development of diabetes complications for each state and territory, this evaluated the effectiveness of individual health care systems and their capacity to manage diabetes. This is reported in Chapter 5 of the thesis.

With the increasing prevalence of diabetes and complications across the globe there is an urgency to the development of public health strategies that can address the condition. From the perspective of health care policy makers there are a number of alternative strategies that could be used.[325] However, these strategies are difficult to compare. With regard to preventing complications there is dispute as to whether public health agencies should put their efforts into achieving the early diagnosis of diabetes,[326] or whether they should focus on managing patients who have already been diagnosed.[12] These strategies are weighed up in Chapter 6 of the thesis.

Whilst evidence for the clinical effectiveness of the clinical management guidelines is strong, few studies have investigated risk factors related to health care during the pre-diagnosis period. This period is significant because during the pre-diagnosis period, people with diabetes do not attend practitioners for diabetes care, they do not have access to hypoglycaemic medications, nor do they practise diabetes self-management. In hyperglycaemic patients these circumstances could lead to poor metabolic control and the accelerated development of diabetes complications.[12] This is investigated in Chapter 7 of the thesis.

Whilst the relationship between socio-economic status and diabetes complications has been explored both internationally and in Australia - where a higher risk of complications has been found in low socio-economic groups - it is not known whether this is related to health care utilisation. This is explored in Chapters 6 to 8 of the thesis.

Similarly, the relationship between geographic isolation and complications has also been investigated in international and Australian studies. Again it is not known whether this is related to health care utilisation. This is explored in Chapter 9 of the thesis.

The literature on chronic disease management stresses the significance of the role of practitioners in determining the standard of care. In this literature this is often related to the cultural and attitudinal characteristics of practitioners.[41] However, in these

studies quality of care is most often measured by process outcomes, such as the provision of diabetes education or pathology testing.[327] Yet, these are intermediate outcomes in the development of advanced diabetes complications and may be tenuously related. Hence the relationship between practitioner factors and health status is not well understood. This is explored in Chapter 10 of the thesis.

With the prevalence of diabetes growing and risk factors increasing,[7] and in the context of social trends that are accentuating the risk of diabetes and its complications, it is vital to understand the capacity of the major institution involved in providing health care to manage diabetes. By exploring the relationship between health care utilisation and the development of advanced complications at the national level as well as within states, at critical periods and for high risk groups, the thesis should provide a comprehensive assessment of the capacity of the Australian health care system to manage diabetes.

Chapter 3

Methods

Introduction

The literature review has documented the clinical and epidemiological characteristics of diabetes and its complications, described the management of diabetes, the nature of the health care system as well as the most significant equity issues with regard to diabetes. However, having identified these issues as highly important with regard to the development of diabetes complications, it has also been argued that the effectiveness of diabetes management and the equity of health service provision in this regard, has not been well evaluated in Australia. These observations formed the basis of the research questions presented in Chapter 1.

The research questions were tested in a series of seven population-based case control studies. In the first study, documented in Chapter 4, health care utilisation over seven years was compared between case and control groups to determine if there was a relationship between patterns of care and the development of diabetes complications. In the second study, set out in Chapter 5, this same relationship was explored within states and territories to determine whether local health care systems influenced the development of advanced complications. In the third study, documented in Chapter 6, the relationship between patterns of care and complications was investigated in subjects whose diabetes was diagnosed comparatively early. The fourth study in Chapter 7, examined whether patterns of care prior to the diagnosis of diabetes determined the development of advanced diabetes complications. In Chapter 8, the fifth study investigated the relationship

between socio-economic status and the development of complications in Australia. In Chapter 9 the sixth study investigated the relationship between geographic isolation and the development of advanced complications, which is another source of health inequality. The final study, set out in Chapter 10, extended the analysis by investigating the relationship between the characteristics of GPs and the development of complications. Chapter 3 describes the methods used in these studies.

Section 2: Characteristics of studies

STUDY POPULATION

The population with which the studies in the thesis are concerned is estimated to number approximately 500,000 individuals, that is approximately 0.25% of the Australian population.[60] This includes all people who have been diagnosed with diabetes in Australia, which is estimated to be about of 50% total diabetes population.[1] Whilst it would have been desirable to have investigated subjects with types 1 and 2 diabetes separately, the database did not allow them to be disaggregated.

DATA COLLECTION

To examine the relationship between the quality of care and the development of diabetes complications, extracts from an administrative database were used. This database has substantial coverage of the Australian population, enabling the examination of the research questions from a national perspective.[328]

Administrative databases are commonly used in research as they often contain information that is useful for examining epidemiological questions. They may include large and definable populations, which is a consequence of often expansive administrative systems and the need to narrowly define eligibility for payment or

accountability purposes.[329] In addition, as a by-product of the management of health care systems the data they contain are often closely aligned to the operation of that system,[330] thus they can provide a good measure of how diseases are managed.

The present studies utilised the Medicare database, which is the national archive of the compulsory and universal health insurance system that funds health care provided by privately practising GPs, specialists, consultant physicians and some optometrists throughout Australia.[173] The database has been recognised as the only systematic national collection of health care data relevant to GPs and specialists in Australia.[190]

The Medicare system was established in February 1984 and contains records of health care utilisation from that time to the present.[206] It is an important resource for the study of diabetes with the Health Insurance Commission, which administers the system, estimating that 494,611 patients utilised Medicare between 1999 and 2000 for diabetes care.[60]

The record of fees charged to Medicare (identified as item numbers in the Medicare Benefits Schedule, MBS) creates a comprehensive record of health care utilisation for each individual patient.[254] For each item of service the Health Insurance Commission receives information on the patient, the provider, the items of health care supplied as well as the location and time of the consultation.[33]

Whilst Medicare has substantial coverage of the Australian health care system not all care is funded by it. The most notable gap concerns care provided to public patients in public hospitals which is funded by states and territories. [173] It is estimated that Medicare funds 75% of health care in Australia.[258]

While the Medicare database provides an accurate record of the processes of care, it does not include records of health outcomes.[183] Nevertheless, in some cases it is possible to study disease outcomes using these processes of care. This occurs when a process of care is used exclusively to treat a particular condition and thus can be taken as a direct marker of the outcome.[91] As laser photocoagulation therapy is used exclusively for the treatment of vision-threatening retinopathy, the item number for this process of care was able to be used in the studies comprising the thesis, as a proxy indicator of that diabetes outcome.[91]

In addition, a long-standing funding condition in the MBS made it possible to select out diabetes patients from the rest of the database using a straightforward and reliable indicator: the HbA1c test. Not only is this the most commonly used pathology test in the management of diabetes, it only attracts a Medicare rebate when it can be shown that it was used on patients with an existing diagnosis of diabetes.[206] Hence selecting the sample on the basis of this test creates an exclusive sample of people diagnosed with diabetes.[183]

STUDY DESIGNS

Population based case-control studies were used in each of the studies comprising the thesis.[331] Case-control studies compare a group of individuals who have experienced an outcome (cases) to a group who have not (controls).[13] The aim of the analysis is to determine if the patterns of exposure to risk factors differ between the groups, and hence help to explain the development of the outcome.[331] In this regard, the first six studies (the results of which are documented in Chapters 4 to 9) compared the medical care obtained by people with diabetes who developed vision-threatening retinopathy (cases) to similar patients who did not develop the complication (controls) over a seven-year period. In the final study (set out in Chapter 10) the characteristics of cases' GPs were compared to those of controls to determine whether there were any systematic differences between the groups that could be related to the development of complications.

DATABASES USED IN THE STUDY

Patient database (Chapters 4-9)

The patient database consisted of the Medicare records of 9264 people with diabetes over the period 1993 to 2000. The database was divided into equal numbers of cases and controls (4632 in each group). Cases were diabetes patients who had received laser photocoagulation therapy in 2000, while controls were patients of a similar age and diabetes status that had not received this treatment.

Figure 3.1: Patient database

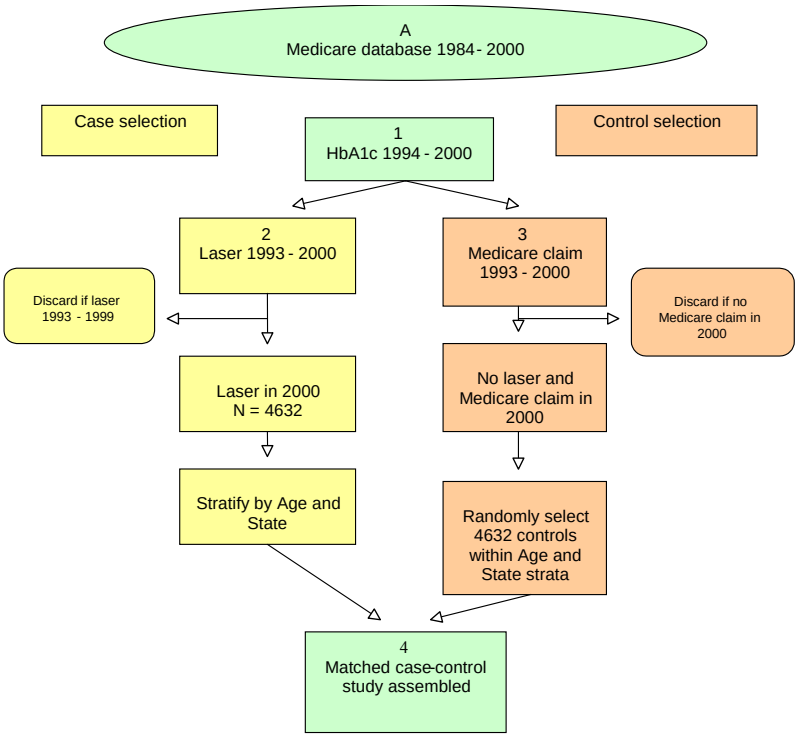


Figure 3.1 presents the steps involved in assembling the database. The process of data retrieval involved the creation of a series of matched population-based case-control studies from Medicare records.

The first step involved retrieving the study population by selecting all people who had diabetes between 1994 and 2000 from the Medicare database. This was accomplished by identifying all people on the Medicare database with an HbA1c test in these years.

Once this group had been selected, the case group was assembled, as represented on the left hand side of Figure 3.1. This process involved selecting all patients who had evidence of laser therapy between 1993 and 2000. In a second step all of those who

had laser between 1993 and 1999 were discarded. This left a sample of 4632 patients who were new laser therapy patients in 2000. These became the cases.

The control selection followed from the identification of the cases, as documented on the right side of Figure 3.1. Controls were selected from the database from which all laser therapy patients had been removed. To be eligible to become a control, patients needed to have a Medicare claim between 1993 and 2000, and to *not* have received laser treatment in any of those years. As the next step, patients who had no Medicare claim in 2000 were removed from the database, which left a large sample of patients who had not received laser but had a Medicare claim in 2000. It was from this group that controls were selected.[c]

Once the case and control databases had been created, the age and state characteristics of individual cases were used to define a sampling frame from which controls were to be selected. Once this sampling frame had been established, subjects eligible to become controls were assembled and the control selection procedure was conducted. One subject was selected from the sampling frame on a random basis and became the control. This procedure was repeated for each control selected.

[c] In the original data request controls needed to have a Medicare record in 2000 to be considered for inclusion in the study. However, this specification was not met for a small number of controls (186) and there was a concern that this could have led to bias in the studies. For an examination of the impact of the inclusion of these controls in the study see the methods of Chapter 6 below.

Once the case and control groups had been assembled they were disaggregated by state and territory to create eight individual population-based case-control studies. The final step involved the aggregation of studies to create one national study which was used in the majority of analyses comprising the thesis.

Provider database (Chapter 10)

The provider database consisted of the Medicare records for the year 1999 of all 12,283 GPs involved in the treatment of subjects comprising the patient database. The database is made up of three more or less equal groups: GPs who treated cases; GPs who treated controls; and those who treated both. Only one year of data was available at the time that the data were extracted as the previous years had been placed in Commonwealth Health Department archives. Whilst the year 2000 was available to be used in the studies, it was unsuitable as it would have included records of practitioners that related to both the development and treatment of vision-threatening retinopathy.

Figure 3.2: Provider database

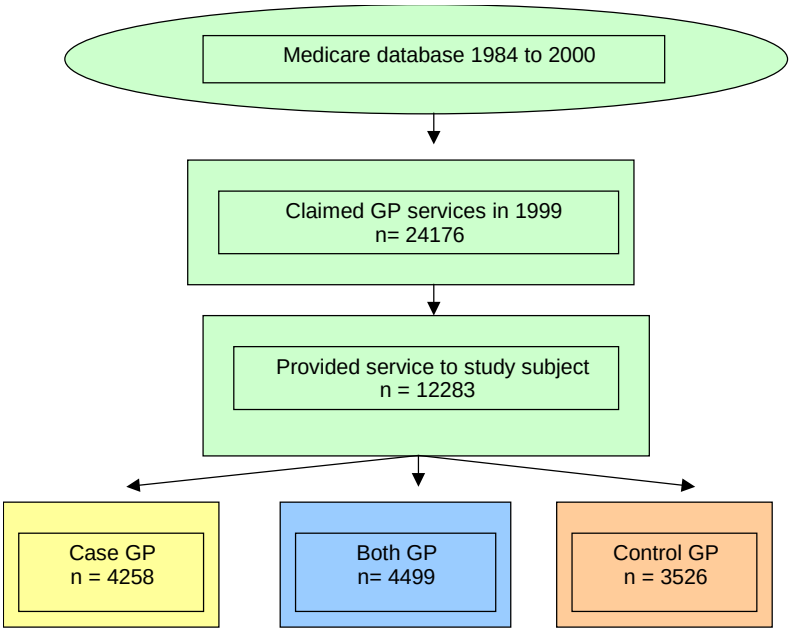


Figure 3.2 presents the steps involved in the composition of the provider database used in Chapter 10. Whilst provider data were used for the analysis, the subjects were identified from information included in the patient database (Figure 3.1). The first step involved identifying all medical care providers in Australia that had claimed for a GP service in the Medicare database in 1999. This was achieved by selecting all GPs who had claimed an A1 or A2 item in that year.

The second step involved retrieving the Medicare provider numbers of practitioners who had treated study subjects in 1999 from the patient database. Medicare provider numbers identify whether the practitioner is able to claim from Medicare, and is widely regarded as essential for the practice of medicine in Australia.[332] Providers

are readily identifiable in the database as each Medicare claim includes details of both the patient and provider.

Once this group had been selected, data on the number of cases and controls seen by each provider in 1999, along with the practitioner variables (see below), were retrieved. This resulted in a population-based case-control study[331] that could compare the characteristics of cases' GPs to those of controls with regard to a number of important risk factors relevant to the management of diabetes.

MEASUREMENT

Measurement in Chapters 4-9

The variables used in the first six of the seven studies, the results of which are presented in Chapters 4 to 9, were a standard set of diabetes related Medicare items used by the Health Insurance Commission to investigate diabetes, and which roughly correspond to the clinical management guidelines described in Chapter 2. Unfortunately to date there has been no validation of the items in terms of their relationship to the management of diabetes. However, as most diabetes care would have been captured by this database, the data are likely to bear a strong resemblance to diabetes management that was actually provided.

The MBS items for primary care (general practitioner attendance, HbAlc testing and HDL-cholesterol testing) and those for secondary care (specialist and optometry

attendances) comprise the independent variables, while laser photocoagulation therapy is the study outcome.

Whilst the pathology tests, retinal photography and laser therapy can each be explicitly linked to diabetes,[12, 330] the generic nature of the attendance items mean that diabetes related utilisation cannot be isolated. Therefore all attendances which might have involved diabetes care were included in the analyses. Table 3.1 sets out the Medicare items used in the first six studies comprising the thesis

Table 3.1: Medicare items used in patterns of care studies (Chapters 4 to 9)

Medicare items	Medicare item numbers
Retinal photocoagulation	42809
Retinal photography	11218
HDL- c	66536
HbA1c[±]	66551
Microalbumin	66560
GP attendances	A1 and A2
Specialist and consultant physician attendances	A3 and A4
Optometrist attendances	A10
Age	
Sex	
State	
SEIFA	
RRMA	

[±] Haemoglobin A1c tests

Age

In the original database, that is the Medicare database from 1993 to 2000, age was provided as a series of 20 categorical variables. However, there were two scales, one for large states and another for small states and territories whose categories overlapped when they were combined in the one (national) database. In order to

create an indicator that could be used across the whole sample, a continuous variable was created using a smoothing function across all age categories.

Gender

In the original database gender was not supplied for subjects from Tasmania, the Northern Territory and the Australian Capital Territory (hereafter ACT) because of the possibility that this variable could enable the identification of individuals in these small samples. Therefore, in these jurisdictions gender was imputed according to the distribution of the sexes in the national sample.

State or territory of residence

For cases, state and territory were assigned according to the state in which laser therapy had occurred. However, for controls it was assigned according to the state and territory of the earliest HbA1c test. That state and territory were assigned differently was a result of the computer program involved in the data retrieval, which would not allow the allocation of state and territory on the same basis for the two groups. Although using different methods was not ideal there was no evidence that there was bias in sampling.

Socio-Economic Index for Areas Index of Social Deprivation (SEIFA)

The SEIFA Index of Social Deprivation is a measure of socio-economic status derived from the Australian Bureau of Statistics (ABS) Australian Census of Population and Housing, which is an aggregate measure derived from up to 50

variables related to socio-economic status. [260] The index used in the thesis was that derived from the 2001 census.

The Index is based on two levels of variables related to social disadvantage: level 1 includes education, income and occupation, while level 2 measures the effects of disadvantage such as the number of bedrooms in a house, whether a house is owned or rented and whether it has access to the Internet. [260] In the present studies SEIFA was assigned to individuals by their postcode.[260]

There were 70 subjects (0.3%) who had non-residential post-codes, such that SEIFA was not supplied. These subjects were distributed more or less evenly between cases and controls. SEIFA values were imputed for these subjects. This was based on the proportion of the sample in each state and territory and the median value of SEIFA quintiles in these jurisdictions.

Rurality and Remoteness Index of Areas (RRMA)

RRMA is a measure of geographic remoteness derived from the ABS Australian Standard Geographical Classification (ASGC) Remoteness Areas Classification, which allocates a category of remoteness to areas based on an average of the road distance to the closest population centre.[333] RRMA areas are classified as either major cities, inner regional or outer regional, or remote and very remote. In this study the distinction between inner rural and outer rural was not applied. There were 70 subjects (0.3%) with non-residential post-codes for which RRMA was not

supplied. For these subjects, RRMA values were imputed according to each state or territory and based on the proportion of subjects within RRMA categories within each jurisdiction.

General practitioner attendances (1993 – 2000)

For the Australian population most clinical care for diabetes occurs through GPs.[193] Thus the level of attendance at GPs is an important indicator of diabetes management. The GP variable included all attendances at vocationally registered GPs (according to the A1 schedule) and other medical practitioners who had provided GP services.[334] The latter are termed Other Medical Practitioners (OMPs) and use Medicare schedule A2. In the present studies A1 and A2 were combined to give one indicator of GP services.

Specialist and consultant physician attendances (1993 – 2000)

Whilst diabetes patients attend specialists and consultant physicians for a range of reasons the most routine need for attendance is to be screened for diabetic retinopathy.[223] In the Medicare Schedule there are two classifications of medical specialists: A3 includes practitioners identified as medical specialists, while A4 includes consultant physicians. Whilst these two types of practitioner provide similar services, consultant physicians are the more senior of the two and receive a higher level of reimbursement.[328] In the analysis these two indicators were combined to give one indicator of specialist attendances.

Optometrist attendances (1993 – 2000)

During the studies optometrists were the only non-medical practitioners that could be reimbursed by Medicare, and were denoted by A10 Schedule.[328] In the management of diabetes optometrists are involved in screening for retinopathy.[336]

HbA1c tests (1993 – 2000)

HbA1c is an important pathology test used to measure blood glucose in the management of diabetes.[207] The test has its own Medicare item numbers: 66551 and 66557. The latter item identifies whether the test has been ordered for a pregnant woman, while the former test is for the remainder of the diabetes population. As there were very few claims for 66557 in the database, these item numbers were combined to give one indicator of HbA1c testing.

HDL-c tests (1993 – 2000)

HDL-cholesterol is an important pathology test in the management of dyslipidaemia in people with diabetes.[12] The item number for this test is 66560. The need to monitor HDL-cholesterol, as opposed to total cholesterol and LDL-cholesterol is not commonly understood by medical practitioners. Hence HDL- cholesterol testing can be an indicator of how knowledgeable practitioners are about the management of diabetes.[335]

Microalbumin tests (1998-2000)

Microalbumin testing is used to monitor microalbuminuria, which is an indication of diabetic kidney damage.[92] The test has its own item number (66536), and is commonly used for people with diabetes.

Retinal photography (1993 – 2000)

Retinal photography is a method of screening for diabetic retinopathy.[336] The procedure has its own item numbers that are often found in the Medicare histories of people with diabetes. 11215 refers to photography of one eye and 11218 to both eyes. In the present studies these items were combined to give one indicator of retinal photography.

Laser photocoagulation therapy (2000)

Vision-threatening retinopathy was identified in the database by the occurrence of laser photocoagulation therapy, marked by the Medicare item number 42809. Laser photocoagulation therapy is a reliable indicator of vision-threatening retinopathy as it is the major and almost singular treatment for this condition.[91] It has been estimated that appropriately timed treatment for vision-threatening retinopathy can prevent up to 98% of severe vision loss associated with diabetic retinopathy.[91]

Matching[337]

Controls were matched to cases on age (within one year) because of the strong association between vision-threatening retinopathy and the duration of diabetes.[25] It

was thought that had they not been matched, cases would have been on average older than controls and may have had diabetes for longer. Thus matching on age controlled for confounding by the duration of diabetes.

Matching by state or territory was conducted in order to facilitate within and between jurisdiction comparisons of the patterns of care. It was thought that without matching, state and territory differences in health care systems could have resulted in administrative related differences in patterns of care between cases and controls that might have mistakenly been attributed as risk factors for complications. Thus matching by state and territory controlled for confounding by different methods of data collection.[329]

Measurement in Chapter 10

The measures used in the final study of the thesis, the results of which are presented in Chapter 10, refer to the characteristics of GPs that were available in the data from 1999. There are three types of measures used in the study: these concern the nature of the case load (variables 1 and 2), the characteristics of GPs themselves (variables 3 to 7), and the characteristics of the GP's practice (variables 8 and 9). The three types of variables were selected in order to provide a multidimensional picture of GPs.

However, as the nature of GP data in the Medicare database is very limited, there is a range of potentially important factors that were not able to be included in the study

such as whether the practitioner had a special interest in diabetes.[328] Nevertheless, these limitations had to be accommodated to enable any examination of the relationship between the characteristics of GPs and the study outcome.

Table 3.2: GP characteristics used in Chapter 10

	Variables	Unit of measurement	Level of measurement
1	No cases seen in 1999	Individual	Continuous
2	No controls seen in 1999	Individual	Continuous
3	Gender of GP	Individual	Dichotomous
4	Vocational registration in 1999	Individual	Dichotomous
5	Years of practice in 1999	Individual	Continuous
6	Age in 1999	Individual	Continuous
7	Overseas trained	Individual	Dichotomous
8	SEIFA of major practice	Aggregate	Quintiles
9	RRMA of major practice	Aggregate	Quartiles

Age in 1999

The age of practitioners can be an important indicator of the nature of medical care. Older GPs tend to have longer consultation times,[338] which perhaps gives them more opportunity to provide more effective chronic disease management. Age was provided as a continuous variable for the sample of GPs.

Gender of GP

Gender is a potentially important variable as it has been shown that women GPs provide different kinds of services to men.[339] Gender was provided as a binary variable.

Overseas training

Whilst overseas trained doctors need to demonstrate their proficiency in medical care in order to work in Australia, they often have different methods of practice, which may impact on the management of diabetes. They are also more likely to provide services to their own ethnic group, which may be at a higher risk of developing diabetes.[340] Overseas training was provided as a binary variable, where 0 equalled Australian trained and 1 was overseas trained. The source of the training could not be identified.

No of cases seen in 1999

This indicator enumerated the number of cases seen by a GP in 1999 and together with the indicator below was the basis by which GP status was ascribed in the study. This variable was provided as a continuous variable with a minimum of 1.

No of controls seen in 1999

This indicator enumerated the number of controls seen by a GP in 1999. Similar to the variable above, this was the basis upon which GPs were allocated to the study groups. This variable was provided as a continuous variable with a minimum of 1.

Years of practice in 1999

Years in medical practice has been shown to be an important indicator of the patterns of care, with differences associated with the nature of medical training as

well as clinical experience.[338] There is some evidence that younger doctors are more likely to perform more up to date (and perhaps more evidence based) practices. This variable was supplied as a continuous variable denoting years in practice in the relevant year.

Vocational registration in 1999

Vocational registration is an accreditation scheme conducted by the Royal Australian College of General Practitioners.[334] To attain accreditation doctors need to demonstrate certain proficiencies in general practice and provide particular services (such as after hours medical care), some of which are related to the management of chronic disease.[254] This variable was supplied as a binary variable where 0 was equal to no registration and 1 indicated that the practitioner was registered.

Socio-Economic Index for Areas of major practice (SEIFA)(1999)

As discussed in the literature review, socio-economic status is an important indicator of the risk of complications and access to medical care. If a GP principally works in a deprived area this is likely to be reflected in a greater caseload of diabetes. The SEIFA variable used in respect of the geographic area in which the GPs practised was the same as that used in the patient database.[260] However, instead of referring to the post-code of the patient, this indicator refers to the post-code of the major practice of the GP. SEIFA was provided as a continuous variable, which was transformed into quintiles for use in the analyses.

Rurality and Remoteness Index of Areas of major practice (RRMA)(1999)

For similar reasons to those associated with SEIFA, remoteness and rurality, as denoted by RRMA can be an important indicator of health need and access to care. The RRMA variable used was the same as that used in the patient database. However, instead of referring to the post-code of the patient, this indicator refers to the post-code of the major practice of the GP.[341] RRMA was provided as a categorical variable with four categories indicating whether the main practice of the GP was in a metropolitan or outer-metropolitan area, or a rural or remote locality.

Section 3: Methods used in individual studies

Chapters 4 to 9 used samples derived from Table 3.3 below. Whilst Chapters 4,5,8 and 9 used the entire sample, Chapter 6 used 1993 and 1994 only, and Chapter 7 the sample from 2000.

Table 3.3: Year of earliest HbA1c[±] test, n (%)

Year	Case	Controls	Total	P of diff
1993	345 (7.4)	917 (19.8)	1262 (13.6)	<0.0001
1994	320 (6.9)	566 (12.2)	886 (9.6)	<0.0001
1995	345 (7.4)	543 (11.7)	888 (9.6)	<0.0001
1996	269 (5.8)	460 (9.9)	729 (7.9)	<0.0001
1997	269 (5.8)	466 (10.0)	729 (7.9)	<0.0001
1998	255 (5.5)	536 (11.6)	761 (8.2)	<0.0001
1999	291(6.3)	538 (11.6)	829 (8.9)	<0.0001
2000	2538 (54.8)	606[*] (13.1)	3144(33.9)	<0.0001
Total	4632	4632	9264	

[±] Haemoglobin A1c tests [*]Five subjects tested using item code for HbA1c during pregnancy.

Chapter 4

The patterns of care as a risk factor for the development of vision-threatening diabetic retinopathy: a population-based matched case-control study using insurance claims (Medicare) data

The aim of this study was to test the first research question: To determine whether patterns of primary and secondary care is a risk factor for the development of diabetes complications in the population with diabetes in Australia. This was achieved by comparing the medical care received by cases to that of controls over a period of seven years. This study used the total sample in Table 3.3. The level of medical care was measured by attendances at general practitioners and medical

specialists, as well as diabetes related pathology tests such as HbA1c and HDL-cholesterol testing.

The statistical analyses consisted of between groups comparisons of independent variable histories. Differences in proportions were calculated using χ^2 tests; frequencies were compared using independent samples t-tests; weighted logistic regression was used to measure trends in proportions;[342] and weighted multiple linear regression was used to measure trends in frequencies (means). Multivariate conditional logistic regression was used to identify risk factors for the development of vision-threatening retinopathy (Table 4.5). [342] The analyses used a stepwise process with the backwards conditional method of variable selection, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Chapter 5

To determine whether state and territory health care systems play a role in the effectiveness of diabetes management in Australia.

Having examined the relationship between medical care and the risk of vision-threatening retinopathy at the national level, Chapter 5 presents the investigation of this relationship for all states and territories. This was to test the second research question: To determine whether state based health care systems helped to determine the risk of diabetes complications in Australia. This was achieved by repeating the study reported in Chapter 4, but disaggregating the national data by the state and territory variable so that each of the 8 states and territories could be compared and

examined individually. There were equal numbers of cases and controls within each state and territory sample and the study used the whole sample in Table 3.3.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. When risk factors were compared between states and territories, for proportions, χ^2 tests for trend were used, and analysis of variance was used for frequencies (the Bonferroni adjustment was used to account for type 2 error).[342] For each risk factor, and within cases and controls in each state and territory, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analyses were conducted using conditional logistic regression, where the paired study design could be taken into account (Tables 5.9 to 5.16), and conventional logistic regression where a matched variable was included as a risk factor (state and territory in Table 5.8).[342] The regression analyses used a stepwise process with the backwards conditional method of variable selection, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Chapter 6

What goal should a health system have: delayed diagnosis or improved diabetes management?

Chapter 6 represents a sub-study of Chapter 4 and developed out of the finding that cases had on average received their earliest HbA1c test (an indicator of diagnosis)

much later than controls.[344] This suggested that delayed diagnosis, and perhaps not the pattern of care was responsible for the development of vision-threatening retinopathy. This study sought to test the third research question: To determine whether patterns of care or delayed diagnosis is the greater risk factor for the development of diabetes complications in the population with diabetes in Australia.

This research question was tested using a population-based case-control study,[331] which compared the demographic characteristics and patterns of care of case and control groups. Subjects were selected based on having their earliest HbA1c test in 1993 or 1994, as shown in Table 3.3.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests, and frequencies by independent samples t-tests. For each risk factor, and within cases and controls, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means.[342] The regression analyses used a stepwise process with the backwards conditional method of variable selection.[342] Socio-economic status was entered as four dummy variables in Table 6.4 (for a broader analysis of socio-economic status see Chapter 8), and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Following further analysis, it was found that 186 (12.5%) subjects of the control group in this study did not have a Medicare item in 2000, suggesting that they may

have died or emigrated. As it would have been impossible to relate their records of health care utilisation to the study outcome they were excluded from the study.

To assess how the exclusion of these controls affected the findings, excluded controls were compared to those who were included on major risk factors (Table 6.1). In this analysis it was found that had excluded controls been included, the control group would have been slightly older, the proportion of males would have been greater and there would have been some minor differences in health care utilisation. In particular, in the early years, differences between cases and controls would have become more extreme, but in the latter years the control group would have become more like cases. All of the subjects that had missing data were in the 1993 to 1994 sample. Whilst this methodological flaw is not corrected in Chapters 4,5, 8 and 9, because of the small numbers affected it was thought that it would have had little influence on studies that used the whole sample in Table 3.3

Table 3.4: The demographic and health utilisation characteristics of controls excluded from Chapter 6, compared to controls that were included in the study

	Included	Excluded	P
N	1297	186	1483
Age, mean (sd)	62.9 (13.7)	72.6 (11.5)	<0.0001
Gender (% male)	681(52.5)	128 (68.8)	<0.0001
GP attendances, mean (sd)			
1993	11.3(10.8)	14.9 (13.0)	<0.0001
1994	11.6(9.1)	14.6 (18.6)	<0.0001
1995	11.4(9.6)	12.0 (20.9)	0.48
1996	11.4(9.9)	7.9 (14.8)	<0.0001
1997	12.0(10.3)	5.5 (11.2)	<0.0001
1998	11.9(10.4)	2.07 (5.9)	<0.0001
1999	12.0(11.2)	0.03 (0.44)	<0.0001
S&CP, mean (sd)			
1993	2.5 (3.9)	4.4 (6.4)	<0.0001
1994	2.6 (3.7)	4.9(8.9)	<0.0001
1995	2.7(4.3)	3.2(7.9)	0.21
1996	2.7(4.4)	3.0 (10.3)	0.49
1997	2.6(3.9)	1.8 (4.9)	0.10
1998	2.6(3.9)	0.6 (2.7)	<0.0001
1999	3.1(7.0)	0.0 (0.0)	<0.0001
HbA1c testing, mean (sd)			
1993	0.89(0.93)	0.92(0.80)	0.71
1994	1.14(0.96)	0.92(0.91)	0.003
1995	0.86(1.03)	0.51(0.93)	<0.0001
1996	0.84(1.07)	0.39(0.81)	<0.0001
1997	0.88(1.07)	0.25(0.70)	<0.0001
1998	0.89(1.05)	0.07 (0.38)	<0.0001
1999	0.95(1.12)	0.005 (0.07)	<0.0001

Do the patterns of care prior to the diagnosis of diabetes determine the risk of advanced diabetes complications?

Having explored delayed diagnosis as a risk factor for the development of vision-threatening retinopathy in Chapter 6, the investigation in Chapter 7 sought to answer the fourth research question: To determine whether the patterns of care prior to the diagnosis of diabetes are a risk factor for the development of advanced diabetes complications. The study examined whether patient demographic characteristics, GP, specialist and optometry attendances were risk factors for diabetes complications by comparing cases to controls. The study used the 2000 sample in Table 3.3.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. For each risk factor, and within cases and controls, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means.[342] The regression analyses used a stepwise process with the backwards conditional method of variable selection.[342] Socio-economic status was entered as four dummy variables in Table 7.4 (for a broader analysis of socio-economic status see Chapter 8), and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Does socio-economic status determine the risk of complications in people with diabetes?

Chapter 8 reports the test of the fifth research question, which related to equity: To determine whether socio-economic status is a risk factor for diabetes complications in the population with diabetes in Australia. A population-based case-control study similar to those in Chapters 4 and 5 was used.[331] The study examined patient demographic characteristics, the utilisation of primary and secondary care, diabetes related pathology tests and the risk of complications between cases and controls across socio-economic groups, using the entire sample in Table 3.3.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. When risk factors were compared between socio-economic groups, for proportions, χ^2 tests for trend were used, and for frequencies analysis of variance was used (the Bonferroni adjustment was used to account for type 2 error).[342] For each risk factor, and within cases and controls in each socio-economic group, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analyses were conducted using conditional logistic regression, which could take into account the paired study design (Tables 8.8 to 8.13).[342] The regression analyses used a stepwise process with the backwards conditional method of variable selection (Tables 8.8 to 8.13). Socio-

economic status was entered as four dummy variables in Table 8.8, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Chapter 9

Are geographically isolated patients at greater risk of complications because of poor access to health care?

In Chapter 9 the sixth research question is tested: To determine whether geographic isolation is a risk factor for the diabetes complications in the population with diabetes in Australia. A population-based case-control study, similar to those in Chapters 4, 5 and 8 was used.[331] The study examined patient demographic characteristics, the utilisation of primary and secondary care, diabetes related pathology tests and predicted complications across remoteness groups, and used the whole sample in Table 3.3.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. When risk factors were compared between remoteness groups, for proportions, χ^2 tests for trend were used, and for frequencies analysis of variance was used (the Bonferroni adjustment was used to account for type 2 error).[342] For each risk factor, and within cases and controls in each remoteness group, trends over time were calculated. For proportions multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analyses were conducted using conditional logistic regression to take account of the paired study design, and the regression analyses used a stepwise process with the backwards conditional method for variable

selection. (Tables 9.8 to 9.12). Geographic isolation was entered as three dummy variables in Table 8.9, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Chapter 10

Do the characteristics of GPs determine the risk of complications?

Table 3.5: GPs in the provider database

Group	Case GPs	Control GPs	Both	Total
n (%)	4258(34.7)	4499(36.6)	3526(28.7)	12283 (100)

Studies reported in Chapters 4 to 9 used patient data to investigate the research questions, Chapter 10, on the other hand, used practitioner data, which was also collected in Medicare. This study tested the seventh research question: To determine whether the characteristics of GPs are associated with the development of complications in the population with diabetes in Australia. The study was a population-based case-control study [331] of all GPs who had been attended by cases or controls in 1999. In the analysis case GPs were compared to control GPs to determine whether there were any systematic differences between them.

The study population consisted of GPs who had made a Medicare claim for a general practice service in 1999 (schedules A1 and A2).[328] Once these practitioners had been identified GPs who had been attended by a subject included in Table 3.3 were selected to be included in the study. The linkage of GPs to patients was conducted through patient records as each Medicare claim includes information on both the patient and the provider.[328] Once the GP sample

had been chosen the demographic characteristics, accreditation status and the location of their principal practice were collected from the Medicare database. The data items used in the study are presented in Table 3.2.

In the univariate analyses, which compared case to control practitioners, as well as to those who treated both, proportions were compared using χ^2 tests and frequencies by analysis of variance (the Bonferroni adjustment was used to account for type 2 error).[342] The multivariate analysis in Table 10.2 was conducted using logistic regression, which used a stepwise process with backwards conditional as the variable selection criteria.[342] Socio-economic status was entered as four dummy variables and RRMA as three dummy variables in Table 10.2. The regression analyses used a stepwise process with the backwards conditional method of variable selection, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Section 4: Limitations of the thesis

Limitations of case control studies

While the studies in the thesis suggest that the pattern of care causes advanced diabetes complications to develop, case-control studies cannot establish causation.[331] This is because subjects in these studies are not randomly selected, and the way in which the subjects were selected may be responsible for the relationships between variables that are found.[331] Given this limitation, case-control studies can only show that study factors and outcomes are associated with each other.

Where patients had not received HbA1c test

Diabetes patients who had not received an HbA1c test between 1994 and 2000 would not be included in the thesis. This would exclude people with diabetes who had not been diagnosed during these years, and those who had a diagnosis but had not been tested. This could lead to selection bias which would favour patients who were more likely to be tested. Such patients could include those with easier access to health care or from less deprived areas.[277]

Inability to differentiate between type 1 and type 2 diabetes.

Types 1 and 2 diabetes are separate clinical entities with different aetiologies and populations at risk.[1] This is reflected in, amongst other things, different levels of risk of advanced diabetes complications.[12] As they require different types of medical management, it would have been useful to examine them separately.

However, it was not possible to differentiate the types in the Medicare database. As type 2 diabetes is much more prevalent, the studies are likely to reflect the relationship between patterns of care and the development of complications for this condition. The findings may be less applicable to type 1.

Use of procedure as outcome

The use of laser therapy as an indicator of vision-threatening retinopathy as the outcome may have resulted in selection bias in cases. This would occur as patients with poorer access to laser therapy would have been less likely to be included in the case group. If access to laser therapy is determined by similar factors to those that determine access to specialists, which provide the procedure, the use of laser therapy as the outcome could result in fewer patients of low socio-economic status,[22] Aboriginal and Torres Strait Islander[30] and other populations in cases. As these groups typically suffer more from diabetes complications,[273, 299] their exclusion could bias the case sample towards patients with fewer diabetes symptoms.

Where patients had received care outside of the Medicare system

The measurement of health care utilisation was limited to that which had been funded by Medicare. As the Medicare database does not cover all health care in Australia, patients may have obtained more treatment than that which was investigated in the studies.[183] When comparing cases and controls, under-enumeration is problematic only when it differs between groups,[331] whether or how it differs could not be determined by the studies in the thesis.

Earliest HbA1c test as an indicator of diagnosis

The study used the earliest HbA1c test as an indicator of the timing of diagnosis, however, this indicator may not be accurate. As patients need to have been diagnosed with diabetes to receive a Medicare funded HbA1c test, thus it can precisely identify diabetes. However, patients may have been diagnosed well before the earliest HbA1c test indicates. This may mean that the findings in the thesis that concern the timing of diagnosis do not relate to diagnosis, but to the ease of access to HbA1c testing. This may mean that patients who have poorer access to HbA1c testing are more likely to be counted as late diagnosed.[22] However, as this limitation applies to all subjects the discrepancy is likely to be similar among both groups, thus it may have little bearing on the findings.

Limitations of the variables

Whilst HbA1c, HDL cholesterol and microalbumin testing can be specifically linked to diabetes[12] the attendance items were generic, meaning that whether an attendance was diabetes related could not be determined. Thus some of the medical care studied in the thesis may not concern diabetes. However, the studies included all GP, specialist and optometrist attendances that *could* have concerned diabetes over the period of the study. However, as this limitation applies to all subjects the discrepancy is likely to be similar among both groups, thus it may have little bearing on the findings.

Limitations in the range of variables

It would have been desirable to include additional diabetes management variables, such as blood pressure tests [72] and foot testing,[116] however, these tests

do not have their own Medicare item numbers. Other key parameters that were not captured include measures for weight and height.

The GP data available in the Medicare database are very limited and there is a range of potentially important factors that could not be included in the study in Chapter 10. Of greatest significance was that there was no indicator that could measure the level of involvement a GP had in the care of diabetes patients. Thus the contribution of individual practitioners to the management of diabetes patients could not be determined.[172] Thus the study only allows limited inferences about the role of GP characteristics in the development of diabetes outcomes.

Chapter 10 – one years worth of data may not be representative of involvement in diabetes care

GPs were only chosen from the 1999 records of patients. However, medical care provided over one year may be insufficient to present an accurate picture of GP involvement in diabetes care. This may mean that case and control GPs are less distinct, as study subjects would have had the opportunity to attend a greater range of practitioners, including practitioners who treated either group in 1999.

Clustering of GPs not able to be taken into account

GP studies conventionally use clustered study designs in order to adjust for the lower level of variation in characteristics between practitioners who work in the

same practices.[342] However, this requires a variable through which clusters can be defined. Unfortunately at the time of the data collection, there was not a suitable variable that could be used in this manner. Therefore in this study, a more conventional analytical approach was taken that treated each GP as an independent practitioner. By not adjusting for clustering, however, the confidence intervals may not accurately reflect the true level of variation in GP characteristics across the sample.[342]

Conclusion

A number of significant knowledge gaps have been identified in the literature review regarding the current level of evidence related to the capacity of the Australian health care system to manage diabetes. The methods chapter described a series of case-control studies that were aimed at addressing these gaps and thus providing information about the capacity of the Australian health care system to manage diabetes.

The studies described were concerned with investigating the nature of the relationship between health care utilisation and the development of complications. They represent an improvement over previous studies that have had similar aims in that they are population-based, longitudinal in design and use a process of care that is highly correlated with an advanced diabetes complication as the outcome of the studies.

The seven chapters that follow represent the main body of the thesis in that they report on the evaluation of the research questions. The studies represent a thorough evaluation of the capacity of the Australian health care system to manage diabetes.

Chapter 4

The patterns of care as a risk factor for the development of vision-threatening diabetic retinopathy: a population-based matched case-control study using insurance claims (Medicare) data

Abstract

OBJECTIVES: To evaluate systematically the effectiveness of the primary health care system in Australia in preventing the development of advanced diabetes complications.

METHODS: 4632 diabetes patients who had received their first laser photocoagulation treatment in 2000 were compared to a random sample of diabetes patients who had never received this treatment (n = 4632). Patterns of health care utilisation were compared over a seven-year period (1993-1999) using the Australian Medicare database.

RESULTS: There were significant differences in levels of health care utilisation between cases and controls: a lesser proportion of cases attended GPs, from 69.6% in 1993 to 85.2% in 1999, compared to 93.5% and 91.0% in these same years in controls ($P<0.0001$ in all years). In addition, fewer cases attended specialist and consultant physicians, from 21.5% in 1993 to 36.6% in 1999, compared to 49.3% and 56.2% in these same years for controls ($P<0.0001$ in all years). Moreover, fewer cases were tested for HbA1c, from 7.4% in 1993 to 17.1% in 1999, compared to 19.8% and 44.1% in these same years for controls. Finally, fewer cases were tested for HDL-cholesterol with 0.5% in all years, compared to 11.4% in 1993 and 19.5% in 1999 for controls. The multivariate analysis emphasised timely diagnosis, HDL-cholesterol testing and optometry attendances in the prevention of advanced diabetes complications.

CONCLUSIONS: The study supports the contention that health care utilisation may be as important a determinant of health outcomes as clinical risk factors such as blood glucose control. This highlights the importance of early diagnosis and the need to address systemic barriers to increase primary care utilisation for people at risk of advanced diabetes complications.

Introduction

One million people in Australia are estimated to have diabetes,[288] where this disease is ranked eighth in frequency of disorders managed in general practice.[345] With the prevalence of diabetes set to double within 20 years [346] the prevention of diabetes and its complications is a major public health priority.[1]

Whilst diabetes takes a heavy toll on individual and population health, there are evidence-based clinical and health service interventions that delay the development of diabetes complications.[74] For example, the Diabetes Control and Complications Trial[3] and the United Kingdom Prospective Diabetes Study[57] established the efficacy of blood glucose and blood pressure control for preventing microvascular complications, while Griffin demonstrated the effectiveness of computerised central recall systems for improving the quality of care.[197]

However, evidence for these interventions has largely been derived from clinical studies focused on individual risk factors, using highly motivated and homogenous groups of selected individuals. Whilst this is entirely appropriate for determining the efficacy of clinical interventions, it often means that we do not know if they will work in routine settings of care.[11] Moreover, interventional studies do not usually take into account factors such as access, poverty, knowledge or competency on the part of the patient or provider that may impact on the nature of care delivered. These types of factors are hypothesised to be key

upstream determinants of the quality of care which if not addressed will lead to a higher than expected incidence of complications in at risk groups.

In Australia, the adoption of diabetes as a national health priority in 1996 forged a cross-government commitment for tackling the disorder and reaffirmed primary care as the key modality of care linked to specialist care settings.[1] Various strategies to improve awareness, knowledge and the capacity to detect diabetes complications have been introduced.[74, 200] However, the reach or success of these strategies as evidenced by outcomes such as delay in the development of diabetes complications has not been determined as to date there has been no systematic evaluation of the effectiveness of current care models.

In this study the evaluation of current care models was conducted by testing the relationship between patterns of health care utilisation over a seven year period among a representative sample of Australian diabetes patients[174] and the development of a quantifiable advanced diabetes complication, vision-threatening retinopathy.[24]

This corresponds to the first research question of the thesis: whether patterns of primary health care utilisation are a risk factor for the development of diabetes complications in the population with diabetes in Australia. Whilst case-control studies can only provide evidence of epidemiological association, when conducted robustly the evidence they provide is highly suggestive of causation.[331]

The use of vision-threatening retinopathy as the outcome of the study is highly significant as it is one of the most common advanced complications of diabetes, with 2-3% of patients estimated to suffer from the condition in Australia. [218, 347] More broadly, vision-threatening retinopathy is the most common cause of blindness among people of working age.[35] Vision-threatening retinopathy also has profound clinical significance as its development can be slowed by glycaemic control[3, 57] facilitated by blood glucose testing[207] and retinopathy screening.[24] It is also highly treatable by laser photocoagulation therapy,[91] with early detection readily able to prevent further morbidity.

In this study we aimed to test the research question of whether the pattern of care delivered to an individual with diabetes is a risk factor for diabetes complications, in other words, whether appropriate quality of care (as defined by clinical management guidelines) would facilitate better health outcomes.

Methods

This research question was tested using a population-based case-control study,[331] which compared the demographic characteristics and health care utilisation of cases and controls. Subjects' characteristics are set out in Table 4.1 below. Cases comprised a national sample of 4632 patients who had received their first laser photocoagulation therapy in 2000, while controls were a sample of 4632 people with diabetes who had not received this treatment (this included the total sample in Table 4.2). Controls were matched to cases on age (within one year) and state of residence at the time of their earliest HbA1c test.

The statistical analyses consisted of between groups comparisons of independent variable histories. Differences in proportions were calculated using χ^2 tests; frequencies were compared using independent samples t-tests; weighted logistic regression was used to measure trends in proportions;[342] and weighted multiple linear regression was used to measure trends in frequencies.[342] Multivariate conditional logistic regression was used to identify risk factors for the development of vision-threatening retinopathy (Table 4.5).[342] The variable selection algorithm was backwards conditional and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF THE SAMPLE

The age of subjects ranged from 12 to 97 years, with the mean age being 62.4 years (sd = 13.1 years). Table 4.1 shows that when stratified by tertiles, the sample was concentrated in the age group 59 years and over, with one third of subjects aged 59 to 69.

Table 4.1: Characteristics of study subjects

		Cases (%)	Controls(%)	Total, n(%)
Age	12 – 58	1544 (33.3)	1544(33.3)	3088(33.3)
	59 – 69	1544(33.3)	1544(33.3)	3088(33.3)
	70 - 97	1544(33.3)	1544(33.3)	3088(33.3)
Gender	M	2488 (53.7)	2539 (54.8)	5027(54.3)
	F	2144 (46.3)	2093 (45.2)	4237(45.7)
Total		4632	4632	9264(99.7)

Table 4.1 shows that 54.3% of subjects were male and 45.7% female, reflecting the gender distribution of diabetes in Australia.[288] When case and control groups were compared, the gender distributions were found to be very similar in each group ($\chi^2 = 1.11$, 1df, $p = 0.3$), suggesting that whilst the risk of diabetes was higher in men, the risk of developing vision-threatening retinopathy was not determined by gender.

EARLIEST HBA1C TEST

The year in which patients' earliest HbA1c test occurred was used as an approximate indicator of the timing of diabetes diagnosis.[183] It was assumed that patients with an earliest HbA1c test in 1993 or 1994 had a diagnosis of diabetes in these years or before, but that those with an earliest test between 1995 and 2000 had been diagnosed during the period covered by the study. Table 4.2 sets out the year of the earliest HbA1c test for cases and controls.

Table 4.2: Year of earliest HbA1c± test, n (%)

Year	Case	Controls	Total	P of diff
1993	345 (7.4)	917 (19.8)	1262 (13.6)	<0.0001
1994	320 (6.9)	566 (12.2)	886 (9.6)	<0.0001
1995	345 (7.4)	543 (11.7)	888 (9.6)	<0.0001
1996	269 (5.8)	460 (9.9)	729 (7.9)	<0.0001
1997	269 (5.8)	466 (10.0)	729 (7.9)	<0.0001
1998	255 (5.5)	536 (11.6)	761 (8.2)	<0.0001
1999	291(6.3)	538 (11.6)	829 (8.9)	<0.0001
2000	2538 (54.8)	606* (13.1)	3144(33.9)	<0.0001
Total	4632	4632	9264	

± Haemoglobin A1c tests *Five subjects tested using item code for HbA1c during pregnancy.

The table shows cases and controls exhibited significant differences in the timing of their earliest HbA1c test, with cases on average receiving their earliest test much later than controls. Indeed, at least 50% of cases received their earliest HbA1c test in the same year as they received their first laser therapy (2000), suggesting that they were diagnosed with diabetes in the same year that they were treated for the complication. In comparison, only 13% of controls received their earliest HbA1c test in 2000. This difference was highly statistically significant ($p<0.0001$).

GP ATTENDANCES

Table 4.3 shows that in each year a significantly lower proportion of cases than controls attended GPs. Whilst there were significant differences in all years, they were particularly marked in 1993 and 1996. For example, in 1993 30% of cases did not see a GP at all for any reason as compared to 6.5% of controls. Overall, the level of attendance among controls was near to the Australian average in all years (90% of the population attend a GP in a year).[254] Although the level of attendance at GPs for cases increased over the study period, the proportion of attendees did not reach that of controls and remained significantly below the Australian average.

The frequency of GP attendances was also lower among cases, as shown in Table 4.4. For example, cases attended an average of 4.3 times in 1993, increasing to an average of 6.9 times in 1999. By contrast, controls attended an average of 9.5 times in 1993, which increased to an average of 10.5 times in 1999. In all years these differences were highly statistically significant ($p<0.0001$).

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES

Specialist and consultant physician attendances include visits to all medical specialists including ophthalmologists and endocrinologists. Table 4.3 shows that a smaller proportion of cases attended specialists and consultant physicians as compared to controls. For example, in 1993, 21.5% of cases attended a specialist or consultant physician, while almost 50% of controls attended these

practitioners. Similarly, in 1999 approximately 37% of cases attended a specialist or consultant physician compared to 56% of controls. These differences were highly statistically significant ($p<0.0001$).

The differences in the proportion of cases and controls attending a specialist or consultant physician each year were reflected in the frequency of attendances, as is presented in Table 4.4. In 1993 cases attended a specialist or consultant physician an average of 0.64 times compared to 1.9 times for controls. Whilst in 1999 the level of attendance in both groups increased, however, the differential remained with cases attending specialists and consultant physicians an average of 1.4 times, compared to 2.5 times for controls. Again these differences were highly statistically significant.

OPTOMETRIST ATTENDANCES

A similar pattern was found with optometrist attendances, as presented in Table 4.3, where only 1.6% of cases attended an optometrist in 1993, compared to 22.7% of controls. In 1999 3.0% of cases attended an optometrist, compared to 24.7% of controls.

Again the differences in the proportions were reflected in the frequency of attendances, as presented in Table 4.4. In 1993 cases attended optometrists 0.02 times on average compared to 0.27 times on average for controls. In 1999 cases attended optometrists 0.03 times on average, compared to 0.31 times for controls. These differences were highly statistically significant ($p<0.0001$).

Table 4.3: Health care utilisation between 1993 and 1999 for cases and controls, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
	GP	3325(69.6)	3368(72.7)	3462(74.7)	3549(76.6)	3622(78.2)	3760(81.2)	3944(85.2)	1.15*	<0.0001
	HbA1c ±	345(7.4)	458(9.9)	583(12.6)	552(11.9)	639(13.8)	698(15.1)	791(17.1)	1.14#	<0.0001
	HDL-c†	23(0.5)	16(0.2)	24(0.5)	23(0.5)	23(0.5)	23 (0.5)	23(0.5)	1.02#	<0.0001
	S&CP‡	996(21.5)	103922.4)	1117(24.1)	1151(24.8)	1253(27.1)	1379(29.8)	1697(36.6)	1.17*	<0.0001
	Optometrist	74(1.6)	74(1.6)	99(2.1)	98(2.1)	116(2.5)	126(2.7)	137(3.0)	1.11*	<0.0001
Controls										
	GP	4332(93.5)	4343(93.8)	4361(94.1)	4347(93.8)	4307(93.0)	4277(92.3)	4217(91.0)	0.93*	<0.0001
	HbA1c±	917(19.8)	1089(23.5)	1264(27.3)	1333(28.8)	1558(33.6)	1828(39.5)	2043(44.1)	1.21#	<0.0001
	HDL-c †	528(11.4)	628(13.6)	759(16.4)	729(15.7)	809(17.5)	887(19.1)	905(19.5)	1.10#	<0.0001
	S&CP‡	2283(49.3)	2416(52.2)	2438(52.6)	2543(54.9)	2539(54.8)	2575(55.6)	2602(56.2)	1.04*	<0.0001
	Optometrist	1126(22.7)	1035(22.3)	1162(25.1)	1146(24.7)	1178(25.4)	1167(25.2)	1146(24.7)	1.02*	<0.0001

The differences in the proportion of attending or testing for each year for cases vs controls was significant at p<0.0001.* Reference group = not attended, # reference group = not tested
±Haemoglobin A1c tests, † HDL cholesterol tests and ‡ Specialist and consultant physician attendances

Table 4.4: Health care utilisation between 1993 and 1999 for cases and controls, mean (sd)

					Year					
	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
GP	Case	4.31(7.13)	4.78 (7.92)	5.05 (7.92)	5.55 (8.60)	5.76 (8.61)	6.28 (8.96)	6.86 (9.16)	0.99	<0.0001
	Control	9.46 (10.30)	9.77 (10.08)	10.27(10.60)	10.3 (10.07)	10.5 (9.91)	10.52(10.04)	10.45(9.86)	0.89	<0.0001
S&CP[‡]	Case	0.64(2.17)	0.66 (2.24)	0.78 (3.04)	0.79 (3.49)	0.90 (3.13)	1.05 (3.91)	1.36 (5.60)	0.93	<0.0001
	Control	1.92(3.53)	2.0 (3.74)	2.21(4.76)	2.32 (4.50)	2.31(4.03)	2.31 (4.12)	2.51 (5.43)	0.94	<0.0001
Optom	Case	0.019(0.18)	0.017 (0.13)	0.024 (0.17)	0.026 (0.22)	0.028 (0.18)	0.03 (0.19)	0.03 (0.21)	0.94	<0.0001
	Control	0.27 (0.54)	0.26 (0.53)	0.29(0.57)	0.30 (0.60)	0.30 (0.58)	0.31 (0.62)	0.31 (0.64)	0.91	<0.0001
HbA1c[±]	Case	0.10 (0.40)	0.13 (0.43)	0.16 (0.48)	0.15 (0.48)	0.19 (0.53)	0.20 (0.53)	0.23 (0.57)	0.97	<0.0001
	Control	0.28 (0.66)	0.36 (0.75)	0.41 (0.78)	0.44 (0.82)	0.53 (0.88)	0.62 (0.92)	0.70 (0.97)	0.99	<0.0001
HDL-c[†]	Case	0.006 (0.09)	0.005 (0.09)	0.005 (0.07)	0.005 (0.07)	0.005 (0.07)	0.006 (0.9)	0.005(0.08)	0.0	1.0
	Control	0.14 (0.43)	0.17 (0.49)	0.22 (0.56)	0.21 (0.54)	0.24 (0.59)	0.25 (0.61)	0.26 (0.60)	0.95	<0.0001

The differences in all annual means for each variable for cases vs controls were significant at $p<0.0001$. [±]Haemoglobin A1c tests,[†] HDL cholesterol tests,[‡] Specialist and consultant physician attendances

HbA1c AND HDL-CHOLESTEROL TESTS

Table 4.3 shows in all years, the proportion of cases tested for HbA1c was less than half that of controls. Whilst the trend was for increased testing in both groups, the increase was greatest in controls (OR = 1.14 for cases and 1.21 for controls).

The differences between the groups in respect of the proportion of patients tested were reflected in the frequency of tests (Table 4.4). In 1993, cases received an average of 0.1 HbA1c tests per year compared to almost three times as many tests for controls (an average of 0.28). In 1999, although the level of testing had significantly increased, cases still only received an average of 0.23 tests per year and the three-fold differential remained. In all years the differences between the groups were highly significant ($p<0.0001$).

Table 4.3 also shows the proportions of subjects who were tested for HDL-cholesterol each year, again indicating very large differentials between the groups. Whilst testing was inadequate in both groups, it was very rare in cases, with only 0.5% being tested within a year. This is despite the HDL-cholesterol testing being included in clinical management guidelines for diabetes during this period.[74] In addition, there was little evidence of the level of testing substantially increasing over the study period for these patients.

PATIENT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS

The study also investigated whether patient characteristics and seven-year health care utilisation predicted laser photocoagulation therapy. This was tested using a conditional logistic regression analysis captured in Table 4.5 below. The utility of this model lies in its capacity to predict the occurrence of laser therapy from patient demographic characteristics and health care utilisation over a period of seven years.[342]

The model showed that the most consistent predictors of laser therapy in 2000 were whether patients had attended an optometrist or received an HDL cholesterol test in the preceding years. In addition, cases were much more likely to have received retinal photography.

Table 4.5: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999

YEAR Risk factor	OR	95% CI	P
Gender*	0.75	0.60 – 0.94	0.01
Dx before 2000[Γ]	0.14	0.10 – 0.20	<0.0001
1993			
GP	0.96	0.94 – 0.98	<0.0001
S&CP[‡]	0.95	0.90 – 0.99	0.02
Optometry	0.25	0.17 – 0.37	<0.0001
HDL-c[†]	0.27	0.12 – 0.33	0.002
Retinal Ph[§]	1.93	0.63 – 5.93	0.25
1994			
S&CP	0.92	0.88 – 0.96	<0.0001
Optometry	0.12	0.07 – 0.21	<0.0001
HDL-c	0.17	0.07 – 0.39	<0.0001
Retinal Ph	3.46	0.83 – 14.5	0.09
1995			
GP	0.98	0.96 – 1.004	0.11
S&CP	0.95	0.91 – 0.98	0.003
Optometry	0.20	0.12 – 0.30	<0.0001
HDL-c	0.07	0.02 – 0.17	<0.0001
Retinal Ph	2.41	0.86 – 6.78	0.09
1996			
Optometry	0.37	0.26 – 0.54	<0.0001
HDL-c	0.11	0.04 – 0.27	<0.0001
Retinal Ph	5.68	1.22 – 26.3	0.03
1997			
Optometry	0.20	0.14 – 0.34	<0.0001
HDL-c	0.11	0.03 – 0.20	<0.0001
Retinal Ph	2.85	0.99 – 8.15	0.05
1998			
Optometry	0.20	0.13 – 0.3	<0.0001
HDL-c	0.13	0.05 – 0.24	<0.0001
Retinal Ph	2.59	0.97 – 6.91	0.06
1999			
GP	1.02	1.003 – 1.03	0.02
Optometry	0.21	0.14 – 0.33	<0.0001
HbA1c[†±]	0.74	0.61 – 0.89	0.001
HDL-c	0.02	0.008 – 0.07	<0.0001
Retinal Ph	26.8	8.64 – 83.2	<0.0001
Microalbumin	2.57	1.90 – 3.50	<0.0001

Reference group = controls,*reference group = females,
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 3103.6$, 31 df, p <0.0001.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances.
[§] Retinal photography

Discussion

The study showed that diabetes patients who developed vision-threatening retinopathy had significantly lower levels of diabetes-related health care utilisation across almost all aspects of primary and secondary care examined. Overall, those who developed vision-threatening retinopathy had a pattern of care that included delayed diagnosis, lower levels of medical care attendances, under-testing and under-referral over a seven-year period when compared to controls. This population level finding strongly supports the contention that patterns of primary care utilisation may be as important a determinant of diabetes outcomes as clinical risk factors such as blood glucose control and hypertension.[55, 57]

Perhaps the most notable observation concerned the timing of diagnosis. Alarmingly, over half of the cases obtained their earliest HbA1c test in the same year as they were treated for laser photocoagulation therapy, suggesting a relationship between delayed diagnosis and vision-threatening retinopathy. The evidence suggests that the deprivation of medical care resulting from the delayed diagnosis of diabetes could itself have led to the development of complications,[12] as people with diabetes who have not been diagnosed would not have received appropriate treatment. The issue of timing of diagnosis is examined in detail in Chapters 6 and 7 below.

A second major finding was the under-utilisation of GPs among those who developed vision-threatening retinopathy, and the study suggests both

quantitative and qualitative dimensions to this risk factor. On the quantitative dimension, the number of attendances at GPs may have been critical in determining the quality of care and thereby the progress of diabetes, as GP attendance enables access to most aspects of diabetes management.[39]

Qualitative differences in care are suggested by the major disparities in testing for HDL-cholesterol between cases and controls. The significance of this test lies in its specificity to glucose metabolism conditions and its rare use for other disorders.[348] However, HDL- cholesterol is not the most common test ordered by practitioners for detecting dyslipidaemia in people with diabetes, which is usually total or LDL-cholesterol.[22] Therefore, its use can be regarded as a marker of a greater understanding of diabetes among practitioners. These findings suggest that there were deficiencies in provider behaviour perhaps explained by a lack of time or even poor competency,[349] which may have contributed to the development of vision-threatening retinopathy.

Looking beyond utilisation to risk groups, the multivariate analysis indicated an increased risk of vision-threatening retinopathy among women. While two hypotheses emerge from this finding, the data do not allow a conclusive explanation to be made. It may be that women are at an apparent higher risk of vision-threatening retinopathy because of a health status predisposition or, alternatively, the higher risk may reflect easier access to laser photocoagulation therapy. However, as is examined in a later chapter, the gender difference was only apparent in Victoria (Table 5.10), SEIFA 1 (Table 8.9) and RRMA 3 (Table 9.11). As the increased risk in women was confined to these particular sub-

populations it is unlikely to reflect differentials in the predisposition to vision-threatening retinopathy between the sexes.

In conclusion, the findings highlight the need for timely diagnosis, improved access to medical care and greater quality of care if diabetes complications such as vision-threatening retinopathy are to be prevented. Together, these imperatives demand an intensification of effort, at both the primary care and policy levels, to truly reflect the status of diabetes as a national health priority.

Chapter 5

Diabetes management across Australian states and territories: Do different models of tertiary care impact on the nature and effectiveness of diabetes management?

Abstract

OBJECTIVES: To evaluate the role of state and territory health care systems in the management of diabetes and the prevention of complications.

METHODS: Diabetes patients (n = 4632) who received their first laser photocoagulation treatment in 2000 were compared with a random sample of diabetes patients from the same states and territories who had never received this treatment (n = 4632). Patterns of health care utilisation were compared over a seven-year period (1993-1999) within state and territories using the Australian Medicare database.

RESULTS: Similar differences between cases and controls to those reported in Chapter 4 were evident in all jurisdictions. Cases were diagnosed earliest in Victoria and latest in South Australia, whilst controls were diagnosed earliest in New South Wales and latest in South Australia. For GP attendances, among cases, these were highest in South Australia (7 year average 80.7%), and lowest in the Northern Territory (7 year average = 60.4%), P<0.0001. Among controls, the highest proportion that attended GPs was in Queensland (7 year average = 94.6%), and the lowest was in Western Australia (7 year average = 90.1%), P<0.0001. With regard to specialist and consultant physician attendances: for cases the highest proportion of attendances was in New South Wales (7 year average = 29.2%), whilst the lowest was in the Northern Territory (7 year average = 14.3%), P<0.0001. For HbA1c testing, among cases the highest proportion tested was in South Australia (7 year average = 29.3%), and the lowest in the Northern Territory (7 year average = 14.3%), P<0.0001. For controls, the highest proportion tested was in Victoria (7 year average = 32.7%) and the lowest was in the Northern Territory (7 year average = 24.6%), P<0.0001. State and territory was tested as a risk factor in a logistic regression analysis, with the finding that the highest risk of vision-threatening retinopathy was in Queensland and Tasmania and the lowest was in the Australian Capital Territory, (P<0.0001 for model). The major risk factors for vision-threatening retinopathy were delayed diagnosis, optometry attendances, HDL cholesterol testing and retinal photography (which was higher in cases), with P<0.0001 for all models.

CONCLUSIONS: The findings show that levels of practitioner attendances and pathology testing differed between jurisdictions, however, these were often difficult to relate to the risk of vision-threatening retinopathy. State and territory health care systems appeared to play little role in the management of diabetes, and as a result, suggest that the health care system at the national level is more important in determining the risk of complications.

Introduction

The study reported in the previous chapter found that patients who developed vision-threatening retinopathy (cases) had significantly lower levels of general practice, specialist, and optometrist attendances, as well as poorer rates of HbA1c and HDL-cholesterol testing during the seven years prior to the development of complications than controls. This relationship was strong, multifaceted and consistent. However, having made these findings at the national level, we were interested to investigate whether different patterns emerged in individual states and territories. This corresponds to testing the second research question of the thesis: whether state and territory health care systems influence the risk of diabetes complications in Australia.

As was discussed in the literature review, the federal system of government in Australia is such that some aspects of health care, most significantly primary care are the domain of national policy, while other aspects of care are state and territory responsibilities, most importantly tertiary care.[173] Therefore each state and territory has its own unique health care system that provides some important aspects of diabetes care, particularly as it relates to public hospitals.[173] Whilst medical care provided by states and territories is primarily delivered through hospitals, there are also state-based diabetes prevention programs such as clinical management guidelines targeted at GPs and specialists that can also influence the management of diabetes.[74]

Whilst differences in hospital care are frequently found between jurisdictions,[350] differences in care provided through the Medicare system are also evident.[286] These relate to how Medicare operates within each state and territory[286] and perhaps also to differences in hospital care which can also influence how Medicare is utilised.

As primary, secondary and tertiary care are closely related,[173] how one part of the system operates affects the operation of other parts, in some cases resulting in clinically significant differences in health outcomes.[350] Thus even though state and territory health systems have only a limited role in the provision of primary care, they can influence Medicare through the operation of their hospital and broader health care systems.[173] Therefore, understanding the use of Medicare within states and territories is important for understanding the relationship between health care and diabetes complications across Australia.

Methods

To investigate the relationship between health care utilisation and diabetes outcomes across Australian states and territories, a population-based case-control study similar to that presented in Chapter 4 was used.[331] The study examined patient demographic characteristics, utilisation of primary and secondary care and use of diabetes related pathology tests, over a period of seven years, as risk factors for the development of complications across all eight Australian states and territories.

Cases comprised a national sample of 4632 patients who had received their first laser photocoagulation therapy in 2000, and controls were a random sample of 4632 people with diabetes who had not received this treatment (the total sample in Table 4.2). Controls were matched to cases on age (within one year) in 2000, and state of residence at the time of their earliest HbA1c test. There were equal numbers of cases and controls within each state and territory sample.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests, and frequencies by independent samples t-tests. When risk factors were compared between states and territories, for proportions, χ^2 tests for trend were used, and for frequencies analysis of variance was used (the Bonferroni adjustment was used to account for type 2 error).[342] For each risk factor and for cases and controls in each state and territory, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted

means.[342] The multivariate analyses were conducted using conditional logistic regression, where the paired study design could be taken into account (Tables 5.9 to 5.16), and conventional logistic regression where a matched variable was included as a risk factor (state and territory in Table 5.8).[342] The regression analyses used a stepwise process with backwards conditional as the variable selection criteria. All statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF SUBJECTS BY STATE AND TERRITORY

Table 5.1 shows the distribution of subjects by state and territory, where the highest incidence of vision-threatening retinopathy was in the Northern Territory (37 per 100,000 population in 2000) and South Australia (31 per 100,000 population in 2000), and the lowest was in the Australian Capital Territory (16 per 100,000 population in 2000) and Queensland (20 per 100,000 population in 2000). The remaining states were near to the national average, showing that the incidence of laser therapy patients was roughly proportional to the size of the state or territory population.[351]

Table 5.1 shows that the mean age of subjects ranged from 56.3 years (sd = 11.9) in the Northern Territory to 63.5 years (sd = 14.1) in the Australian Capital Territory (Analysis of variance (ANOVA), was not significant (ns) for all states and territories except the Northern Territory). The age differences between states and territories were all non-significant, with the exception of the Northern Territory, where subjects were younger (ANOVA, $p<0.05$ New South Wales, Victoria, Queensland, Western Australia, South Australia, Tasmania, Australian Capital Territory).[351]

Whilst there were more men than women in both case and control groups, this occurred in all states and territories (ANOVA, ns for all states and territories). Thus the gender distribution was similar in all localities.

In Chapter 4 delayed diagnosis was identified as a risk factor for diabetes complications (see Table 4.5 above). When this risk factor was examined, it was found to be important in all states and territories. Whilst overall, cases had been diagnosed later than controls, there were some important differences: in Victoria the diagnosis of diabetes occurred earlier in cases than it did in other localities, whilst the timing of diagnosis for controls was about the same across jurisdictions (ANOVA, $p<0.05$, New South Wales, Queensland, Western Australia, South Australia). However, in South Australia, diagnosis occurred later among both groups (ANOVA, $p<0.05$ for New South Wales, Victoria, Queensland, Western Australia, Tasmania), which may have been reflected in the higher proportion of vision-threatening retinopathy in this state in the univariate analysis.

Table 5.1: Characteristics of study subjects by state and territory

		NSW	Victoria	Qld	WA	SA	Tas	NT	ACT	Total
Cases, n (%)		1590 (34.3)	1164 (25.1)	684 (14.7)	493 (10.6)	460 (9.9)	123 (2.6)	70 (1.5)	48 (1.0)	4632
Pop, n (%)[#]		6,432,000 (33.8)	4,661,000 (24.8)	3,456,000 (18.4)	1,831,000 (9.8)	1,487,000 (7.9)	472,000 (2.5)	190,000 (1.0)	308,000 (1.6)	18,751,000
Difference (%)		0.5	0.3	-3.7	0.8	2.0	0.1	0.5	-0.6	0.012
P of difference		0.47	0.67	<0.0001	0.043	<0.0001	0.55	0.0007	0.001	
Incidence[±](95%CI)		25(23 to 26)	25(23 to 26)	20(18 to 21)	27(24 to 29)	31(28 to 37)	26(21 to31)	37(28 to 45)	16(11 to 20)	25(24 to 25)
Age, mean (sd)[*]		62.6 (12.6)	62.3 (13.0)	62.1 (14.0)	62.6 (13.2)	63.4 (12.8)	61.2 (13.8)	56.3 (11.9)	63.5 (14.1)	62.4 (13.1)
Gender[**]	Male,n(%)	54.0 (1717)	54.5 (1268)	52.7 (721)	54.9 (541)	56.3 (518)	54.1(133)	55.0 (77)	54.2 (52)	54.5
	Female,n(%)	46.0 (1463)	45.5 (1060)	47.3 (647)	45.1 (445)	43.7 (402)	45.9 (113)	45.0 (63)	45.8 (44)	45.5
Dx before 2000	Cases, n(%)	661 (41.6)	642 (55.2)	281 (41.1)	234 (47.5)	158 (34.3)	66(53.7)	31 (44.3)	21 (43.8)	45.2
	Controls,n(%)	1405(88.4)	1022 (87.8)	594 (86.8)	430 (87.2)	367(79.8)	108 (87.8)	61 (87.1)	39 (81.3)	85.2
N		3180	2328	1368	986	920	246	140	96	9264

[*]ANOVA testing differences in age distribution in states: $F^{7, 9256\ df,} = 5.81$, $p<0.0001$, [**] χ^2 test for differences in gender distribution between states: 3.19, 7df, p = 0.87.

[#] Population distribution from 1998 Australian Census of Population and Housing.[±] per 100,000 population in 2000.

GP ATTENDANCES BY STATE AND TERRITORY

Tables 5.2 and 5.3 show that there were noteworthy differences in the proportion and frequency of general practice attendances. Firstly, the difference between cases and controls evident in Chapter 4, was found to exist in all states and territories. Secondly, when states and territories were compared, GP attendances were highest in Queensland and lowest in the Northern Territory. This may reflect different methods of management, access to care or diabetes severity in these populations.

With regard to trends in GP attendances, Table 5.2 shows that the proportion of cases that attended GPs increased in all states and territories over the study period, however, attendance by controls declined. However, the *frequency* of attendances increased in both groups. This suggests that whilst the proportion of controls that attended GPs declined over time, if the frequency of attendances can be interpreted as an indicator of the quality of care, this may have improved in most states and territories over the study.

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Table 5.2: GP attendances between 1993 and 1999 by state and territory, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	NSW	1135(71.4)***	1160(73.0)***	1197(75.3)***	1224(77.0)***	1254(78.9)***	1309(82.3)***	1369(86.1)***	1.16	<0.0001
	Victoria	806 (69.2)***	840 (72.2)***	869 (74.7)***	895 (76.9)***	893 (76.7)***	939 (80.7)***	1003(86.2)**	1.15	<0.0001
	Queensland	468 (68.4)***	494(72.2)***	504 (73.7)***	527 (77.0)***	542 (79.2)***	537 (78.5)***	567 (82.9)***	1.13	<0.0001
	WA	339 (68.8)***	352 (71.4)***	359 (72.8)***	362 (73.4)***	383 (77.7)***	402 (81.5)***	403 (81.7)**	1.13	<0.0001
	SA	329 (71.5)***	361 (78.5)***	361 (78.5)***	370 (80.4)***	372 (80.9)***	394 (85.7)***	412 (89.6)$^{\phi}$	1.18	<0.0001
	Tasmania	82 (66.7)***	87 (70.7)***	92 (74.8)***	95 (77.2)***	96 (78.0)***	98 (79.7)**	100 (81.3)**	1.13	0.002
	NT	31 (44.3)***	38 (54.3)**	44 (62.9)***	43 (61.4)**	47 (67.1)**	46 (65.7)**	47 (67.1)**	1.16	0.002
	ACT	35 (72.9)*	36 (75.0)**	36 (75.0)**	33(68.8)***	35 (72.9)*	35 (72.9)**	43 (89.6)$^{\phi}$	1.09	0.18
	P of diff	0.001	0.004	0.017	0.015	0.18	0.001	<0.0001		
Controls										
	NSW	1511 (92.2)	1523(95.8)	1518 (95.5)	1501 (94.4)	1489 (93.6)	1474 (92.7)	1447 (91.0)	0.84	<0.0001
	Victoria	1073 (92.2)	1076 (92.4)	1087 (93.4)	1093 (93.9)	1079 (92.7)	1065 (91.5)	1057 (90.8)	0.97	0.10
	Queensland	656 (95.9)	644 (94.2)	654 (95.6)	650 (95.0)	646 (94.4)	642 (93.9)	638 (93.3)	0.93	0.03
	WA	442 (89.7)	443 (89.9)	450 (91.3)	447 (90.7)	444 (90.1)	445 (90.3)	438 (88.8)	0.99	0.69
	SA	427 (92.8)	428 (93.0)	424 (92.2)	432 (93.9)	429 (93.1)	428 (93.0)	420 (91.3)	0.98	0.59
	Tasmania	114 (92.7)	114 (92.7)	117 (95.1)	116 (94.3)	113 (91.9)	115 (93.5)	114 (92.7)	0.99	0.89
	NT	65 (92.9)	69 (98.6)	66 (94.3)	61 (87.1)	63 (90.0)	63 (90.0)	62 (88.6)	0.85	0.051
	ACT	44(91.7)	46(95.8)	45 (93.8)	47(97.9)	44(91.7)	45(93.8)	41(85.4)	0.87	0.21
	P of diff	<0.0001	<0.0001	0.006	0.012	0.13	0.34	0.19		

Differences between cases and controls: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 5.3: GP attendances between 1993 and 1999 by state and territory, mean (sd)

					Year					
State	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
NSW	Case	4.6(6.9)***	5.0(7.2)***	5.4(7.3)***	5.6(7.7)***	5.9(7.3)***	6.4(8.2)***	7.1(8.7)***	0.99	<0.0001
	Control	9.9 (9.8)	10.3(10.2)	10.6(11.1)	10.6(11.1)	10.7 (9.2)	10.5 (9.3)	10.6 (9.6)	0.73	<0.0001
Victoria	Case	4.3(6.6)***	4.7(6.6)***	4.9(6.4)***	5.5(7.4)***	5.7(8.1)***	6.2(7.8)***	6.6(7.7)***	0.99	<0.0001
	Control	9.1 (9.8)	9.4 (9.6)	10.2(10.1)	10.0(10.1)	10.4(10.9)	10.2 (9.8)	10.4 (11.0)	0.86	<0.0001
Queensland	Case	4.2(10.2)***	4.7(12.4)***	5.1(12.7)***	5.7(13.4)***	5.9(13.6)***	6.4(13.9)***	7.4(14.1)***	0.99	<0.0001
	Control	10.1 (11.8)	10.7 (12.2)	11.0 (11.9)	10.9 (9.6)	11.0 (10.3)	11.4 (9.7)	11.3 (9.4)	0.90	<0.0001
WA	Case	3.5 (4.9)***	4.1(5.7)***	4.5 (6.1)***	4.8 (6.3)***	5.0 (6.3)***	5.2 (6.1)***	5.7 (7.0)***	0.98	<0.0001
	Control	9.1 (9.6)	9.5 (9.3)	9.7 (9.0)	9.8 (8.9)	10.3 (10.1)	10.2 (9.9)	10.1 (9.2)	0.91	<0.0001
SA	Case	4.6 (6.1)***	5.2 (6.6)***	4.9 (5.9)***	6.1 (8.2)***	6.0 (6.7)***	7.0 (7.2)***	7.2 (6.9)***	0.95	<0.0001
	Control	9.4 (12.7)	9.4 (9.6)	10.2 (11.2)	10.8 (11.9)	10.5 (9.4)	11.2 (12.9)	10.7 (9.9)	0.87	<0.0001
Tasmania	Case	4.8 (7.4)*	5.1 (7.7)*	5.6 (8.2)*	5.3 (7.0)**	6.8 (9.1)*	7.2 (10.5)$^{\phi}$	7.3 (8.4)$^{\phi}$	0.94	<0.0001
	Control	6.9 (6.1)	7.0 (6.3)	8.3 (6.8)	8.3 (6.8)	9.6 (8.4)	9.9 (12.3)	8.8 (7.7)	0.85	<0.0001
NT	Case	1.8 (2.8)***	2.7 (4.3)***	2.8 (4.2)***	3.2 (4.1)*	3.3 (4.1)**	4.0 (5.6)*	3.8 (4.8)*	0.95	<0.0001
	Control	6.4 (6.3)	6.4 (6.3)	7.0 (6.7)	5.7 (6.2)	6.8 (7.7)	6.7 (6.4)	5.9 (4.9)	-0.18	<0.0001
ACT	Case	3.4 (4.4)*	5.2 (6.2)$^{\phi}$	3.9 (5.4)*	5.3 (6.3)$^{\phi}$	5.3 (8.1)$^{\phi}$	5.8 (8.2)$^{\phi}$	7.4 (8.8)$^{\phi}$	0.87	<0.0001
	Control	5.9 (4.7)	6.2 (4.5)	6.1 (4.2)	6.1 (3.9)	5.7 (5.4)	6.5 (5.9)	5.2 (4.3)	-0.35	<0.0001

Differences between cases and controls: $^{\phi}$t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001
Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years except 1994 (p=0.11) and 1996 (p=0.10).
Controls: Statistically significant difference between states in all years.

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES BY STATE AND TERRITORY

Tables 5.4 and 5.5 show that there were significant differences between cases and controls in the proportion and frequency of specialist and consultant practitioner attendances. Whilst Table 5.4 shows that the proportion of cases that attended was between a third and a half that of controls, there were also significant differences between jurisdictions. The highest proportions were in South Australia, followed by New South Wales and Victoria. The lowest proportions were in Western Australia and the Northern Territory. These differences perhaps point to differentials in access to specialist care or diabetes management practices between states and territories.

For controls, the χ^2 tests showed similar differences between states and territories in specialist attendances to those found in cases. The proportions of controls attending specialists were highest in New South Wales, Victoria and South Australia. The lowest proportions were in the Northern Territory and the Australian Capital Territory. That the highest and lowest proportions for controls occurred in similar jurisdictions to cases suggests that states and territories provide broadly comparable levels of access to these practitioners for the two patient groups.

With regard to the frequency of specialist and consultant physician attendances, Table 5.5 shows that there were similar differences to those captured in Table 5.4. Whilst the highest frequencies were in New South Wales and Victoria, the

lowest were in the Northern Territory, the Australian Capital Territory and Western Australia (ANOVA, $p<0.05$ in all years).

The proportion and frequency of specialist and consultant physician attendances found in this study may be an indicator of the availability of these practitioners in individual states and territories. Several states and territories, especially those with sparse populations, have low numbers of medical practitioners and this results in poor access and low levels of utilisation.[320] In other jurisdictions, levels of utilisation may be higher because specialists and consultant physicians are much more accessible.

The data also suggest that there was a strong relationship between GP and specialist attendances. Where attendance at GPs was low, this tended to result in fewer specialist attendances, and where GP attendances were high, similarly high levels were found in specialists.

Table 5.4: Specialist and consultant physician attendances between 1993 and 1999 by state and territory, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	p
	NSW	387(24.3)***	396(24.9)***	430(27.0)***	426(26.8)***	477(30.0)***	515(32.4)***	631(38.7)***	1.12	<0.0001
	Victoria	259(22.3)***	284(24.4)***	279(24.0)***	308(26.5)***	329(28.3)***	378(32.5)***	441(37.9)***	1.13	<0.0001
	Queensland	127(18.6)***	123(18.0)***	139(20.3)***	156(22.8)***	156(22.8)***	157(23.0)***	228(33.3)***	1.12	<0.0001
	WA	86 (17.4)***	90 (18.3)***	106(21.5)***	95 (19.3)***	99 (20.1)***	118(23.9)***	122(24.7)***	1.07	0.001
	SA	96(20.9)***	109(23.7)***	115(25.0)***	121(26.3)***	142(30.9)***	155(33.7)***	205(44.6)**	1.19	<0.0001
	Tasmania	23(18.7)**	18 (14.8)***	28 (22.8)***	28 (22.8)***	31 (25.2)***	37 (30.1)***	38 (30.9)**	1.15	0.001
	NT	10(14.3)*	5 (7.1)***	10 (14.3)$^{\phi}$	7 (10.0)**	10 (14.3)$^{\phi}$	10 (14.3)*	18 (25.7)$^{\phi}$	1.15	0.03
	ACT	8(16.7)***	14 (29.2)$^{\phi}$	10 (20.8)***	10 (20.8)**	9 (18.8)*	9 (18.8)*	14 (29.2)$^{\phi}$	1.03	0.64
	P of difference	0.006	<0.0001	0.008	0.001	<0.0001	<0.0001	<0.0001		
Controls										
	NSW	880(55.3)	931 (58.6)	894 (56.2)	957 (60.2)	964 (60.6)	981 (61.7)	974 (61.3)	1.04	<0.0001
	Victoria	537 (46.1)	594 (51.0)	633 (54.4)	665 (57.1)	650 (55.8)	646 (55.5)	668 (57.4)	1.07	<0.0001
	Queensland	331(48.4)	339 (49.6)	348 (50.9)	344 (50.3)	342 (50.0)	336 (49.1)	341 (49.9)	1.004	0.79
	WA	219 (44.4)	236 (47.9)	236 (47.9)	232 (47.1)	237 (48.1)	249 (50.5)	256 (51.9)	1.04	0.02
	SA	218 (47.4)	226 (49.1)	220 (47.8)	236 (51.3)	244 (53.0)	248 (53.9)	255 (55.4)	1.06	0.002
	Tasmania	45(36.6)	44 (35.8)	64 (52.0)	61 (49.6)	65 (52.8)	68 (55.3)	62 (50.4)	1.12	0.001
	NT	23 (32.9)	24 (34.3)	15 (21.4)	21 (30.0)	17(24.3)	24 (34.3)	23 (32.9)	1.005	0.92
	ACT	30 (62.5)	22 (45.8)	28 (58.3)	27 (56.3)	20 (41.7)	23 (47.9)	23 (47.9)	0.92	0.14
	P of difference	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		

Differences between cases and controls: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 5.5: Specialist and consultant physician attendances between 1993 and 1999 by state and territory, mean (sd)

					Year					
State	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
NSW	Case	0.7(2.1)***	0.7(1.9)***	0.7(2.0)***	0.7(1.9)***	0.9(2.3)***	1.0(3.3)***	1.3(3.2)***	0.87	<0.0001
	Control	2.3 (3.9)	2.3 (3.7)	2.4 (4.6)	2.6 (3.8)	2.6 (3.8)	2.7 (4.2)	2.8 (4.8)	0.98	<0.0001
Victoria	Case	0.7(2.6)***	0.7(2.6)***	0.7(2.5)***	0.7(2.2)***	1.1(3.9)***	1.2(3.9)***	1.3(3.9)***	0.90	<0.0001
	Control	1.8 (3.2)	2.1 (4.1)	2.3 (4.5)	2.5 (5.6)	2.4 (4.1)	2.4 (4.4)	2.8 (6.7)	0.91	<0.0001
Queensland	Case	0.6(1.8)***	0.6(2.9)***	1.1(5.5)**	1.3(10.7)$^{\phi}$	0.9(4.0)***	1.2 (5.3)*	1.9(12.0)$^{\phi}$	0.83	<0.0001
	Control	1.7 (3.2)	1.7 (3.3)	2.1 (4.8)	2.0 (4.0)	1.9 (3.8)	1.9 (3.8)	2.3 (5.9)	0.72	<0.0001
WA	Case	0.5(1.6)***	0.5(1.8)***	0.6(2.2)***	0.4(1.1)***	0.5(1.5)***	0.6(2.1)***	0.7(2.0)***	0.55	<0.0001
	Control	1.5 (2.9)	1.6 (2.8)	1.9 (3.6)	1.7 (3.5)	1.7 (3.2)	1.8 (3.7)	1.7 (2.8)	0.48	<0.0001
SA	Case	0.7(2.4)***	0.6(1.6)***	0.6(1.5)***	0.7(1.8)***	1.0(3.5)***	1.3 (4.8)*	1.7 (4.2)*	0.71	<0.0001
	Control	1.9 (3.9)	2.1 (4.4)	1.8 (3.4)	2.2 (4.3)	2.3 (4.9)	2.3 (4.9)	2.5 (5.7)	0.85	<0.0001
Tasmania	Case	0.5* (1.8)*	0.3 (1.0)$^{\phi}$	1.3(5.5)*	0.5(1.7)***	0.9 (2.9)$^{\phi}$	1.2 (3.9)**	0.8 (2.5)*	0.47	<0.0001
	Control	1.5 (3.3)	1.1 (2.4)	2.7 (12.4)	2.8 (5.9)	2.3 (4.5)	1.8 (2.9)	1.8 (2.8)	0.23	<0.0001
NT	Case	0.3 (0.9)*	0.4 (2.6)$^{\phi}$	0.6 (2.7)$^{\phi}$	0.1 (0.5)*	0.2 (6.2)$^{\phi}$	0.4 (1.4)$^{\phi}$	0.7 (1.7)$^{\phi}$	0.29	<0.0001
	Control	1.0 (2.8)	1.3 (4.4)	0.8 (2.9)	0.9 (2.8)	1.4 (6.3)	1.2 (3.8)	1.5 (4.6)	0.56	<0.0001
ACT	Case	0.5 (1.8)*	1.1 (3.0)$^{\phi}$	0.4(0.8)***	0.4 (0.8)**	0.7 (2.2)$^{\phi}$	0.4 (0.9)**	0.7 (1.4)*	-0.15	0.006
	Control	1.3 (1.4)	1.7 (3.2)	1.6 (1.9)	1.3 (1.8)	1.3 (2.1)	2.3 (3.9)	1.8 (3.2)	0.50	<0.0001

Differences between cases and controls: $^{\phi}$t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001. Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years. Controls: Statistically significant difference between states in all years.

HbA1C TESTS BY STATE AND TERRITORY

Tables 5.6 and 5.7 show that there were major differences in the proportions and frequencies of HbA1c testing between cases and controls. Table 5.6 shows that the proportion of cases tested in each state and territories was between a third and a half that of controls. For cases, the highest proportions were in Victoria, whilst the lowest were in South Australia, the Northern Territory and the Australian Capital Territory. Among controls, the highest proportions tested were in Victoria also and the lowest in the Northern Territory and the Australian Capital Territory. Whilst states and territories showed similar trends of increased testing in cases, the greatest improvement was in controls.

With regard to the frequency of HbA1c testing, for cases this was highest in Victoria and lowest in Queensland, South Australia and the Northern Territory (ANOVA, $p < 0.05$ in all years). For controls, the frequencies were highest in Victoria and lowest in the Australian Capital Territory, showing that the patterns in frequencies closely followed those of proportions. With regard to trends, there were positive odds-ratios for both groups in all states and territories, with the frequency of testing increasing over time. Nevertheless, in all jurisdictions both cases and controls remained below clinical management guidelines, which recommend that HbA1c testing be conducted annually (which would represent a frequency of 1 or more in a particular year).[74]

Table 5.6: HbA1c testing between 1993 and 1999 by state and territory, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	NSW	106(6.7)***	141(8.9)***	156(9.8)***	163(10.3)***	173(10.9)***	224(14.1)***	255(16.0)***	1.16	<0.0001
	Victoria	112(9.6)***	164(14.1)**	217(18.6)***	209(18.0)***	236(20.3)***	239(20.5)***	282(24.2)***	1.15	<0.0001
	Queensland	47(6.9)***	45(6.6)***	64(9.4)***	73(10.7)***	78(11.4)***	89(13.0)***	89(13.0)***	1.14	<0.0001
	WA	35(7.1)***	50(10.1)***	74(15.0)***	55(11.2)***	65(13.2)***	68(13.8)***	70(14.2)***	1.09	0.001
	SA	27(5.9)***	33(7.2)***	42(9.1)***	30 (6.5)***	47(10.2)***	45(9.8)***	54(11.7)***	1.11	0.001
	Tasmania	8(6.5)*	13 (10.6)$^{\phi}$	15(12.2)*	14(11.4)*	22 (17.9)*	24(19.5)**	23(18.7)***	1.20	<0.0001
	NT	8(11.4)$^{\phi}$	8(11.4)$^{\phi}$	9(12.9)$^{\phi}$	6 (8.6)*	11(15.7)$^{\phi}$	7(10.0)**	8(11.4)*	1.0	1.0
	ACT	2(4.2)$^{\phi}$	4(8.3)$^{\phi}$	6(12.5)$^{\phi}$	2(4.2)$^{\phi}$	7(14.6)$^{\phi}$	2(4.2)*	10(20.8)$^{\phi}$	1.19	0.06
	P of difference	0.051	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
Controls										
	NSW	341 (21.4)	388 (24.4)	447(28.1)	477(30.0)	559 (35.2)	629(39.6)	720 (45.3)	1.20	<0.0001
	Victoria	211 (18.1)	272 (23.4)	333 (28.6)	365(31.4)	434 (37.3)	499 (42.9)	556 (47.8)	1.26	<0.0001
	Queensland	133 (19.4)	157 (23.0)	170 (24.9)	178(26.0)	208 (30.4)	275 (40.2)	290 (42.4)	1.21	<0.0001
	WA	120 (24.3)	138 (28.0)	154 (31.2)	141(28.6)	158 (32.0)	187 (37.9)	195 (39.6)	1.12	<0.0001
	SA	70(15.2)	84(18.3)	102 (22.2)	112(24.3)	136 (26.9)	156 (33.9)	188 (40.9)	1.24	<0.0001
	Tasmania	21 (17.1)	24 (19.5)	28(22.8)	33 (26.8)	42 (34.1)	48(39.8)	56(45.5)	1.27	<0.0001
	NT	12(17.1)	15(21.4)	18(25.7)	19(27.1)	9(12.9)	24(34.3)	24(34.3)	1.13	0.02
	ACT	9(18.8)	11(22.9)	12(25.0)	8 (16.7)	12(25.0)	10 (20.8)	14(25.0)	1.06	0.39
	P of difference	0.011	0.041	0.036	0.029	<0.0001	0.006	0.003		

Differences between cases and controls: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, χ^2 = is significant at p<0.0001

Table 5.7: HbA1c testing between 1993 and 1999 by state and territory, mean (sd)

					Year					
State	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
NSW	Case	0.09(0.4)***	0.1(0.4)***	0.1(0.4)***	0.1(0.4)***	0.1(0.4)***	0.2(0.5)***	0.2(0.5)***	0.82	<0.0001
	Control	0.3 (0.7)	0.4 (0.8)	0.4 (0.8)	0.5 (0.8)	0.6 (0.9)	0.6 (0.9)	0.7 (0.9)	0.98	<0.0001
Victoria	Case	0.1 (0.5)***	0.2(0.6)***	0.3(0.7)***	0.3(0.7)***	0.3(0.7)***	0.3(0.7)***	0.4(0.8)***	0.89	<0.0001
	Control	0.3 (0.7)	0.3 (0.8)	0.4 (0.8)	0.5 (0.9)	0.6 (0.9)	0.7 (0.9)	0.8 (1.0)	0.99	<0.0001
Queensland	Case	0.07(0.3)***	0.08(0.3)***	0.1(0.3)***	0.1(0.4)***	0.1(0.4)***	0.1(0.4)***	0.1(0.4)***	0.80	<0.0001
	Control	0.3 (0.6)	0.3 (0.8)	0.4 (0.8)	0.4 (0.8)	0.5 (0.9)	0.6 (0.9)	0.7 (0.9)	0.97	<0.0001
WA	Case	0.09(0.4)***	0.1(0.3)***	0.2(0.5)***	0.1(0.4)***	0.1(0.4)***	0.2(0.5)***	0.2(0.4)***	0.60	<0.0001
	Control	0.3 (0.7)	0.4 (0.8)	0.4 (0.8)	0.4 (0.7)	0.5 (0.9)	0.6 (0.9)	0.6 (0.9)	0.95	<0.0001
SA	Case	0.07(0.3)***	0.09(0.3)***	0.1(0.4)***	0.07(0.3)**	0.1(0.4)***	0.1(0.4)***	0.1(0.4)***	0.60	<0.0001
	Control	0.2 (0.6)	0.2 (0.6)	0.3 (0.6)	0.4 (0.8)	0.4 (0.8)	0.5 (0.9)	0.6 (0.9)	0.98	<0.0001
Tasmania	Case	0.06 (0.2)*	0.1 (0.4)$^{\phi}$	0.1 (0.3)*	0.1 (0.4)**	0.2 (0.5)**	0.2(0.5)***	0.2(0.6)***	0.92	<0.0001
	Control	0.2 (0.7)	0.2 (0.5)	0.3 (0.7)	0.4 (0.7)	0.5 (0.9)	0.6 (0.9)	0.7 (0.9)	0.99	<0.0001
NT	Case	0.1 (0.3)$^{\phi}$	0.1 (0.4)$^{\phi}$	0.2 (0.5)$^{\phi}$	0.1 (0.3)*	0.2 (0.5)$^{\phi}$	0.1(0.3)***	0.1 (0.4)*	0.0	1.0
	Control	0.2 (0.6)	0.3 (0.7)	0.3 (0.6)	0.3 (0.6)	0.1 (0.4)	0.5 (0.8)	0.5 (0.8)	0.58	<0.0001
ACT	Case	0.04 (0.2)*	0.08 (0.3)*	0.1 (0.3)$^{\phi}$	0.06(0.3)$^{\phi}$	0.1 (0.4)$^{\phi}$	0.06(0.3)*	0.2 (0.6)$^{\phi}$	0.64	<0.0001
	Control	0.2 (0.5)	0.2 (0.5)	0.3 (0.6)	0.2 (0.7)	0.3 (0.6)	0.3 (0.8)	0.4 (0.8)	0.82	<0.0001

Differences between cases and controls: $^{\phi}$t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001. Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years. Controls: Statistically significant difference between states in all years.

PATIENT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS BY STATE AND TERRITORY

In Table 5.8 below, whether state and territory, patient characteristics and patterns of care predicted laser photocoagulation therapy was tested using a logistic regression analysis. In this analysis, state and territory was as added as a risk factor (as seven dummy variables) to the logistic regression model in Table 4.6.

This analysis revealed that patients in Victoria, Queensland and Tasmania were at higher risk of vision-threatening retinopathy than those in other states and territories. This points to the influence of local health care systems,[173] and perhaps also to characteristics of local populations,[351] in determining the risk of diabetes complications. There were also similar risk factors for vision-threatening retinopathy to those captured in Table 4.6: delayed diagnosis and low levels of optometry attendances, HDL-cholesterol testing, as well as retinal photography, and microalbumin testing. The findings suggest that these risk factors are important in determining the risk of complications at the national level.

Table 5.8: Logistic regression analysis predicting laser therapy in 2000 using state and territory characteristics, demographic characteristics, and health care utilisation between 1993 and 1999, Australia

YEAR Risk factor	OR	95% CI	P
NSW (ref)	1.0		
Victoria	1.27	1.05 – 1.52	0.01
Queensland	1.36	1.09 – 1.70	0.007
Western Australia	1.01	0.79 – 1.70	0.91
South Australia	0.74	0.57 – 0.94	0.01
Tasmania	1.36	0.85 – 2.20	0.20
Northern Territory	0.69	0.39 – 1.20	0.19
ACT	0.52	0.29 – 0.95	0.03
Gender*	0.77	0.67 – 0.89	<0.0001
Dx before 2000[Γ]	0.19	0.16 – 0.22	<0.0001
1993			
GP	0.96	0.95 – 0.97	<0.0001
S&CP[‡]	0.92	0.89 – 0.95	<0.0001
Optometry	0.22	0.17 – 0.30	<0.0001
HDL-c[†]	0.29	0.28 – 0.46	<0.0001
Retinal Ph[§]	1.80	0.76 – 4.24	0.18
1994			
GP	1.0	0.99 – 1.01	0.86
S&CP	0.92	0.89 – 0.95	<0.0001
Optometry	0.12	0.07 – 0.21	<0.0001
HDL-c	0.22	0.13 – 0.37	<0.0001
Retinal Ph	2.63	1.03 – 6.67	0.04
1995			
GP	0.98	0.97 – 0.99	0.003
S&CP	0.98	0.95 – 0.99	0.04
Optometry	0.22	0.17 – 0.28	<0.0001
HbA1c[±]	1.04	0.91 – 1.17	0.56
HDL-c	0.14	0.08 – 0.23	<0.0001
Retinal Ph	2.30	1.13 – 4.64	0.02
1996			
S&CP	0.99	0.98 – 1.01	0.59
HbA1c	0.92	0.81 – 1.04	0.19
Optometry	0.26	0.20 – 0.34	<0.0001
HDL-c	0.16	0.09 – 0.27	<0.0001
Retinal Ph	5.82	2.16 – 15.7	<0.0001
1997			
Optometry	0.22	0.17 – 0.29	<0.0001
HDL-c	0.12	0.07 – 0.19	<0.0001
Retinal Ph	5.40	2.5 – 11.7	<0.0001
1998			
GP	1.004	0.99 – 1.02	0.54
S&CP	0.99	0.97 – 1.01	0.50
Optometry	0.20	0.16 – 0.26	<0.0001
HbA1c	0.93	0.83 – 1.04	0.19
HDL-c	0.15	0.09 – 0.23	<0.0001
Retinal Ph	3.93	1.92 – 8.03	<0.0001
Continued below			

Table 5.8: Continued

YEAR Risk factor	OR	95% CI	P
1999			
GP	1.02	1.007 – 1.03	0.002
Optometry	0.26	0.20 – 0.33	<0.0001
HbA1c	0.75	0.67 – 0.84	<0.0001
HDL-c	0.10	0.06 – 0.17	<0.0001
Retinal Ph	41.9	18.5 – 94.7	<0.0001
Microalbumin	2.40	1.96 – 2.89	<0.0001

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall χ^2 = 7733.6, 45 df, p <0.0001.
[±] Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§] Retinal photography.

PATIENT CHARACTERISTICS AND HEALTH CARE UTILISATION FOR CASES VS CONTROLS FOR INDIVIDUAL STATES AND TERRITORIES

Tables 5.9 to 5.16 present the findings of logistic regression models for individual states and territories. In Table 5.9 the logistic regression model for New South Wales shows that the risk factors for vision-threatening retinopathy in that state were very similar to those identified through the national model (Table 4.5), with the only significant difference being the absence of gender.

Table 5.10 presents the logistic regression model for Victoria. This analysis showed similar risk factors to the national model and to New South Wales. However, women were at higher risk of vision-threatening retinopathy. When this is considered in the light of Table 5.8, which showed that patients in Victoria as a whole were at a higher risk of diabetes complications, it is possible that this elevated risk is due to the excess in women in this state.

Table 5.11 shows the risk factors for laser therapy in Queensland. Table 5.8 had shown that the risk of laser therapy in Queensland was greater than in most other states and territories. However, the results of logistic regression analysis for this state were very similar to those nationally and in New South Wales and Victoria, with no distinguishing characteristics evident. The apparent higher risk of vision-threatening retinopathy in Queensland may be due to the influence of local health care systems,[173] or perhaps also the characteristics of local populations in determining the risk of complications.[351]

Table 5.12 shows the logistic regression model for vision-threatening retinopathy in Western Australia. It indicates that the risk factors in this state were very similar to those in respect of the national model, along with New South Wales, Victoria and Queensland. With an average risk of vision-threatening retinopathy, there were no risk factors that distinguished this jurisdiction.

Table 5.13 presents the logistic regression model for South Australia. In the crude analysis captured in Table 5.1, people with diabetes in South Australia appeared to be at higher risk of diabetes complications. However, this higher risk was not evident in the logistic regression analysis in Table 5.8. This suggests that the increased prevalence of vision-threatening retinopathy in South Australia was due to a correlated risk factor (such as delayed diagnosis) being greater in this state. The logistic regression model also showed similar risk factors in South Australia as were found nationally and in respect of New South Wales, Victoria, Queensland and Western Australia.

The logistic regression model in Table 5.8 also showed that the risk of vision-threatening retinopathy was higher in Tasmania than in most other states and territories. However, the logistic regression model captured in Table 5.14 indicates that the risk factors in Tasmania were very similar to those in other localities. The apparent higher risk vision-threatening retinopathy in this state may be due to the influence of local health care systems, or perhaps to the characteristics of local populations, in determining the risk of complications.

Table 5.15 presents the analysis from the Northern Territory, which was distinguished in having the youngest population of all jurisdictions in this study. Although in some years there were no significant differences between cases and controls in the Northern Territory, where they did occur, they were similar to those found in other states and territories (for example those for optometry attendances). This suggests that the lower number of risk factors in this jurisdiction was not a reflection of a different relationship between patterns of care and vision-threatening retinopathy, but is likely to be a result of the smaller sample size used in the model.[342]

Whilst the logistic regression analysis in Table 5.8 showed that people with diabetes from the Australian Capital Territory had the lowest risk of vision-threatening retinopathy of all jurisdictions, Table 5.16 indicates that it shared some of the same risk factors as were found in other states and territories, such as delayed diagnosis. As with the Northern Territory, the lower number of risk factors may not be a reflection of a different relationship between patterns of care and diabetes complications, but is most likely a result of the small sample size used in the model for this jurisdiction.[342]

Table 5.9: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, New South Wales

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.09	0.047 – 0.17	<0.0001
1993			
GP	0.96	0.93 – 0.99	0.02
S&CP[‡]	0.93	0.84 – 1.02	0.14
Optometry	0.11	0.04 – 0.29	<0.0001
HDL-c[†]	0.17	0.03 – 1.12	0.07
Retinal Ph[§]	1.33	0.21 – 8.49	0.76
1994			
S&CP	0.87	0.78 – 0.97	0.01
Optometry	0.13	0.03 – 0.47	0.002
HDL-c	0.10	0.02 – 0.53	0.007
Retinal Ph	6.17	0.26 – 145.7	0.26
1995			
S&CP	0.89	0.80 – 0.99	0.03
Optometry	0.17	0.07 – 0.41	<0.0001
HDL-c	0.13	0.03 – 0.53	0.004
Retinal Ph	21.2	2.3 – 193.7	0.007
1996			
S&CP	1.05	0.95 – 1.16	0.36
Optometry	0.13	0.05 – 0.35	<0.0001
HbA1c[±]	0.60	0.34 – 0.95	0.03
HDL-c	0.05	0.006 – 0.48	0.009
Retinal Ph	15.8	0.50 – 498.9	0.12
1997			
Optometry	0.026	0.007 – 0.10	<0.0001
HDL-c	0.21	0.07 – 0.66	0.007
1998			
Optometry	0.24	0.09 – 0.59	0.002
HDL-c	0.43	0.012 – 0.15	<0.0001
Retinal Ph	3.45	0.62 – 19.0	0.15
1999			
Optometry	0.20	0.08 – 0.50	<0.0001
HbA1c	0.58	0.39 – 0.85	0.005
HDL-c	0.002	0.000 – 0.06	<0.0001
Retinal Ph	15.0	2.05 – 109.3	0.008
Microalbumin	5.4	2.7 – 10.9	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 = 1111.1, 29 df, p <0.0001.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 5.10: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Victoria

YEAR Risk factor	OR	95% CI	P
Gender*	0.54	0.34 – 0.88	0.01
Dx before 2000[Γ]	0.10	0.05 - 0.19	<0.0001
1993			
GP	0.98	0.93 – 1.02	0.28
S&CP[‡]	0.97	0.90 – 1.04	0.39
Optometry	0.39	0.18 – 0.82	0.01
HDL-c[†]	0.48	0.05 – 4.13	0.50
Retinal Ph[§]	0.63	0.08 – 4.81	0.65
1994			
S&CP	0.90	0.83 – 0.98	0.02
Optometry	0.11	0.04 – 0.30	<0.0001
HDL-c	0.02	0.002 – 0.18	0.001
Retinal Ph	5.7	0.32 – 99.2	0.23
1995			
GP	0.96	0.92 – 1.01	0.14
S&CP	1.005	0.93 – 1.09	0.91
Optometry	0.18	0.07 – 0.45	<0.0001
HbA1c[±]	0.99	0.69 – 1.43	0.97
HDL-c	0.03	0.003 – 0.29	0.002
Retinal Ph	3.2	0.56 – 18.0	0.19
1996			
S&CP	0.93	0.84 – 1.02	0.14
Optometry	0.45	0.26 – 0.77	0.004
HDL-c	0.17	0.04 – 0.72	0.02
Retinal Ph	0.97	0.06 – 14.4	0.98
1997			
GP	0.96	0.93 – 0.99	0.02
Optometry	0.15	0.06 – 0.39	<0.0001
HDL-c	0.02	0.002 – 0.26	0.003
Retinal Ph	10.5	1.4 – 78.2	0.02
1998			
Optometry	0.17	0.07 – 0.37	<0.0001
HbA1c	1.5	1.07 – 2.01	0.02
HDL-c	0.004	0.000 – 0.21	0.006
Retinal Ph	19.1	2.1 – 171.2	0.008
1999			
Optometry	0.16	0.07 – 0.38	<0.0001
HDL-c	0.04	0.007 – 0.19	<0.0001
Retinal Ph	19.7	3.58 – 108.6	0.001
Microalbumin	2.5	1.50 – 4.30	0.001

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall χ^2 = 744.9, 33 df, p <0.0001.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 5.11: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Queensland

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.10	0.04 – 0.29	<0.0001
1993			
GP	0.91	0.84 – 0.97	0.007
S&CP[‡]	0.83	0.65 – 1.06	0.14
Optometry	0.14	0.06 – 0.35	<0.0001
1994			
S&CP	0.84	0.73 – 0.97	0.02
Optometry	0.06	0.01 – 0.34	0.001
HbA1c[±]	0.71	0.37 – 1.40	0.32
1995			
Optometry	0.13	0.05 – 0.36	<0.001
HbA1c	1.70	0.73 – 3.83	0.22
HDL-c[†]	0.001	0.000 – 0.13	0.006
1996			
Optometry	1.01	0.54 – 1.89	0.98
HDL-c	0.04	0.002 – 0.78	0.04
1997			
Optometry	0.96	0.44 – 2.12	0.92
HDL-c	0.29	0.01 – 5.60	0.29
Retinal Ph	156.7	0.001 – 41303808	0.43
1998			
GP	1.03	0.98 – 1.08	0.23
Optometry	0.37	0.12 – 1.15	0.09
HbA1c	0.29	0.14 – 0.64	0.002
HDL-c	0.016	0.000 – 4.29	0.15
1999			
Optometry	0.06	0.01 – 0.26	<0.0001
HbA1c	0.49	0.26 – 0.94	0.03
HDL-c	0.05	0.003 – 0.76	0.03
Retinal Ph	449.4	6.23 – 32438.0	0.005
Microalbumin	4.9	1.26 – 18.8	0.02

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 479.6$, 24 df, $p < 0.0001$.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 5.12: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Western Australia

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.13	0.04 – 0.43	0.001
1993			
GP	0.92	0.86 – 0.98	0.01
Optometry	0.11	0.007 – 1.80	0.12
1994			
S&CP	0.98	0.86 – 1.12	0.78
Optometry	0.03	0.003 – 0.35	0.005
HbA1c[±]	0.25	0.10 – 0.64	0.004
1995			
Optometry	0.10	0.000 – 0.31	0.008
1996			
Optometry	0.009	0.000 – 0.54	0.02
HDL-c[†]	0.001	0.000 – 3.6[17]	0.77
1997			
Optometry	0.11	0.02 – 0.52	0.005
HDL-c	0.000	0.000 – 3.01[14]	0.72
1998			
Optometry	0.03	0.002 – 0.37	0.007
1999			
Optometry	0.08	0.01 – 0.56	0.01
HDL-c	0.02	0.001 – 0.36	0.008
Microalbumin	2.62	0.77 – 8.90	0.12

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 330.1$, 15 df, $p < 0.0001$.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 5.13: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, South Australia

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.13	0.056 – 0.34	<0.0001
1993			
GP	0.94	0.88 – 0.10	0.05
S&CP[‡]	0.81	0.69 – 0.96	0.02
Optometry	0.24	0.04 – 1.37	0.11
1994			
S&CP	0.98	0.79 – 1.21	0.84
Optometry	0.03	0.003 – 0.34	0.004
1995			
GP	0.99	0.93 – 1.06	0.87
Optometry	0.14	0.03 – 0.76	0.02
1996			
Optometry	0.45	0.003 – 0.66	0.02
HbA1c[±]	0.88	0.43 – 1.8	0.73
HDL-c[†]	0.07	0.007 – 0.76	0.03
1997			
Optometry	0.06	0.008 – 0.48	0.008
HbA1c	0.61	0.31 – 1.20	0.15
1998			
Optometry	0.10	0.02 – 0.49	0.004
1999			
Optometry	0.19	0.03 – 1.13	0.07
HDL-c	0.06	0.008 – 0.48	0.008

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 = 295.9, 16 df, p <0.0001.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 5.14: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Tasmania

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.32	0.04 – 2.44	0.27
1993			
HbA1c[±]	0.56	0.06 – 5.52	0.62
1994			
S&CP	0.39	0.10 – 1.60	0.19
Optometry	0.24	0.005 – 12.9	0.48
1995			
Optometry	0.02	0.000 – 0.94	0.05
1996			
GP	0.73	0.57 – 0.93	0.01
Optometry	0.000	0.000 – 9.83[10]	0.59
1997			
Optometry	0.000	0.000 – 3.52[8]	0.38
1998			
GP	1.06	0.98 – 1.15	0.11
Optometry	0.05	0.001 – 3.90	0.18
1999			
Optometry	0.02	0.001 – 0.76	0.03
HDL-c[†]	0.04	0.001 – 2.53	0.13

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall χ^2 = 82.7, 12 df, p <0.0001.
±Haemoglobin A1c tests
† HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Northern Territory

Table 5.15: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Northern Territory

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.11	0.017 – 0.77	0.02
1993			
GP	0.40	0.02 – 0.80	0.009
1995			
Optometry	0.001	0.000 – 2.22	0.08
1996			
Optometry	0.09	0.005 – 1.71	0.11
1998			
GP	1.30	1.02 – 1.60	0.03
HbA1c[±]	0.03	0.001 – 0.65	0.03

Reference group = controls, *reference group = female,
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 47.05$, 6 df, p <0.0001.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Australian Capital Territory

Table 5.16: Conditional logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999, Australian Capital Territory

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.15	0.03 – 0.88	0.03
1993			
S&CP[‡]	0.76	0.46 – 1.3	0.30
1995			
S&CP	0.34	0.13 – 0.88	0.03
1999			
GP	1.15	0.99 – 1.33	0.06
HbA1c[±]	0.19	0.04 – 0.88	0.03
Microalbumin	100.2	1.43 – 7025.2	0.03

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 26.9$, 6 df, p <0.0001.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Discussion

The study found significant differences between cases and controls with regard to the timing of diagnosis and the patterns of care which were consistent across all states and territories in Australia. This suggests that similar factors were involved in the development of diabetes complications in all jurisdictions. This is despite the likelihood that patients had obtained some of their care in state and territory health care systems, which may have different methods of managing diabetes.[286]

Whilst there were a number of significant differences between states and territories in the timing of diagnosis, the proportion and frequency of attendances, and HbA1c testing, the analysis showed that these were difficult to relate to the risk of vision-threatening retinopathy. In states where specialists and consultant physicians played a greater role in patients' care, such as New South Wales, this was also reflected in higher levels of GP utilisation. Where specialists played a lesser role, this was evident in the workload of GPs. This suggests that the greater utilisation of one type of medical practitioner tends to increase the use of others. Thus states that are well off in terms of their medical workforce tended to result in higher levels of health care utilisation.[286] Similarly, in poorly-off jurisdictions such as the Northern Territory, the smaller workforce appears to limit the utilisation of all practitioners.[286] This suggests that some aspects of diabetes care may be driven by the requirements of practitioners,[259] rather than the health needs of patients, as higher levels of utilisation did not necessarily lead to better health outcomes.

The logistic regression analysis shown in Table 5.8 indicated that patients in Victoria and Queensland had a higher risk of developing diabetes complications than those in other jurisdictions. However, these findings are hard to reconcile with the other findings that patients in these states had average or above average levels of health care utilisation. In addition, they do not accord with the general finding that higher levels of health care utilisation reduce the risk of diabetes complications.

This discrepancy between the univariate and multivariate analyses suggests that there may be some other factors operating in Victoria and Queensland that increased the risk of diabetes complications. This may relate to the use of a medical procedure as an indicator of a disease outcome, as is the case in this study. It could be that in Victoria and Queensland the risk of vision-threatening retinopathy was not elevated but that patients had better access to laser therapy and that this resulted in an apparent greater risk of complications identified by the logistic regression analysis in Table 5.8.

In the logistic regression analyses in Tables 5.9 to 5.16, risk factors for the development of vision-threatening retinopathy were found to be similar for individual states and territories to those found in the national model in Table 4.5. These risk factors included delayed diagnosis, and lower levels of optometry attendances, of HDL-cholesterol testing, and of specialist and consultant physician attendances (in some states and territories), but higher levels of retinal photography and microalbumin testing. Whilst there were some minor differences in risk factors between jurisdictions, for example, a greater risk

associated with gender in Victoria, on the whole the risk factors for laser therapy appear to be very similar across states and territories. This suggests that the care provided for diabetes is broadly similar in each state and territory, and that the quality of diabetes management is primarily determined at the national level. Thus nationally driven systems such as Medicare appear to have a much greater impact on diabetes outcomes than do state-based systems of tertiary or other care.

In addition to findings in relation to patterns of care, there were some important findings with regard to the risk groups emerging in different jurisdictions. Perhaps most significant was the younger age of people with diabetes in the Northern Territory captured in Table 5.1.[351] This may reflect the high prevalence of diabetes in the indigenous population in Australia, as the Northern Territory contains the largest proportion of indigenous people in Australia, who are not only younger on average than other Australians, but who also are at a significantly greater risk of developing diabetes and complications.[30] In addition, Table 5.6 shows that people with diabetes in the Northern Territory were at higher risk of developing complications, which would be consistent with the often more severe manifestations of diabetes that is found in the Aboriginal population.[30]

Whilst the study shows that poor quality care leads to the development of complications, it also suggests that the quality of care may have improved over the study period. This is evident in the trends in specialist and consultant physician attendances, HbA1c testing and the frequency of GP attendances. The

broad uniformity of increased frequency across all states and territories suggests that improvements in the quality of care were driven by something at the national level.

Some of the national changes that occurred during the study period included the introduction of Clinical Practice Guidelines for the Management and Prevention of Diabetic Retinopathy,[200] as well as Clinical Management Guidelines for Diabetes in Adults that were developed in New South Wales [74] In addition, diabetes became a National Health Priority in 1996, which increased the profile of the condition within the national health care system.[1] These initiatives may have contributed to the improvements in the quality of care that were observed uniformly across states and territories.

In summary, the findings suggest that the factors that determine the risk of diabetes complications were similar for individual states and territories, and that local factors were not important in defining diabetes management. The study also showed that primary and secondary care is more important in determining diabetes outcomes than hospital care. This implies that the key to reducing complications lies in changes to the primary and secondary care, for example through Medicare, rather than through the introduction or extension of state or territory-based diabetes programs.

Chapter 6

Across a national population, what is the most effective strategy for preventing diabetes complication: early diagnosis or improved diabetes management?

Abstract

OBJECTIVES: In the previous studies (Chapters 4 and 5), it was found that the development of diabetes complications was associated with low levels of health care utilisation, HbA1c and HDL-c testing over a seven-year period. However, it was also found that patients who developed vision-threatening retinopathy had been diagnosed with diabetes later than those who remained free of this condition. These studies, however, could not determine whether the pattern of care, or delayed diagnosis, was the stronger predictor of diabetes complications. As this issue has significant implications for understanding how complications develop, the study sought to identify which of these risk factors had the stronger association with diabetes complications.

METHODS: Diabetes patients (n = 665) who were diagnosed with diabetes seven or more years prior to receiving laser photocoagulation therapy in 2000 were compared to a random sample of diabetes patients, diagnosed in these same years, who had never received this treatment (n=1297). Patterns of health care utilisation were compared over a period of seven years.

RESULTS: Controls were slightly older than cases (cases = 61.5 years (sd = 13.0) and controls = 62.8 years (sd = 13.7), $P<0.05$). There was a greater proportion of men in both case and control groups (cases = 51.7% and controls = 52.5%, P=ns). There were significant differences in health care utilisation between cases and controls. With regard to GP utilisation: in 1993, 84.5% of cases attended, compared to 97.5% of controls, $P<0.0001$. In 1999, 89.4% of cases attended, compared to 97.6% of controls, $P<0.0001$. For medical specialist attendances: 34.6% of cases attended in 1993, compared to 60.3% of controls, $P<0.0001$. In 1999, 39.8% of cases attended, compared to 63.2% of controls, $P<0.0001$. For HbA1c testing: in 1993, 51.9% of cases were tested, which compared to 60.8% of controls, $P<0.0001$. In 1999, 29.6% of cases were tested, which compared to 52.6% of controls, $P<0.0001$. Similar differences were found in other years and in respect of other risk factors. Annual trends showed that cases were more likely to utilise health services as they approached their first episode of laser therapy, although their levels of utilisation at no time reached that of controls. In a logistic regression model, the strongest predictors of vision-threatening retinopathy were optometry attendances, HDL-cholesterol testing and retinal photography (which was higher in cases), over a seven-year period.

CONCLUSIONS: We found that lower levels of diabetes management related health care utilisation was a stronger predictor of vision-threatening retinopathy than delayed diagnosis. Whilst timely diagnosis is important, the study highlights the provision of adequate medical management as more significant for the prevention of complications across a national population.

Introduction

In Chapters 4 and 5 it was found that patients who developed vision-threatening retinopathy had significantly lower levels of general practice and specialist and consultant physician attendances, as well as of HbA1c and HDL-cholesterol testing than the controls, and that these patterns of care may have been related to the development of complications. However, the preceding studies also found that patients who developed complications may have been diagnosed with diabetes later than those who were unaffected, as evidenced by their earliest HbA1c test (see Table 4.5), which may in itself have led to the development of complications.[12] Thus, it was not possible to determine whether complications were associated with the pattern of care or with delayed diagnosis. This combination of risk factors was evident in Australia (Chapter 4), as well as in all states and territories (Chapter 5).

Patterns of care and delayed diagnosis suggest different pathways leading to the development of complications. On the one hand, patterns of care could be indicative of poor diabetes management, which may lead to a lack of control over hyperglycaemia or hypertension, thus increasing the risk of complications.[3, 5] On the other hand, delayed diagnosis may mean that patients being deprived of appropriate care may also lead to the development of complications.[12] In addition, whilst both of these risk factors might lead to the same outcome, they imply very different strategies for the prevention of complications.[74, 326]

In the two previous chapters the patterns of care could not be examined independently of delayed diagnosis because both early and later diagnosed patients had been included in the studies. In this study, however, these risk factors were examined independently. The study tested the third research question: whether patterns of care or early diagnosis is the greater risk factor for the development of diabetes complications in the population with diabetes in Australia. This was achieved by controlling for the timing of diagnosis by including only early-diagnosed patients. The subjects were a group who had evidence of having a diagnosis of diabetes in 1993, 1994 or earlier, as indicated by an HbA1c test in either or both of these years.

Methods

The research question of whether low levels of diabetes management-related health care utilisation is a greater predictor of diabetes complications than delayed diagnosis was tested using a population-based case-control study,[331] which compared the demographic characteristics and patterns of care for case and control groups. Subjects were selected based on having their earliest HbA1c test in 1993 or 1994. From this group, cases were assembled from subjects who had a record of receiving laser photocoagulation therapy in 2000. In a second step, patients who had received laser therapy prior to 2000 were excluded from the study, which left a group of 665 subjects who received their first laser therapy in that year. This group became the cases. Controls were assembled by the random selection of subjects from the database from which laser therapy patients had been removed. The case and control groups were drawn from the 1993 and 1994 samples shown in Table 4.2.

Following further analysis, it was found that 186 (12.5%) subjects in the control group did not have a Medicare item in 2000, suggesting that they may have died or emigrated during the study. As it would have been impossible to relate their records of health care utilisation to the study outcome, they were excluded from the study (see Chapter 3 for a discussion on the implications of this exclusion). This left a sample of 665 cases and 1297 controls in the study.

In the univariate analyses which compared cases to controls, proportions were compared using χ^2 tests, and frequencies by independent samples t-tests. For each

risk factor, and within cases and controls, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analysis was conducted using logistic regression, which used a stepwise process with backwards conditional as the variable selection criteria.[342] Socio-economic status was entered as four dummy variables in Table 6.4 (for a broader analysis of socio-economic status see Chapter 8), and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF THE SAMPLE

Table 6.1 shows that cases were aged on average 61.5 years (sd =13.0), compared to 62.8 years (sd = 13.7) for controls. Whilst there was an over-representation of males among study subjects, this occurred in both groups and was consistent with the samples of the studies presented in Chapters 4, 5, 7, 8 and 9, as well as with the gender distribution of diabetes in Australia.[60]

Table 6.1: Characteristics of study subjects

	Cases	Controls	Total, n (%)
Age, mean (sd)	61.5(13.0)	62.8 (13.7)*	
Gender M,n(%)	344 (51.7)	681 (52.5)	1025(52.2)
F, n(%)	321 (48.3)	616 (47.5)	937 (47.8)
Total, n(%)	665	1297	1962

*Difference between ages significant at $p<0.05$

GP ATTENDANCES

Table 6.2 shows that around 85% of cases attended a GP on an annual basis, compared to approximately 100% of controls. The odds ratios for trends show that the proportion of cases that attended a GP increased slightly over the study. This compared with no increase in controls.

With regard to the frequency of attendances, Table 6.3 shows that cases attended between about a half and third as often as controls. Whilst there was a trend of increasing frequency for cases, at no time did their attendance reach that of

controls. These analyses indicate that when compared to controls, fewer cases attended GPs, and they attended on fewer occasions over the seven-year period. Because of the central role GPs play in diabetes care, this may explain the pattern of under-referral and under-testing, as described below.[195]

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES

The proportions of cases who attended specialists and consultant physicians over the study period were between about half and two-thirds that of controls (Table 6.2). In addition, cases attended between 1.9 and 2.7 fewer times per year than controls (Table 6.3). Thus there were major differences in specialist attendances and referrals between those who developed vision-threatening retinopathy and those who remained free of the condition.

OPTOMETRIST ATTENDANCES

The proportion of cases that attended optometrists was between 5% and 10% that of controls, as shown Table 6.2. The frequency of attendances was also significantly lower, with cases attending between 24 and 10.3 fewer times per year than controls (Table 6.3). As the role of optometrists in diabetes management is to screen for diabetic retinopathy, the higher levels of attendance among controls may reflect higher levels of screening.[352]

Table 6.2: Health care utilisation between 1993 and 1999 for cases and controls, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
	GP	562(84.5)***	571(85.9)***	558(83.9)***	564(84.8)***	564(84.8)***	571(85.9)***	594(89.4)***	1.04	0.03
	S&CP‡	230(34.6)***	203(30.6)***	204(30.7)***	224(33.7)***	215(32.3)***	243(36.5)***	265(39.8)***	1.05	0.002
	Optometrist	7(1.1)***	12(1.8)***	15(2.3)***	11(1.7)***	16(2.5)***	14(2.1)***	19(2.9)***	1.12	0.03
	HbA1c$^{±}$	345(51.9)***	458(68.9)**	238(35.8)***	205(30.8)***	199(29.9)***	199(29.9)***	197(29.6)***	0.77	<0.0001
	HDL-c†	9(1.4)***	6(0.9)***	6(0.9)***	4(0.6)***	8(1.2)***	6(0.9)***	4(0.6)***	0.93	0.32
Controls										
	GP	1265(97.5)	1269(97.8)	1259(97.1)	1270(97.9)	1267(97.7)	1267(97.7)	1266(97.6)	1.008	0.81
	S&CP	782(60.3)	833(64.2)	803(61.9)	821(63.3)	799(61.6)	795(61.3)	820(63.2)	1.004	0.71
	Optometrist	267(20.5)	275(21.2)	312(24.1)	284(21.9)	304(23.4)	316(24.4)	330(25.4)	1.04	0.001
	HbA1c	789(60.8)	968(74.6)	664(51.2)	621(47.9)	655(50.5)	675(52.0)	682(52.6)	0.90	<0.0001
	HDL-c	228(17.6)	287(22.1)	259(20.0)	216(16.7)	246 (19.0)	263(20.3)	24.5 (18.9)	0.99	0.89

Differences between cases and controls: $^{ϕ}\chi^2$ = is not significant,* χ^2 = is significant at p=0.05 level,** χ^2 = is significant at p=0.001 level,*** χ^2 = is significant at p<0.0001

$^{±}$Haemoglobin A1c tests, † HDL cholesterol tests, ‡ Specialist and consultant physician attendances

Table 6.3: Health care utilisation between 1993 and 1999 for cases and controls, mean (sd)

					Year					
	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
GP	Case	6.09(11.0)***	6.73(13.0)***	6.54(12.9)***	6.84(13.4)***	7.27(14.1)***	7.37(14.0)***	7.96(13.4)***	0.96	<0.0001
	Control	11.31 (10.8)	11.61 (9.1)	11.42 (9.6)	11.42 (9.9)	12.02 (10.3)	11.99 (10.4)	12.02 (11.2)	0.85	<0.0001
S&CP‡	Case	1.07(2.5)***	1.03 (2.9)***	1.15 (4.3)***	1.01 (2.5)***	1.28 (4.6)***	1.40 (4.7)***	1.32 (3.0)***	0.81	<0.0001
	Control	2.50 (3.9)	2.57 (3.7)	2.71 (4.3)	2.72 (4.4)	2.60 (3.9)	2.63 (3.9)	3.13 (7.0)	0.71	<0.0001
Optometry	Case	0.01 (0.1)***	0.019(0.1)***	0.025(0.2)***	0.016(0.1)***	0.024(0.1)***	0.024(0.2)***	0.034(0.2)***	0.82	<0.0001
	Control	0.24 (0.5)	0.25 (0.5)	0.29 (0.6)	0.27 (0.6)	0.29 (0.6)	0.31 (0.6)	0.31 (0.6)	0.92	<0.0001
HbA1c$^{±}$	Case	0.71 (0.8)***	0.90 (0.8)***	0.53 (0.8)***	0.46 (0.8)***	0.47 (0.9)***	0.46 (0.8)***	0.46 (0.8)***	-0.76	<0.0001
	Control	0.89(0.9)	1.14 (0.9)	0.86 (1.0)	0.84 (1.1)	0.88 (1.1)	0.89 (1.0)	0.95 (1.1)	-0.23	<0.0001
HDL-c†	Case	0.015(0.1)***	0.013(0.2)***	0.009(0.09)***	0.006(0.08)***	0.013(0.1)***	0.009(0.09)***	0.006(0.08)***	-0.67	<0.0001
	Control	0.22 (0.5)	0.28 (0.6)	0.26 (0.6)	0.21 (0.5)	0.26 (0.56)	0.26 (0.6)	0.25 (0.6)	0.16	<0.0001

Differences between cases and controls: $^{\phi}$ t-test is not significant, * t-test is significant at p=0.05 level, ** t-test is significant at p=0.001 level, *** t-test is significant at p<0.0001.
$^{±}$Haemoglobin A1c tests, † HDL cholesterol tests, ‡ Specialist and consultant physician attendances.

HbA1C TESTS

In addition, the proportion of cases tested for HbA1c was significantly lower than that of controls in all years, with this difference being particularly marked after 1994 (Table 6.2). The frequency of tests among cases was also lower, with cases receiving on average between 1.2 and 2.0 fewer tests per year than controls. As was noted in the literature review, HbA1c is an important indicator of metabolic control and low levels of testing may have significant implications for the management of diabetes.[74]

HDL – CHOLESTEROL TESTS

Table 6.2 shows dramatic differences in HDL-cholesterol testing between cases and controls. During the study, less than 1.5% of cases were tested in any year, as compared to at least 16.7% of controls. Whilst the frequency of tests for both groups was not high, it was between 22 and 41.6 times greater among controls (Table 6.3). This may point to an increased risk of diabetes related dyslipidaemia[348] and perhaps also to lower levels of knowledge and skill on the part of the health care providers of cases.[353]

SUBJECT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS

Whether patient characteristics and patterns of health care utilisation predicted laser photocoagulation therapy was tested using a logistic regression model, and

this is captured in Table 6.4. In this analysis, socio-economic status was also entered as an additional risk factor (as four dummy variables).

The model revealed consistent differences between the case and control groups in levels of health care utilisation. The strongest predictors of vision-threatening retinopathy were low HDL-cholesterol testing and low optometry attendances. However, socio-economic status was eliminated in the regression procedure. That patterns of care retained their predictive power suggests that the quality of diabetes management following the diagnosis of diabetes is a stronger risk factor for the development of complications than delayed diagnosis.

Table 6.4: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999

Risk factor	OR	95%CI	P
Age	1.01	1.001 – 1.02	0.03
1993			
GP	0.96	0.93 – 0.98	0.001
S&CP[‡]	0.96	0.90 – 1.02	0.16
Optometry	0.12	0.05 – 0.30	<0.0001
HDL-c[†]	0.24	0.11 – 0.52	<0.0001
1994			
S&CP	0.90	0.85 – 0.96	0.001
Optometry	0.14	0.06 – 0.30	<0.0001
HbA1c[±]	1.008	0.83 – 1.22	0.93
HDL-c	0.17	0.08 – 0.37	<0.0001
1995			
Optometry	0.23	0.12 – 0.43	<0.0001
HDL-c	0.10	0.03 – 0.29	<0.0001
Retinal Ph	2.64	0.89 – 7.80	0.08
1996			
S&CP	0.91	0.86 – 0.97	0.003
Optometry	0.20	0.09 – 0.42	<0.0001
HbA1c	0.97	0.79 – 1.2	0.86
HDL-c	0.18	0.06 – 0.55	0.001
Retinal Ph	3.26	0.82 – 12.9	0.09
1997			
Optometry	0.22	0.12 – 0.42	<0.0001
HDL-c	0.29	0.12 – 0.66	0.003
Retinal Ph	5.4	1.5 – 19.9	0.01
1998			
Optometry	0.17	0.09 – 0.31	<0.0001
HbA1c	0.74	0.79 – 1.17	0.07
HDL-c	0.2	0.08 – 0.51	0.001
Retinal Ph	3.3	0.86 – 12.4	0.08
1999			
GP	1.02	0.99 – 1.04	0.06
Optometry	0.28	0.17 – 0.47	<0.0001
HbA1c	0.64	0.52 – 0.79	<0.0001
HDL-c	0.09	0.03 – 0.29	<0.0001
Microalbumin	2.10	1.50 – 2.92	<0.0001
Retinal Ph	9.85	3.5 – 28.2	<0.0001

Reference group is controls, [†]reference group = not tested and [Γ]reference group = not diagnosed.
Model overall χ^2 =1355.1, 30^{df}, p<0.0001.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances

Socio-economic status (SEIFA 1-5) was entered as a risk factor into this model, but was eliminated by the backwards conditional method of variable selection.

Discussion

The study found that patients' patterns of care predicted the development of advanced complications in an early-diagnosed group, suggesting that diabetes management after the diagnosis of diabetes is a stronger predictor of advanced diabetes complications than delayed diagnosis. With regard to public health interventions, the findings thus support the provision of diabetes management in already diagnosed patients,[12] rather than screening for diabetes, as the most effective complications prevention strategy.

The differences between the groups in respect of patterns of care, were similar to those found in Chapters 4 and 5 – although the level of health care utilisation was higher in the current study. This suggests that the diagnosis of diabetes leads to an increase in health care utilisation. However, for some patients this increase is not of a sufficient magnitude for complications to be prevented. This suggests that there is some factor that holds back cases from reaching appropriate levels of health care utilisation.[354]

In an attempt to explain the differences between the case and control group, socio-economic status was entered as a risk factor into the logistic regression model in Table 6.4.[261] The table shows that the stepwise variable selection method eliminated the risk factor from the model, indicating that socio-economic status was not a risk factor for advanced complications in early-diagnosed groups.

Some risk factors that may account for the higher risk among cases but which were not investigated in the study include poorer self-management,[8] less competent practitioners [41, 353] and poorer access to health care,[22] as these factors have all been found to contribute to poor diabetes management.

Another important finding was the decline in the level of HbA1c testing over time. Significantly, this occurred at a time when levels of general practice and specialist attendance were high and increasing. The decline in testing under these conditions is most likely to reflect changes to practitioner, rather than patient behaviour, as pathology testing is largely initiated by the practitioners.[355]

Factors that are known to influence practitioner behaviour in this way include the method and perceived adequacy of payment [356] and time pressure in consultations.[338] However, it is not known whether these factors played a part in the decline in testing that was documented here.

In conclusion, the study showed that poor diabetes management was a stronger predictor of diabetes complications than delayed diagnosis. Whilst timely diagnosis is desirable, it is only beneficial if it initiates appropriate diabetes management over time. Where this did not occur, patients remained at risk of developing advanced diabetes complications such as vision-threatening retinopathy. Thus whilst timely diagnosis is important, the study highlights the provision of adequate medical management over time as more significant for the prevention of complications across the population.[12]

Chapter 7

Does delayed diagnosis increase the risk of complications in Australia?

Abstract

OBJECTIVES: In the previous chapter it was found that the key to preventing diabetes complications was timely diagnosis, followed by appropriate medical management. However, in Chapters 4 and 5, it had been found that over 50% of people who received laser therapy in 2000 might have been diagnosed in that same year. This delayed diagnosis would have disallowed any clinical interventions from effectively preventing vision-threatening retinopathy. This suggested that the pre-diagnosis period had been critical in determining the outcome, and therefore that this period needed to be further explored. In this study, patient characteristics and patterns of health care utilisation during the pre-diagnosis period were examined in order to identify risk factors for vision-threatening retinopathy.

METHODS: Diabetes patients (n = 2538) who were diagnosed with diabetes in 2000 and received laser photocoagulation therapy in that same year were compared to a random sample of diabetes patients, diagnosed in the same year, who had never received this treatment (n=606). Patterns of health care utilisation were compared over a period of seven years.

RESULTS: Cases were slightly older than controls (62.3 years (sd = 14.0) versus 60.7 years (sd = 12.0), P=0.01). There was a greater proportion of men in each group (55.4% of cases and 54.4% of controls, P=ns). There were significant differences in health care utilisation between cases and controls. With regard to GP attendances, in 1993, 65% of cases attended, compared to 91.2% of controls, P<0.0001. In 1999, 82.3% of cases attended, compared to 95.7% of controls, P<0.0001. For specialist attendances, in 1993, 18.3% of cases attended, compared to 42.5% of controls, P<0.0001. In 1999, 32.4% of cases attended, compared to 50.7% of controls, P<0.0001. For optometrist attendances, in 1993, 1.7% of cases attended, compared to 21.2% of controls, P<0.0001. In 1999, 2.9% of cases attended, compared to 26.4% of controls, P<0.0001. Similar differences were found in other years. Annual trends showed that cases were more likely to utilise health services as they approached their first episode of laser therapy, although their levels of utilisation at no time reached that of controls. In a logistic regression model, the strongest predictors of the development of vision-threatening retinopathy were low socio-economic status, optometry attendances and specialist attendances over seven years.

CONCLUSIONS: The findings point to a need for early diagnosis in people at high-risk of developing diabetes complications. This would best be facilitated by active case finding with a focus on low socio-economic groups. In addition, following diagnosis, appropriate diabetes management needs to be established so that prevention of complications can be optimised.

Introduction

Having established that patterns of care are very important risk factors for diabetes complications in Chapter 4, that this relationship existed at the national level, as well as in all states and territories in Chapter 5, and that early diagnosis, coupled with appropriate diabetes management was the key to preventing diabetes complications in Chapter 6, the relationship between patterns of care prior to the diagnosis of diabetes and the development of vision-threatening retinopathy is investigated in this fourth study in the thesis.

Diabetes complications, including vision-threatening retinopathy, have been shown to take many years to develop,[35] and during much of this time patients are often unaware that they are suffering from diabetes or have hyperglycaemia.[35] During the pre-diagnosis period, people with diabetes do not attend practitioners for diabetes care, they do not have access to hypoglycaemic medications; nor do they practise diabetes self-management. In hyperglycaemic patients these circumstances may lead to poor metabolic control and the accelerated development of diabetes complications.[12] Therefore, understanding the risk factors that exist in the pre-diagnosis period is very important for understanding the development of complications. Therefore the fifth research question was posed: whether later diagnosis of diabetes is a risk factor for the development of diabetes complications in the population with diabetes in Australia.

Methods

To investigate whether patterns of care prior to diagnosis determine the risk of diabetes complications, a population-based case-control study was used.[331] The study examined whether patient demographic characteristics, GP, specialist and optometry attendances, were risk factors for diabetes complications by comparing these factors in cases to controls.

Subjects were selected on the basis of having received an earliest HbA1c test in 2000. From this group, cases were assembled from subjects who had a record of laser photocoagulation therapy in that same year. In a second step, patients who had received laser therapy prior to 2000 were excluded, which left a group of subjects who had been diagnosed with diabetes and received their first laser in the same year. This group became the cases. Controls were assembled by the random selection of subjects from the database from which the laser therapy patients had been removed. This group was comprised of people with diabetes who had been diagnosed with diabetes in 2000, but who had never received laser therapy. 2538 cases and 606 controls were included in the study, representing the 2000 sample in Table 4.2.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. For each risk factor, and within cases and controls, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analysis was conducted using logistic regression, which used a

stepwise procedure with backwards conditional as the variable selection criteria.[342] Socio-economic status was entered as four dummy variables, as shown in Table 7.4 (for a broader analysis of socio-economic status see Chapter 8), and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF THE SAMPLE

Cases were aged 62.3 years (sd = 14.0) on average, compared to 60.7 years (sd = 12.0) for controls. Whilst there was an over-representation of males in the study, this was the same in both groups, is similar to the findings in the studies detailed in Chapters 4, 5 and 6, and reflects the gender distribution of diabetes in Australia.[60] The age and gender characteristics of the subjects are presented in Table 7.1.

Table 7.1: Characteristics of study subjects

		Cases	Controls	Total(n (%))
Age, mean (sd)		62.3 (14.0)	60.7(12.0)*	
Gender n(%)	M	1406 (55.4)	328(54.4)	1734 (55.2)
n(%)	F	1132 (44.6)	278(45.8)	1410(44.8)
Total		2538	606	3144

*Difference between ages significant: p=0.01

GP ATTENDANCES

Table 7.2 indicates that over 65% of cases attended a GP annually, with the proportion that attended increasing over the study period. By contrast, over 90% of controls attended in any year. Whilst case and controls attended GPs regularly, controls had higher frequencies of attendances, from almost twice as many visits in 1993 to 1.5 times more in 1999 (Table 7.3).

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES

Table 7.2 indicates that between 18.3% and 32% of cases attended specialists and consultant physicians per year during the study, compared to between 42.5% and 50.7% of controls. In addition, cases attended specialists and consultant physicians on one-third to two-thirds fewer occasions each year than controls, as shown in Table 7.3.

OPTOMETRIST ATTENDANCES

For optometrist attendances, Table 7.2 shows that between 1.7% and 2.9% of cases attended optometrists each year during the study. This compared to between 21.2% and 26.4% of controls. Table 7.3 shows that the frequency of attendances reflects these differences in proportions, as cases attended between 12.3 and 12.5 fewer times per year than controls.

Table 7.2: Health care utilisation between 1993 and 1999 for cases and controls, n(%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
	GP	1699(65)***	1727(68)***	1797(70.8)***	1832(72.2)***	1876(73.4)***	960(77.2)***	2088(82.3)***	1.13	<0.0001
	S&CP‡	464(18.3)***	512(20.2)***	537(21.2)***	511(20.1)***	576(22.7)***	694(25.4)***	822(32.4)***	1.12	<0.0001
	Optometrist	44 (1.7)***	39 (1.5)***	46(1.8)***	54(2.1)***	66(2.6)***	64(2.5)***	74(2.9)***	1.11	<0.0001
Controls										
	GP	553 (91.2)	560 (92.4)	551 (90.9)	560(92.4)	560(92.4)	582(96.0)	580(95.7)	1.13	<0.0001
	S&CP	258 (42.5)	265 (43.6)	256 (42.5)	280(46.3)	280(46.3)	289(47.9)	306(50.7)	1.05	0.001
	Optometrist	128 (21.2)	146 (24.2)	151(25.0)	161(26.7)	158(26.2)	188(31.2)	160(26.4)	1.06	0.001

Differences between cases and controls: $^{ϕ}\chi^2$ = is not significant,* χ^2 = is significant at p=0.05 level,** χ^2 = is significant at p=0.001 level,*** χ^2 = is significant at p<0.0001
.‡ Specialist and consultant physician attendance

Table 7.3: Health care utilisation between 1993 and 1999 for cases and controls, mean (sd)

					Year					
	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
GP	Case	3.9(6.2)***	4.2(6.4)***	4.6(6.8)***	5.0(7.5)***	5.3(7.5)***	5.7(7.7)***	6.3(8.0)***	0.99	<0.0001
	Control	7.7(8.2)	7.6(7.4)	8.0(8.1)	8.1(7.6)	8.4(8.3)	9.0(8.9)	9.5 (8.7)	0.86	<0.0001
S&CP‡	Case	0.5(1.9)***	0.6(2.1)***	0.6(2.8)***	0.6(2.5)***	0.7(2.4)***	0.9(4.0)***	1.2(6.2)***	0.89	<0.0001
	Control	1.5(3.1)	1.4(2.9)	1.5(4.1)	1.8(3.9)	1.7(3.1)	1.8(3.4)	1.9 (3.6)	0.89	<0.0001
Optometrist	Case	0.02(0.2)***	0.01(0.1)***	0.03(0.2)***	0.02(0.2)***	0.03(0.2)***	0.03(0.2)***	0.03(0.2)***	0.67	<0.0001
	Control	0.2(0.5)	0.3(0.5)	0.3(0.5)	0.3(0.5)	0.3(0.6)	0.4(0.6)	0.3 (0.6)	0.67	<0.0001

Differences between cases and controls: ^{ϕ}t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001
.‡ Specialist and consultant physician attendance

SUBJECT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS

Whether patient characteristics and patterns of health care utilisation predicted laser photocoagulation therapy was tested using a logistic regression model and was captured in Table 7.4. In this analysis, socio-economic status was also entered as an additional risk factor into the model (as four dummy variables).

The model showed consistent differences between the case and control groups in levels of health care utilisation. The strongest predictors of vision-threatening retinopathy were socio-economic status, low GP, and low specialists and optometry attendances. The model suggests that the late diagnosed group were socio-economically disadvantaged and that this may have led to lower levels of health care utilisation and the higher risk of diabetes complications.

Table 7.4: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999

Risk factor	OR	95%CI	p
SEIFA 5 high (ref)	1.0		
SEIFA 4	1.34	0.92 – 1.96	0.12
SEIFA 3	1.13	0.78 – 1.62	0.51
SEIFA 2	1.43	0.98 – 2.01	0.06
SEIFA 1	1.89	1.29 – 2.80	0.001
Age	1.03	1.02 – 1.04	<0.0001
1993			
GP	0.96	0.94 – 0.97	<0.0001
S&CP‡	0.91	0.87 – 0.96	0.001
Optometry	0.36	0.24 – 0.55	<0.0001
1994			
S&CP	0.97	0.93 – 1.03	0.33
Optometry	0.10	0.06 – 0.16	<0.0001
1995			
Optometry	0.18	0.12 – 0.27	<0.0001
1996			
S&CP	0.95	0.91 – 0.99	0.02
Optometrist	0.33	0.22 – 0.48	<0.0001
1997			
S&CP	0.95	0.91 – 0.99	0.009
Optometry	0.29	0.20 – 0.41	<0.0001
1998			
GP	0.99	0.97 – 1.003	0.10
Optometry	0.14	0.10 – 0.20	<0.0001
1999			
Optometrist	0.29	0.21 – 0.42	<0.0001

Reference group is controls.
Model overall χ^2 =1227.09, 18^{df}, p<0.0001.
‡ Specialist and consultant physician attendances

Discussion

The findings indicate that the patterns of care predicted the development of complications in this late diagnosed group. This suggests that health care utilisation prior to the diagnosis of diabetes may have determined the development of advanced diabetes complications.

The difference between the groups with regard to health care utilisation was similar to that found in Chapter 6. This suggests that similar factors may have been involved in determining health care utilisation in both early and late diagnosed groups.[354] This points to the level of health care utilisation being a somewhat stable characteristic among people with diabetes.

In an attempt to explain differences between case and control groups, the logistic regression model revealed that low socio-economic status was a risk factor for the development of advanced diabetes complications. This finding contrasts with the study in Chapter 6, where socio-economic status was found not to pose a risk.

When the two studies are considered together, they suggest that there is a higher risk of advanced complications among low socio-economic groups when patients have not been diagnosed. However, and perhaps surprisingly, once diagnosis has occurred, the risk of complications in low socio-economic groups becomes equal to the rest of the population. This suggests that the way in which diabetes management was conducted in Australia during the 1990s was able to address a major inequality in diabetes.

With regard to the health policy implications of these findings, the greater occurrence of delayed diagnosis in low socio-economic groups, and the higher risk of advanced diabetes complications associated with this delay suggests a need to improve the timing of diagnosis in socio-economically disadvantaged populations.[357] However, the lack of significance of socio-economic status in Chapter 6 points to the need for diabetes management interventions to be targeted at the whole population.

When the course of a condition can be significantly altered by early diagnosis, population screening is often proposed as an appropriate prevention intervention.[358] However, for population screening to be effective, very particular conditions are required that are rarely met by diseases [358] (including diabetes).[357]

Perhaps a more appropriate prevention strategy is proactive case finding.[359] This involves doctors actively seeking out diabetes in their patients.[360] Whilst this strategy may miss cases that rarely attend doctors, this is unlikely to occur in this population. Cases were found to have attended GPs on an average five times per year, which should allow plenty of opportunity for the diagnosis of diabetes. Given that cases were such regular attendees at GPs, it would be difficult to justify population screening, as this would be unlikely to identify many people with diabetes who would not have otherwise have been diagnosed in a routine GP attendance.[357] It is more likely that encouraging doctors to be more proactive in identifying diabetes would be the most effective strategy for achieving early diagnosis in this population.

An alternative to clinical interventions to reduce the risk of complications might involve establishing health promotion programs focusing on risk factors for diabetes complications in the non-diagnosed population. However, this would require targeting the whole population with prevention complication programs.[361] Whilst this may appear to be potentially wasteful and ineffective, it could potentially only entail the extension of current programs that target smoking and other cardiovascular risk factors, as they also benefit those with diabetes.[362]

In conclusion, the study suggests that most people who develop diabetes complications are disadvantaged with regard to health care utilisation and that this pre-dates the diagnosis of diabetes. This points to the need for early diagnosis in this population, which would best be facilitated by active case finding with a focus on low socio-economic groups. Yet, even if early diagnosis is established this population still needs to receive appropriate diabetes management over time if prevention of complications is to be optimised.

Chapter 8

Does socio-economic status determine the risk of complications in people with diabetes?

Abstract

OBJECTIVES: In Chapter 7, socio-economic status was identified as a risk factor for diabetes complications in those at imminent risk of vision-threatening retinopathy. However, it was found not to be a risk factor once diabetes management had been established (Chapter 6). Whilst the significance of socio-economic status has been established in the populations included in these studies, it is not known whether socio-economic status is a risk factor for diabetes complications in the broader diabetes population. The study sought to examine this question.

METHODS: 4632 diabetes patients who had received their first laser photocoagulation treatment in 2000 were compared to a random sample of diabetes patients who had never received this treatment (n = 4632). Patterns of health care utilisation were compared within and between socio-economic groups over a seven-year period (1993-1999) using the Australian Medicare database.

RESULTS: Similar differences between cases and controls to those found in Chapter 4 were evident in all socio-economic groups. There was a greater proportion of cases in lower socio-economic groups. SEIFA 1 (lowest) had 21% of cases, which compared to 18.7% of controls; SEIFA 2 had 20.4% of cases, which compared to 19.5% of controls; SEIFA 3 had 19.9% of cases, which compared to 20.1% of controls; SEIFA 4 had 19.6% of cases, as compared to 20.5% of controls; and SEIFA 5 (highest) had 18.7% of cases, compared to 21.3% of controls. These differences were highly significant (P=0.001). With regard to health care utilisation, for GP attendances, in cases, the highest proportion attended was in SEIFA 1 (7 year average of 79.4%), whilst the lowest was in SEIFA 5 (7 year average of 74.7%), P<0.0001. For controls, the highest proportion attended was in SEIFA 3 (7 year average = 93.8%), whilst the lowest proportion was in SEIFA 5 (7 year average of 91.9%), P<0.0001. For specialist attendances, in cases, the highest proportion of attendances was in SEIFA 5 (7 year average of 32.2%), whilst the lowest was in SEIFA 2 (7 year average of 23.6%), P<0.0001. For controls, the highest proportion of attendances was in SEIFA 5 (7 year average of 55.3%), whilst lowest was in SEIFA 2 (7 year average of 51.6%), P<0.0001. With regard to HbA1c testing, in cases, the highest proportion of testing was in SEIFA 5 (7 year average of 14.2%), whilst the lowest proportion was in SEIFA 1 (7 year average of 11.9%), P<0.0001. For controls, the highest proportion tested was in SEIFA 4 (7 year average = 33.5%), whilst the lowest was in SEIFA 5 (7 year average of 27.3%), P<0.0001. Socio-economic status was tested as a risk factor for vision-threatening retinopathy in a logistic regression model. Although it was found not to be statistically significant, there was evidence of a gradient from low risk in high socio-economic groups to high-risk in low socio-economic groups. The major risk factors for vision-threatening retinopathy were delayed diagnosis, optometry attendances, HDL cholesterol testing and retinal photography (higher in cases), which was similar across all socio-economic groups, P<0.0001 for all models.

CONCLUSIONS: The findings suggest that socio-economically disadvantaged populations may be at higher risk of developing diabetes complications. However, in light of the findings in Chapters 6 and 7, this disadvantage may be confined to late diagnosed groups. This suggests that strategies for early diagnosis should have a focus on disadvantaged populations, but that diabetes management interventions should target the broader diabetes population.

Introduction

Having established in Chapter 4 that patterns of care are significant risk factors for diabetes complications; that this relationship occurs at the national level, as well as in all states and territories in Chapter 5; that early diagnosis, coupled with appropriate diabetes management is the key to preventing diabetes complications in Chapter 6; and that patterns of care prior to the diagnosis of diabetes are important predictors of complications in Chapter 7; this study investigates whether socio-economic status determines the risk of diabetes complications.

In Chapter 7, socio-economic status was identified as a risk factor for diabetes complications in late diagnosed patients, concurring with the international and Australian epidemiological evidence cited in the literature review. This literature showed that diabetes, complications, risk factors and health care utilisation were all determined, at least partially, by socio-economic status.[22, 262, 268, 269] In Chapter 6, however, socio-economic status was found not to be a risk factor for diabetes complications, which suggested that once diagnosis had occurred diabetes management was unaffected by socio-economic status. However, neither of these investigations was able to examine the role of socio-economic status across the entire population, and thus could not clarify whether early diagnosis or diabetes management interventions needed to be targeted at particular groups, or whether they would be better provided across the population for the greatest proportion of diabetes complications to be prevented. Hence the fifth research question of the thesis was tested: whether socio-economic status is

a risk factor for diabetes complications in the population with diabetes in Australia.

Methods

To investigate the relationship between socio-economic status and diabetes complications, a population-based case-control study similar to those in Chapters 4 and 5 was used.[331] The study examined patient demographic characteristics, the utilisation of primary and secondary care and of diabetes related pathology tests, and the risk of complications between cases and controls across socio-economic groups.

In this study, cases comprised a national sample of 4632 patients who had received their first laser photocoagulation therapy in 2000, and controls were a random sample of 4632 people with diabetes who had not received this treatment (the total sample in Table 4.2). Controls were matched to cases on age (within one year) in 2000 and state of residence at the time of their earliest HbA1c test.

The measure of socio-economic status used was the Socio-Economic Index For Areas Index of Disadvantage (SEIFA),[260] which is a measure of socio-economic status based on the aggregate of indicators of material resources that characterise localities (see Chapter 3 for a full description). In this study the Index is ascribed to an individual on the basis of their residential post-code.

In the univariate analyses, which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. When risk factors were compared between socio-economic groups, for proportions, χ^2 tests for trend were used, and analysis of variance for frequencies (the Bonferroni

adjustment was used to account for type 2 error).[342] For each risk factor, and within cases and controls in each socio-economic group, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analyses were conducted using conditional logistic regression, which could take into account the paired study design (Tables 8.8 to 8.13).[342] The regression analyses used a stepwise process with backwards conditional as the variable selection criteria (Tables 8.8 to 8.13). Socio-economic status was entered as four dummy variables in Table 8.8, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF THE SAMPLE

Cases comprised 4632 patients who had received their first laser photocoagulation therapy in 2000 and there was the same number of controls (see Table 8.1). The average age ranged from 62.1 years (sd = 12.9) to 62.5 years (sd = 13.8), which was similar across all five socio-economic groups (p = ns). There was a greater proportion of males in all socio-economic groups, although this distribution was the same for both cases and controls.

Most notably, Table 8.1 shows that there was a greater proportion of cases in lower socio-economic groups than controls. Similarly, the proportion of controls was greater in higher status groups, which suggests that at this crude level, there was a relationship between socio-economic status and diabetes complications.

With regard to the timing of diagnoses, cases from lower socio-economic groups had later diagnoses than those who were more affluent, which accords with the findings on socio-economic status and delayed diagnosis shown in Table 7.4. There was no evidence of a similar relationship in controls.

Table 8.1: Characteristics of study subjects by SEIFA

		SEIFA 1	SEIFA 2	SEIFA3	SEIFA 4	SEIFA 5	Total
Age*	Mean (sd)	62.8 (12.4)	62.1 (12.9)	62.4 (12.9)	62.3 (13.7)	62.5 (13.8)	62.4 (13.4)
Gender**	Male%	995 (53.7)	1018 (55.0)	970 (52.3)	1022 (55.0)	1022 (55.2)	5027
	Female%	858 (46.3)	831 (45.0)	883 (47.7)	835 (45.0)	830 (44.8)	4237
	Total%	1853	1849	1853	1857	1852	9264
SEIFA by status***	Case n (%)	989 (21.4)	947 (20.4)	923(19.9)	908 (19.6)	865 (18.7)	4632
	Control n (%)	864 (18.7)	902 (19.5)	930 (20.1)	949 (20.5)	987 (21.3)	4632
	Total n (%)	1853 (20.0)	1859 (20.0)	1853 (20.0)	1857 (20.0)	1852 (20.0)	9264
% Dx before 2000****	Cases%	424 (42.9)	424 (44.8)	424 (45.9)	413 (45.5)	409 (47.3)	2094 (45.2)
	Controls%	760 (88.0)	784 (86.9)	800 (86.0)	833 (87.8)	849 (86.0)	4026 (86.9)
	Total	1184	1208	1224	1246	1258	6120

* Age distribution, $F = 0.71^{4,9259\ df}$, $p = 0.58$
** Gender distribution, $\chi^2 = 4.53^{4\ df}$, $p = 0.34$
*** SEIFA Difference between case and control groups, $\chi^2 = 18.5$, ^{4df}, $p = 0.001$
**** Dx before 2000: Cases $\chi^2 = 3.98$, $^{4\ df}$, $p = 0.41$
Controls $\chi^2 = 2.8$, $^{4\ df}$, $p = 0.59$

GP ATTENDANCES

Tables 8.2 and 8.3 show that there were significant differences in the proportions and frequencies of GP attendances between cases and controls, and also between socio-economic groups. Whilst the differences in the proportions of GP attendances for cases and controls were similar to those found in Chapters 4 and 5, there were also major differences when socio-economic groups were compared.

The highest proportions of attendances were among the lowest socio-economic group, and conversely, the lowest proportions of attendances were among the highest socio-economic group (Table 8.2). This accords with a number of studies that have investigated the use of GPs and socio-economic status in Australia which have found that disadvantaged individuals tend to be higher users of GPs.[254] These findings were also reflected in the frequencies in Table 8.3.

Table 8.2: GP attendances between 1993 and 1999 for cases and controls by SEIFA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	SEIFA1(low)	715(72.3)***	752(76.0)***	749(75.7)***	776(78.5)***	805(81.4)***	843(85.3)***	859(86.9)**	1.16	<0.0001
	SEIFA2	665(70.2)***	692(73.1)***	709(74.9)***	736(77.7)***	736(77.7)***	748(79.0)***	665(70.2)***	1.03	0.05
	SEIFA3	636(68.9)***	655(71.0)***	687(74.4)***	690(74.8)***	699(75.7)***	751(81.4)***	812(85.7)***	1.17	<0.0001
	SEIFA4	631(69.5)***	658(72.5)***	693(76.3)***	697(76.8)***	720(79.3)***	738(81.3)***	785(85.0)***	1.16	<0.0001
	SEIFA5	578(66.8)***	611(70.6)***	624(72.1)***	651(75.3)***	662(76.5)***	680(78.6)***	722(83.5)***	1.14	<0.0001
	P of diff	0.14	0.06	0.30	0.28	0.02	0.002	0.30		
Controls										
	SEIFA1(low)	822(95.1)	813(94.1)	812(94.0)	801(92.7)	799(92.5)	792(91.7)	782(90.5)	0.89	<0.0001
	SEIFA2	845(93.7)	850 (94.2)	851(94.3)	838 (92.9)	837 (92.5)	834(92.5)	823(91.2)	0.93	0.006
	SEIFA3	881(94.7)	878(94.4)	884(95.1)	883(94.9)	874 (94.0)	859(92.4)	853(91.7)	0.91	0.001
	SEIFA4	878(92.5)	888 (93.6)	896 (94.4)	903(95.2)	898(94.6)	889(93.7)	872(91.9)	0.99	0.72
	SEIFA5	906(91.8)	914(92.6)	918 (93.0)	922(93.4)	899(91.1)	903(91.5)	887(89.9)	0.95	0.03
	P of diff	0.01	0.98	0.41	0.08	0.02	0.41	0.50		

Differences between groups: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 8.3: GP attendances between 1993 and 1999 for cases and controls by SEIFA, mean (sd)

					Year					
SES	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
SEIFA1	Case	5.38(7.65)***	5.84(7.92)***	5.96(7.70)***	6.50(8.50)***	6.65(7.53)***	7.38(8.80)***	7.90(9.13)***	0.98	<0.0001
	Control	11.39(11.80)	11.35(10.7)	11.53(11.23)	11.73(10.5)	11.82(10.64)	12.20(10.32)	11.73(10.14)	0.80	<0.0001
SEIFA2	Case	3.92(5.5)***	4.37(5.75)***	4.87(6.54)***	5.25(7.05)***	5.64(7.81)***	5.84 (6.9)***	6.54(7.47)***	0.99	<0.0001
	Control	9.1 (10.4)	9.67(9.19)	10.41(10.0)	10.28(10.06)	10.52(10.41)	10.36(10.56)	10.64(11.08)	0.85	<0.0001
SEIFA3	Case	4.35(9.56)***	5.06(11.56)***	5.23(11.37)***	5.87(12.25)***	6.0(12.32)***	6.6(12.8)***	7.32(12.96)***	0.99	<0.0001
	Control	9.47(8.80)	9.61(9.07)	10.16(9.60)	10.02(8.84)	10.17(8.87)	10.08(8.82)	10.02(8.96)	0.72	<0.0001
SEIFA4	Case	3.72(5.30)***	4.15(5.67)***	4.45(6.08)***	5.0 (6.92)***	5.29(6.8)***	5.77(7.82)***	6.24(7.1)***	0.99	<0.0001
	Control	8.97(9.75)	9.48(9.23)	10.28(10.17)	10.16(9.81)	10.77(10.24)	10.53(9.34)	10.75(9.80)	0.90	<0.0001
SEIFA5	Case	4.09(6.61)***	4.41(6.61)***	4.65(6.63)***	5.05(7.36)***	5.15(7.24)***	5.74(7.78)***	6.22(7.70)***	0.99	<0.0001
	Control	8.58(10.36)	8.91(11.72)	9.15(11.69)	9.47 (10.86)	9.37(9.25)	9.57(10.85)	9.31(9.60)	0.83	<0.0001

Differences between groups: $^{\phi}$ t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001. Test for homogeneity of means (Oneway ANOVA): Cases: statistically significant differences (p<0.0001) between years in all socio-economic groups. Controls: statistically significant differences (p<0.0001) between years in all socio-economic groups.

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES

Tables 8.4 and 8.5 indicate that there were significant differences in the proportions and frequencies of specialist attendances between cases and controls, and between socio-economic groups. Whilst the differences in the proportions of attendances between cases and controls were similar to those found in Chapters 4 and 5, there were major differences when socio-economic groups were compared.

In a pattern that runs counter to that for GP attendances, the highest proportion of specialist attendances was in the high socio-economic group. Similarly, the lowest proportion was in the second lowest socio-economic group. These patterns were also evident in the frequencies captured in Table 8.5. This suggests that the lower level of GP attendances among higher socio-economic groups in Tables 8.2 and 8.3 may have been compensated for by the greater use of specialists by these groups.

Table 8.4: Specialist and consultant physician attendances between 1993 and 1999 for cases and controls by SEIFA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	SEIFA1(low)	207(20.9)***	223(22.5)***	250(25.3)***	244(24.7)***	263(26.6)***	286(28.9)***	230(35.4)***	1.04	0.004
	SEIFA2	175(18.5)***	181(19.1)***	197(20.8)***	212(22.4)***	237(25.0)***	236(24.9)***	329(34.7)***	1.14	<0.0001
	SEIFA3	188(20.4)***	202(21.9)***	201(21.8)***	227(24.6)***	233(25.2)***	256(27.7)***	336(36.4)***	1.13	<0.0001
	SEIFA4	180(19.8)***	195(21.5)***	218(24.0)***	236(26.0)***	234(25.8)***	268(29.5)***	317(34.9)***	1.13	<0.0001
	SEIFA5	246(28.4)***	238(27.5)***	251(29.0)***	232(26.8)***	286(33.1)***	333(38.5)***	365(42.2)***	1.12	<0.0001
	P of diff	<0.0001	0.001	<0.0001	0.23	<0.0001	<0.0001	0.005		
Controls										
	SEIFA1(low)	427(49.4)	474(54.9)	453(52.4)	473(54.7)	478 (55.3)	475(55.0)	466 (53.9)	1.02	0.06
	SEIFA2	424 (47.0)	461(51.1)	459 (50.9)	473(52.4)	485(53.8)	479(53.1)	479(53.1)	1.04	0.004
	SEIFA3	458(49.2)	472(50.8)	485(52.2)	504(54.2)	489(52.6)	497(53.4)	510(54.8)	1.03	0.009
	SEIFA4	455(47.9)	502(52.9)	501(52.8)	525(55.3)	541(57.0)	558(58.8)	574(60.5)	1.08	<0.0001
	SEIFA5	519(52.6)	507(51.4)	542(54.7)	568(57.5)	548(55.3)	566(57.3)	573(58.1)	1.04	0.001
	P of diff	0.14	0.39	0.57	0.26	0.37	0.05	0.006		

Differences between groups: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 8.5: Specialist and consultant physician attendances between 1993 and 1999 for cases and controls by SEIFA, mean (sd)

					Year					
SES	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
SEIFA1	Case	0.70(2.50)***	0.67(2.56)***	0.77(2.64)***	0.69(2.16)***	0.76(2.27)***	0.95(3.33)***	1.05(2.89)***	0.85	<0.0001
	Control	1.82 (3.19)	2.10 (3.46)	2.17 (4.57)	2.21 (3.72)	2.46 (4.15)	2.43(4.27)	2.34 (4.43)	0.88	<0.0001
SEIFA2	Case	0.51(1.73)***	0.56(1.87)***	0.55(2.18)***	0.60(1.95)***	0.71(2.57)***	0.95(4.07)***	1.20(2.90)***	0.90	<0.0001
	Control	1.78 (3.57)	1.99 (4.57)	2.02 (4.61)	2.18 (4.06)	2.15 (3.58)	1.98 (3.31)	2.21(4.99)	0.72	<0.0001
SEIFA3	Case	0.59(1.91)***	0.74(2.75)***	0.69(2.51)***	0.94(8.61)***	0.83(3.02)***	0.91(2.71)***	1.37(4.06)***	0.86	<0.0001
	Control	1.99 (3.60)	1.94 (3.73)	2.20 (4.19)	2.15 (3.99)	2.07 (3.96)	2.17 (3.77)	2.28 (4.41)	0.77	<0.0001
SEIFA4	Case	0.61(2.06)***	0.51(1.51)***	0.72(2.68)***	0.78(2.33)***	0.91(3.15)***	1.18(4.62)***	1.34(4.06)***	0.95	<0.0001
	Control	1.81 (3.21)	1.93 (3.32)	2.16 (3.69)	2.40 (5.94)	2.40 (4.24)	2.36 (4.27)	2.86 (7.11)	0.94	<0.0001
SEIFA5	Case	0.83(2.51)***	0.85(2.27)***	1.19(4.61)***	0.94(3.09)***	1.36(4.37)***	1.30(4.55)***	1.91(9.69)***	0.87	<0.0001
	Control	2.21 (3.98)	2.06 (3.64)	2.48 (6.24)	2.66 (4.84)	2.46 (4.16)	2.60 (2.77)	2.79 (5.54)	0.85	<0.0001

Differences between groups$^{\phi}$ t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001.
Test for homogeneity of means between socio-economic groups (Oneway ANOVA): Cases: Statistically significant differences in 1993, 1994, 1995, 1997, 1999 (other years ns).
Controls: Statistically significant differences in all years.

HbA1C TESTS

Tables 8.6 and 8.7 show that there were significant differences in the proportions and frequencies of HbA1c testing between cases and controls, and also between socio-economic groups. Whilst the differences in the proportions of HbA1c testing for cases and controls were similar to those reported in Chapters 4 and 5, there were major differences when socio-economic groups were compared.

The highest proportions of cases tested were in the highest socio-economic groups, and the lowest were in the lowest two socio-economic groups, although this difference was only statistically significant in 1996 and 1999. However, for controls, the highest socio-economic group had the lowest proportion tested, with testing higher in the second highest and lowest socio-economic groups. These same patterns were also evident in the frequencies captured in Table 8.7.

These are difficult findings to explain as they suggest that the higher status group may have had poorer diabetes management. However, the lower prevalence of cases in this group, as well as the higher utilisation of medical specialists suggests that this is unlikely. The lower level of testing in high socio-economic groups might reflect a greater reliance on other measures of blood glucose, such as urine testing or self-management of blood glucose (SMBG),[207] or that this group made greater use of medical care outside of the Medicare funded health care system (such as diabetes centres), which were not included in the data collection.

Table 8.6: HbA1c testing between 1993 and 1999 for cases and controls by SEIFA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	SEIFA1 (low)	61(6.2)***	100(10.1)***	124(12.5)***	112(11.3)***	133(13.4)***	155(15.7)***	145(14.7)***	1.14	<0.0001
	SEIFA2	78(8.2)***	95 (10.0)***	115(12.1)***	92(9.7)***	116(12.2)***	138(14.6)***	150(15.8)***	1.12	<0.0001
	SEIFA3	70(7.6)***	78(8.5)***	104(11.3)***	107(11.6)***	129(14.0)***	138(15.0)***	161(17.4)***	1.20	<0.0001
	SEIFA4	62(6.8)***	79(8.7)***	113(12.4)***	114(12.6)***	134(14.8)***	131(14.4)***	170(18.7)***	1.18	<0.0001
	SEIFA5	74(8.6)***	106(12.3)***	127(14.7)***	127(14.7)***	127(14.7)***	136(15.7)***	165(19.1)***	1.12	<0.0001
	P of diff	0.26	0.06	0.28	0.02	0.51	0.90	0.05		
Controls										
	SEIFA1 (low)	166 (19.2)	201(23.3)	247(28.6)	259(30.0)	302 (35.0)	366(42.4)	389(45.0)	1.12	<0.0001
	SEIFA2	180 (20.0)	226(25.1)	247 (27.4)	260 (28.8)	280 (31.0)	350(38.8)	403 (44.7)	1.20	<0.0001
	SEIFA3	194 (20.9)	222(23.9)	236(25.4)	278 (29.9)	311(33.4)	360 (38.7)	402(43.2)	1.20	<0.0001
	SEIFA4	198(20.9)	230 (24.2)	307(32.3)	295(31.1)	349(36.8)	407(42.9)	445 (46.9)	1.22	<0.0001
	SEIFA5	179 (18.1)	210(17.1)	227 (23.0)	241(24.4)	316(32.9)	345(35.0)	404(40.9)	1.21	<0.0001
	P of diff	0.52	0.37	<0.0001	0.01	0.07	0.002	0.10		

Differences between groups: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 8.7: HbA1c testing between 1993 and 1999 for cases and controls by SEIFA, mean (sd)

					Year					
SES	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
SEIFA1	Case	0.08(0.33)***	0.12(0.42)***	0.14(0.40)***	0.14(0.41)***	0.16(0.45)***	0.19(0.51)***	0.18(0.47)***	0.95	<0.0001
	Control	0.28(0.67)	0.38 (0.82)	0.44 (0.80)	0.47 (0.84)	0.55 (0.90)	0.67 (0.96)	0.72(0.96)	0.99	<0.0001
SEIFA2	Case	0.12(0.46)***	0.13(0.82)***	0.16(0.47)***	0.12(0.43)***	0.15(0.45)***	0.17(0.45)***	0.20(0.50)***	0.81	<0.0001
	Control	0.28 (0.64)	0.38 (0.77)	0.41 (0.79)	0.43 (0.78)	0.49 (0.85)	0.62 (0.94)	0.72 (0.98)	0.97	<0.0001
SEIFA3	Case	0.09(0.32)***	0.10(0.35)***	0.14(0.43)***	0.15(0.44)***	0.19(0.55)***	0.19(0.53)***	0.23(0.56)***	0.98	<0.0001
	Control	0.30(0.68)	0.34 (0.70)	0.36 (0.72)	0.46 (0.83)	0.52 (0.86)	0.59(0.88)	0.69 (0.95)	0.98	<0.0001
SEIFA4	Case	0.08(0.35)***	0.11(0.41)***	0.16(0.49)***	0.16(0.49)***	0.20(0.54)***	0.19(0.54)***	0.26(0.62)***	0.96	<0.0001
	Control	0.32 (0.71)	0.37 (0.76)	0.49(0.83)	0.49(0.86)	0.58 (0.91)	0.68 (0.94)	0.77 (0.99)	0.99	<0.0001
SEIFA5	Case	0.14(0.51)***	0.18(0.54)***	0.22(0.61)***	0.22(0.60)***	0.23(0.64)***	0.24(0.63)***	0.28(0.68)***	0.95	<0.0001
	Control	0.25 (0.62)	0.31 (0.70)	0.35 (0.74)	0.37 (0.78)	0.49 (0.86)	0.53 (0.86)	0.65 (0.93)	0.98	<0.0001

Differences between groups: $^{\phi}$ t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.001 level,*** t-test is significant at p<0.0001.
Test for homogeneity of means between socio-economic groups (Oneway ANOVA): Cases: statistically significant differences in all years except 1998 (p=0.09).
Controls: statistically significant differences in 1995 (p<0.0001), 1996 (p=0.02) and 1998 (p=0.002).

PATIENT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS

Whether socio-economic status, patient characteristics and patterns of care predicted laser photocoagulation therapy was examined using a multivariate conditional logistic regression analysis and is captured in Table 8.8 below. In addition, Tables 8.9 to 8.13, indicate the relationship between patient characteristics, patterns of care and laser photocoagulation therapy within socio-economic groups.

Table 8.8 shows a socio-economic gradient in the level of risk of vision-threatening retinopathy by socio-economic status, where lower socio-economic groups were at higher risk of developing the complications. However, this relationship was not statistically significant.

Similar to the findings in Chapters 4 to 7, the strongest predictors of vision-threatening retinopathy were delayed diagnosis, low HDL-cholesterol testing and low optometry attendances, which suggests that the introduction of socio-economic status into the analysis did not appreciably alter the national picture (Table 4.5)

When socio-economic groups were investigated individually, these same risk factors were significant but the frequency of GP and specialist and consultant practitioner attendances also became risk factors in some socio-economic groups, especially during the early years of the study. When the second lowest socio-

economic group was investigated, a higher risk of vision-threatening retinopathy was found among women, which may be an indication of greater diabetes severity or better access to laser therapy. Whilst in the middle socio-economic group, age was also found to be significant, the adjusted odds ratio was diminutive and the confidence intervals narrow, indicating a small effect that may be of limited public health significance.

Table 8.8: Conditional logistic regression analysis predicting laser therapy in 2000 using socio-economic status characteristics, demographic characteristics, and health care utilisation between 1993 and 1999

YEAR Risk factor	OR	95% CI	P
SEIFA5 (ref)	1.0		
SEIFA4	1.13	0.77 – 1.64	0.53
SEIFA3	1.27	0.87 – 1.9	0.21
SEIFA2	1.29	0.88 – 1.89	0.20
SEIFA1	1.39	0.96 – 2.01	0.08
Gender*	0.75	0.59 – 0.95	0.015
HbA1c before 2000[Γ]	0.14	0.10 - 0.19	<0.0001
1993			
GP	0.96	0.94 – 0.98	<0.0001
S&CP[‡]	0.95	0.90 – 0.99	0.02
Optometry	0.25	0.16 – 0.37	<0.0001
HDL-c[†]	0.28	0.12 – 0.65	0.003
Retinal Ph[§]	1.90	0.62 – 5.9	0.26
1994			
S&CP	0.92	0.88 – 0.96	<0.0001
Optometry	0.12	0.07 – 0.21	<0.0001
HDL-c	0.17	0.07 – 0.39	<0.0001
Retinal Ph	3.4	0.83 – 14.2	0.09
1995			
GP	0.98	0.96 – 1.002	0.08
S&CP	0.95	0.91 – 0.98	0.004
Optometry	0.20	0.13 – 0.31	<0.0001
HDL-c	0.06	0.02 – 0.17	<0.0001
Retinal Ph	2.5	0.89 – 7.1	0.08
1996			
Optometry	0.38	0.26 – 0.54	<0.0001
HDL-c	0.11	0.04 – 0.27	<0.0001
Retinal Ph	5.40	1.15 – 25.5	0.03
1997			
Optometry	0.22	0.14 – 0.34	<0.0001
HDL-c	0.07	0.03 – 0.19	<0.0001
Retinal Ph	2.8	0.97 – 7.91	0.06
1998			
Optometry	0.19	0.12 – 0.30	<0.0001
HDL-c	0.12	0.05 – 0.25	<0.0001
Retinal Ph	2.63	0.98 – 7.08	0.05
1999			
GP	1.02	1.004 – 1.04	0.01
S&CP	0.99	0.98 – 1.01	0.55
Optometry	0.21	0.14 – 0.33	<0.0001
HbA1c[±]	0.73	0.61 – 0.88	0.001
HDL-c	0.02	0.008 – 0.07	<0.0001
Retinal Ph	26.7	8.60 – 82.2	<0.0001
Microalbumin[ŧ]	2.6	1.89 – 3.5	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 3107.3^{35\ df}$, p <0.0001.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§]retinal photography.

Table 8.9: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (SEIFA 1)

YEAR Risk factor	OR	95% CI	P
Gender*	0.61	0.43 – 0.85	0.004
Dx before 2000[Γ]	0.13	0.08 - 0.20	<0.0001
1993			
GP	0.96	0.94 – 0.99	0.001
S&CP[‡]	0.99	0.93 – 1.07	0.94
Optometry	0.21	0.11 – 0.39	<0.0001
HDL-c[†]	0.35	0.12 – 1.06	0.06
1994			
S&CP	0.89	0.83 – 0.94	<0.0001
Optometry	0.14	0.07 – 0.29	<0.0001
HDL-c	0.08	0.02 – 0.30	<0.0001
Retinal Ph[§]	1.21	0.18 – 8.2	0.84
1995			
Optometry	0.34	0.20 – 0.59	<0.0001
HDL-c	0.03	0.008 – 0.13	<0.0001
Retinal Ph	7.33	0.30 – 179.0	0.22
1996			
S&CP	0.97	0.90 – 1.05	0.47
Optometry	0.21	0.11 – 0.38	<0.0001
HDL-c	0.03	0.005 – 0.21	<0.0001
Retinal Ph	8.9	1.35 – 58.9	0.02
1997			
S&CP	0.93	0.87 – 0.99	0.02
Optometry	0.29	0.16 – 0.52	<0.0001
HDL-c	0.05	0.01 – 0.21	<0.0001
Retinal Ph	5.82	0.98 – 34.6	0.05
1998			
Optometry	0.14	0.08 – 0.25	<0.0001
HDL-c	0.09	0.03 – 0.30	<0.0001
Retinal Ph	11.9	2.08 – 67.7	0.005
1999			
GP	1.03	1.01 – 1.05	0.002
Optometry	0.34	0.19 – 0.60	<0.0001
HbA1c[±]	0.67	0.52 – 0.86	0.002
HDL-c	0.06	0.01 – 0.25	<0.0001
Retinal Ph	9.28	2.46 – 34.9	0.001
Microalbumin	4.15	2.32 – 7.41	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 1625.8$, $^{30\,df}$, p <0.0001.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 8.10: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (SEIFA 2)

YEAR Risk factor	OR	95% CI	P
Age	1.03	1.02 – 1.04	<0.0001
Dx before 2000[Γ]	0.23	0.15 - 0.35	<0.0001
1993			
GP	0.92	0.89 – 0.95	<0.0001
S&CP[‡]	0.93	0.86 – 0.99	0.03
Optometry	0.20	0.10 – 0.39	<0.0001
HbA1c[±]	1.02	0.76 – 1.37	0.89
HDL-c[†]	0.22	0.06 – 0.74	0.01
Retinal Ph[§]	23.6	4.36 – 127.8	<0.0001
1994			
GP	0.98	0.95 – 1.01	0.19
S&CP	0.94	0.88 – 1.001	0.055
Optometry	0.08	0.04 – 0.17	<0.0001
HDL-c	0.24	0.05 – 1.04	0.06
1995			
S&CP	0.93	0.87 – 0.99	0.03
Optometry	0.21	0.12 – 0.36	<0.0001
HDL-c	0.24	0.08 – 0.73	0.01
1996			
S&CP	0.91	0.85 – 0.98	0.02
Optometry	0.23	0.13 – 0.40	<0.0001
HDL-c	0.10	0.03 – 0.37	0.001
Retinal Ph	290.6	12.03 – 7023.0	<0.0001
1997			
Optometry	0.31	0.16 – 0.57	<0.0001
HDL-c	0.18	0.07 – 0.50	0.001
Retinal Ph	3.96	0.61 – 25.6	0.15
1998			
S&CP	1.05	0.99 – 1.10	0.06
Optometry	0.25	0.15 – 0.39	<0.0001
HbA1c	0.78	0.59 – 1.02	0.07
HDL-c	0.09	0.03 – 0.29	<0.0001
1999			
GP	1.03	1.003 – 1.05	0.03
Optometry	0.25	0.14 – 0.46	<0.0001
HbA1c	0.59	0.46 – 0.78	<0.0001
HDL-c	0.25	0.08 – 0.75	0.01
Retinal Ph	21.3	4.03 – 113.15	<0.0001
Microalbumin	2.76	1.71 – 4.45	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 1608.3$, $^{32\,df}$, $p < 0.0001$.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances,
[§] retinal photography.

Table 8.11: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (SEIFA 3)

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.29	0.19- 0.44	<0.0001
1993			
GP	0.92	0.89 – 0.95	<0.0001
S&CP[‡]	0.90	0.84 – 0.97	0.006
Optometry	0.12	0.06 – 0.23	<0.0001
1994			
GP	1.01	0.98 – 1.04	0.39
S&CP	0.98	0.92 – 1.04	0.57
Optometry	0.07	0.03 – 0.15	<0.0001
HbA1c[±]	0.69	0.49 – 0.97	0.03
HDL-c[†]	0.03	0.003 – 0.31	0.003
Retinal Ph[§]	4.93	0.67 – 36.3	0.12
1995			
S&CP	0.91	0.85 – 0.97	0.009
Optometry	0.13	0.07 – 0.24	<0.0001
HDL-c	0.15	0.04 – 0.49	0.002
1996			
GP	1.02	0.99 – 1.06	0.11
Optometry	0.38	0.24 – 0.61	<0.0001
HbA1c	0.84	0.62 – 1.13	0.25
HDL-c	0.12	0.04 – 0.38	<0.0001
Retinal Ph	9.06	0.53 – 154.08	0.13
1997			
Optometry	0.17	0.09 – 0.31	<0.0001
HDL-c	0.04	0.01 – 0.21	<0.0001
Retinal Ph	28.1	1.4 – 571.4	0.03
1998			
GP	1.02	0.99 – 1.05	0.06
S&CP	0.93	0.87 – 0.98	0.01
Optometry	0.23	0.13 – 0.39	<0.0001
HbA1c	0.76	0.57 – 1.0	0.05
HDL-c	0.26	0.09 – 0.73	0.01
Retinal Ph	23.6	2.50 – 218.9	0.005
1999			
S&CP	1.06	1.02 – 1.11	0.007
Optometry	0.21	0.12 – 0.37	<0.0001
HbA1c	0.78	0.59 – 1.02	0.06
HDL-c	0.16	0.06 – 0.41	<0.0001
Retinal Ph	539.9	36.6 – 7964.3	<0.0001
Microalbumin	1.79	1.21 – 2.67	0.004

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 =1610.0, $^{34\ df}$, p <0.0001.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 8.12: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (SEIFA 4)

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.14	0.09 – 0.22	<0.0001
1993			
GP	0.97	0.94 – 1.0	0.048
S&CP[‡]	0.94	0.87 – 1.009	0.08
Optometry	0.43	0.25 – 0.74	0.002
HDL-c[†]	0.15	0.04 – 0.49	0.002
Retinal Ph[§]	1.64	0.37 – 7.2	0.51
1994			
GP	0.96	0.93 – 0.99	0.04
S&CP	0.88	0.81 – 0.95	0.001
Optometry	0.16	0.08 – 0.32	<0.0001
HDL-c	0.35	0.12 – 0.96	0.04
1995			
GP	0.97	0.94 – 1.007	0.13
Optometry	0.23	0.12 – 0.42	<0.0001
HDL-c	0.16	0.06 – 0.48	0.001
Retinal Ph	5.27	0.73 – 38.07	1.0
1996			
S&CP	0.93	0.88 – 0.98	0.01
Optometry	0.16	0.08 – 0.31	<0.0001
HDL-c	0.12	0.04 – 0.37	<0.0001
1997			
Optometry	0.23	0.13 – 0.39	<0.0001
HDL-c	0.10	0.03 – 0.40	0.001
Retinal Ph	27.8	2.4 – 318.9	0.008
1998			
Optometry	0.12	0.07 – 0.23	<0.0001
HDL-c	0.12	0.04 – 0.37	<0.0001
Retinal Ph	3.93	0.76 – 20.17	0.10
1999			
Optometry	0.10	0.05 – 0.19	<0.0001
HbA1c[±]	0.81	0.64 – 1.03	0.09
HDL-c	0.10	0.04 – 0.26	<0.0001
Retinal Ph	321.1	25.6 – 4028.8	<0.0001
Microalbumin	2.52	1.64 – 3.86	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 1646$, $^{28\ df}$, $p < 0.0001$.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 8.13: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (SEIFA 5)

YEAR Risk factor	OR	95% CI	P
Age	1.03	1.02 – 1.05	<0.0001
Dx before 2000[Γ]	0.14	0.09 – 0.21	<0.0001
1993			
GP	0.97	0.94 – 1.004	0.09
S&CP[‡]	0.88	0.82 – 0.94	<0.0001
Optometry	0.23	0.10 – 0.51	<0.0001
HbA1c[±]	0.94	0.68 – 1.3	0.72
HDL-c[†]	0.51	0.20 – 1.3	0.15
Retinal Ph[§]	0.82	0.14 – 4.61	0.82
1994			
GP	0.99	0.97 – 1.02	0.67
S&CP	0.94	0.88 – 1.001	0.051
Optometry	0.11	0.04 – 0.27	<0.0001
HbA1c	1.08	0.79 – 1.47	0.64
HDL-c	0.44	0.17 – 1.18	0.10
Retinal Ph	3.6	0.42 – 29.9	0.24
1995			
GP	0.98	0.95 – 1.02	0.29
Optometry	0.13	0.07 – 0.25	<0.0001
HbA1c	1.2	0.91 – 1.6	0.20
HDL-c	0.09	0.03 – 0.32	<0.0001
Retinal Ph	3.98	1.08 – 14.7	0.04
1996			
S&CP	0.96	0.93 – 1.0	0.048
Optometry	0.18	0.09 – 0.36	<0.001
HDL-c	0.50	0.21 – 1.19	0.12
Retinal Ph	2.15	0.43 – 10.8	0.35
1997			
GP	0.98	0.96 – 1.01	0.31
Optometry	0.17	0.09 – 0.32	<0.0001
HDL-c	0.24	0.08 – 0.73	0.01
1998			
Optometry	0.19	0.10 – 0.35	<0.0001
HDL-c	0.17	0.06 – 0.46	0.001
Retinal Ph	1.9	0.48 – 7.25	0.36
1999			
Optometry	0.36	0.22 – 0.62	<0.0001
HDL-c	0.04	0.01 – 0.15	<0.0001
Retinal Ph	63.4	7.46 – 539.02	<0.0001
Microalbumin	2.74	1.7 – 4.35	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 1532.4$, $^{33\ df}$, $p < 0.0001$.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§] Retinal photography.

Discussion

The study showed that there was a greater risk of complications in lower as compared to higher socio-economic groups. This was evident in the univariate analysis (Table 8.1), as well as in the logistic regression model (Table 8.8), although in the latter socio-economic status was not significant. This accords with a large body of evidence concerning the relationship between socio-economic status and diabetes. For example, Klein et al. found that the incidence of proliferative retinopathy was higher among lower status older men than in similar people with diabetes of higher status.[161]

When the findings are considered in the light of those in Chapters 6 and 7, they might be explained by socio-economic status being influential in the late diagnosed group, but not in the early diagnosed population (Table 6.8). Thus, the strong relationship between socio-economic status and diabetes complications evident in Chapter 7 may have been diluted when the broader diabetes population was included in an analysis of the relationship between socio-economic status and vision-threatening retinopathy. This is apparent in the change in the value of the odds ratio for SEIFA 1 when Tables 7.4 and 8.8 are compared (OR = 1.89 (1.29 ± 2.3) in Table 7.4, and OR = 1.39 (0.96 ± 2.01) in Table 8.8).

With regard to the patterns of care, lower status patients made more use of GPs, attended specialist and consultant physicians less often and were tested for HbA1c more than their higher status counterparts. However, they were also at greater risk of developing diabetes complications. This suggests that the greater

use of medical specialists and lesser reliance on primary care which characterises the affluent group, might have reduced the risk of vision-threatening retinopathy.

However, this finding runs counter to that in Chapter 5 that there was no advantage in greater specialist utilisation, when this was compared between states and territories. This suggests that the advantage in the higher socio-economic group may be the result of some other factors such as fewer complications (less severe diabetes) and that this led to a lower risk of complications.[273]

In Chapter 5 it was also found that states with higher levels of specialist attendances, also had higher levels of GP utilisation. However, this was not reflected in the current study, particularly in SEIFA 5, which also had high specialist attendances. This suggests that the synergistic relationship between GP and specialists attendances may be characteristic of particular states and territory health care systems and not of socio-economic groups.

Tables 8.9 to 8.13 show that the risk factors for diabetes complications were remarkably consistent across socio-economic groups, indicating that patients who develop complications in all groups suffered from similar disadvantages with regard to diabetes management. This suggests that there may have been entrenched structural inadequacies in the health care system that affected all socio-economic groups.[354] This may relate to the current system of primary health care in Australia or to the characteristics of people with diabetes.

In conclusion, socio-economic status was found to be a risk factor for the development of complications and this was evident in the univariate and multivariate analyses. However, when these findings are considered in the light of those in Chapters 6 and 7, it appears that low socio-economic status is a stronger risk factor in late diagnosed groups. The analysis of socio-economic status in these three studies provides support for the argument that early diagnosis interventions should be focused on low socio-economic groups but that interventions to improve diabetes management should target the diabetes population generally.

Chapter 9

Are geographically isolated patients at greater risk of complications because of poor access to health care?

Abstract

OBJECTIVES: In Chapters 7 and 8 socio-economic status was identified as a risk factor for diabetes complications. The effects of socio-economic status on health have often been explained to be a result of living conditions, behaviours and access to health care. One of the implications of Chapters 7 and 8 was that other populations that are similarly disadvantaged might also be at high risk of developing complications. One important group in Australia that also experiences poorer access to care is the rural and remote population. It was hypothesised that poor access to care, because of geographic isolation, would result in a higher risk of complications.

METHODS: 4632 diabetes patients who had received their first laser photocoagulation treatment in 2000 were compared to a random sample of diabetes patients who had never received this treatment (n = 4632). Patterns of health care utilisation were compared within and between geographic remoteness groups over a seven-year period (1993-1999) using the Australian Medicare database.

RESULTS: There was a greater proportion of cases than controls in remote localities. RRMA 4 (remote) contained 2.4% of cases, but only 1.3% of controls. RRMA 1 (metropolitan) contained 49.2% of cases and 50.8% of controls, P<0.0001. People with diabetes in remote localities were younger than those in more populous regions: 57.8 years (sd = 12.9) in RRMA 4, compared to 62.7 years (sd = 13.5) in RRMA 2, P<0.0001. In relation to GP attendances, for cases these were highest in RRMA 2 (7 year average = 78.7%) and lowest in RRMA 4 (7 year average = 64.5%), P<0.0001. For controls, the highest proportion of GP attendances was in RRMA 2 (7 year average = 93.7%), whilst the lowest was in RRMA 4 (7 year average = 90.0%). With regard to specialist attendances, for cases these were highest in RRMA 2 (7 year average = 30.9%), and lowest in RRMA 4 (7 year average = 12.1%), P<0.0001. For controls, specialist attendances were highest in RRMA 2 (7 year average = 56.3%) and lowest in RRMA 4 (7 year average = 38.3%), P<0.0001. For HbA1c testing, among cases, this was highest in RRMA 2 (7 year average = 13.4%) and lowest in RRMA 4 (7 year average = 8.6%), P<0.0001. For controls, HbA1c testing was highest in RRMA 1 (7 year average = 31.6) and lowest in RRMA 4 (7 year average = 24.3%), P<0.0001. Geographic remoteness was also tested as a risk factor for vision-threatening retinopathy in a logistic regression model. Although it was found not to be statistically significant, there was evidence of a gradient in risk from low risk in metropolitan areas to high-risk in remote localities. The major risk factors for vision-threatening retinopathy were delayed diagnosis, optometry attendances, HDL-cholesterol testing and retinal photography (which was higher in cases), which were similar across most groups regardless of remoteness.

CONCLUSIONS: The findings indicated no consistent pattern of disadvantage in access to health care associated with geographic isolation. This suggests that access to health care is not a uniform problem for all isolated groups, but that other more general factors play a greater role in determining the quality and effectiveness of diabetes care.

Introduction

Having established that patterns of care are very significant risk factors for diabetes complications in Chapter 4; that this relationship exists at the national level, as well as in all states and territories in Chapter 5; that early diagnosis, coupled with appropriate diabetes management is the key to preventing diabetes complications in Chapter 6; that the patterns of care prior to the diagnosis of diabetes are predictors of complications in Chapter 7; and that socio-economic status was only a risk factor for diabetes complications in late-diagnosed groups in Chapter 8, this study investigates the role of geographic isolation as a risk factor for diabetes complications.

The relationship between socio-economic status and diabetes complications in Chapters 7 and 8 implied that other populations which were similarly disadvantaged with regard to health status and access to health care may be at a similar high-risk of developing complications. One group of concern in this regard is the rural and remote population.[363] In this study of the thesis, the research question was tested: whether geographic isolation was a risk factor for the diabetes complications in the population with diabetes in Australia.

In national surveys rural and remote populations have been shown to have poorer metabolic control, less healthy lifestyles and poorer access to health care services.[33, 283, 284] It was hypothesised that these factors - as measured by demographic characteristics, the timing of diagnosis and patterns of care - which had been shown to be risk factors for the development of advanced complications

in other populations, are also risk factors for advanced complications in rural and remote populations.

Methods

To investigate the relationship between geographic isolation and diabetes complications, a population-based case-control study similar to those in Chapters 4, 5 and 8 was used.[331] The study examined patient demographic characteristics, the utilisation of primary and secondary care, diabetes related pathology tests and predicted complications across groups categorised by remoteness.

In this study, cases comprised a national sample of 4632 patients who had received their first laser photocoagulation therapy in 2000, and controls were a random sample of 4632 people with diabetes who had not received this treatment (the total sample in Table 4.2). Controls were matched to cases on age (within one year) in 2000, and state of residence at the time of their earliest HbA1c test.

The measure of geographical isolation used in this study was the Regional and Remoteness for Areas (RRMA), a measure of geographic remoteness developed by the Australian Bureau of Statistics.[341] The indicator measures the closeness of localities to major population centres when travelled by road. In this study, four classifications of geographic remoteness were used: RRMA 1 includes metropolitan areas; RRMA 2 outer metropolitan areas; RRMA 3 regional centres and country towns; and RRMA 4 remote locations. Subjects were ascribed an RRMA on the basis of their residential post-code.

In the univariate analyses which compared cases to controls, proportions were compared using χ^2 tests and frequencies by independent samples t-tests. When

risk factors were compared between remoteness groups, for proportions, χ^2 tests for trend were used, and for frequencies analysis of variance was used (the Bonferroni adjustment was used to account for type 2 error).[342] For each risk factor, and within cases and controls in each remoteness group, trends over time were calculated. For proportions, multivariate logistic regression of weighted proportions was used, and for frequencies, multiple linear regression of weighted means. The multivariate analyses were conducted using conditional logistic regression to take account of the paired study design, and the regression analyses used a stepwise process with backwards conditional as the variable selection criteria (Tables 9.8 to 9.12). Geographic isolation was entered as three dummy variables in the analysis reflected in Table 9.8, and all statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF THE SAMPLE

Table 9.1 shows that 72% of cases lived in metropolitan or outer-metropolitan areas compared to 76% of controls (RRMA 1 and RRMA 2 combined). This suggests that there may be a slightly greater prevalence of diabetes in metropolitan and outer-metropolitan areas than in rural and remote localities.[351] However, the distribution of cases suggests that diabetes may be more severe in non-metropolitan areas.

Whilst the average age of people with diabetes in metropolitan, outer-metropolitan and regional areas was similar (62.1 to 62.6 years), subjects were significantly younger in remote locations (57.8). This may in part be an indication of the predominance of diabetes in indigenous groups in remote areas.[30]

Whilst there were greater proportions of males in all areas, this occurred among both cases and controls ($p = 0.45$). Hence, vision-threatening retinopathy was not determined by gender. With regard to the timing of diagnosis, there were no significant differences between RRMA groups, suggesting that the timing of diagnosis of diabetes was not related to living in a rural or remote community.

Table 9.1: Characteristics of study subjects by RRMA

	RRMA 1	RRMA 2	RRMA 3	RRMA 4	Total
Cases n (%)*	2951(63.7)	397 (8.5)	1173(25.0)	111(2.4)	4632
Controls n (%)	3045(65.7)	467(10.0)	1061(22.9)	59 (1.3)	4632
Total n (%)	5996 (64.7)	864 (9.3)	2234 (24.0)	170 (1.8)	9264
Age** (mean (sd))	62.6 (12.9)	62.7(13.5)	62.1(13.3)	57.8(12.9)	62.4(13.1)
Gender***					
Male n (%)	3260(54.4)	457(52.9)	1226(54.9)	84(49.4)	5027
Female n (%)	2736 (45.6)	407(47.1)	1008(45.1)	86(50.6)	4237
% Dx before 2000 ****					
Cases n (%)	1353(45.8)	195(49.1)	498(42.5)	48(43.2)	2094(45.2)
Controls n (%)	2649(87.0)	419(89.7)	907(85.5)	51(86.4)	4026(86.9)

Differences in study groups: $28.7^{3\ df,}$ $p<0.0001$

**ANOVA for age differences: $F= 7.72^{3,9260\ df,}$ $p<0.0001$

*** Gender differences: $\chi^2 = 2.63^{3\ df,}$ $p = 0.45$.

**** Differences in RRMA in Dx before 2000: Cases: $\chi^2 = 6.70^{3\ df,}$ $p = 0.08$

Controls: $\chi^2= 5.17^{3\ df,}$ $p = 0.16$

GP ATTENDANCES

Tables 9.2 and 9.3 show that there were significant differences in the proportions and frequencies of GP attendances between cases and controls, and also between RRMA groups. Whilst the differences in the proportions of GP attendances for cases and controls were similar to those found in Chapters 4 and 5, there were major differences when RRMA groups were compared.

Firstly, Table 9.2 shows that when cases are compared across RRMA groups, lesser proportions of remote patients attended GPs on an annual basis, and Table 9.3 shows that this difference was reflected in the frequency of attendances.

Table 9.2 also indicates that whilst the proportion of cases that attended GPs increased over the study, this did not occur amongst controls, as in metropolitan and outer-metropolitan areas the proportion that attended GPs declined. This suggests that access to GPs may have improved for cases in all localities, but for controls, such improvements occurred in remote localities only.

Table 9.3 shows positive trends for both cases and control groups in the frequencies of attendances. This suggests that the quality of care may have improved across all RRMA groups over time, although the proportion of controls that received care from GPs declined.

Table 9.2: GP attendances between 1993 and 1999 for cases and controls by RRMA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	RRMA1	2085(70.7)***	2191(74.2)***	2228(75.5)***	2308(78.2)***	2356(79.8)***	2435(82.5)***	2551(86.4)***	1.16	<0.0001
	RRMA2	283(71.3)***	291(73.3)***	307(77.3)***	308(77.6)***	327(82.4)***	335(83.4)**	339(85.4)$^{\phi}$	1.16	<0.0001
	RRMA3	794(67.7)***	813(69.3)***	860(73.3)***	860(73.3)***	865(73.7)***	914(77.9)***	979(83.5)***	1.15	<0.0001
	RRMA4	63(56.8)***	73(65.8)*	67(60.4)**	73(65.8)***	74(66.7)***	76(68.5)*	75(67.6)***	1.07	0.07
	P of diff	0.005	0.004	0.001	<0.0001	<0.0001	<0.0001	<0.0001		
Controls										
	RRMA1	2846(93.5)	2857(96.3)	2870(94.3)	2871(94.3)	2838(93.2)	2825(92.8)	2764(90.8)	0.94	<0.0001
	RRMA2	444(95.1)	448(95.9)	450(96.4)	446(95.5)	435(93.1)	426(91.2)	417(89.3)	0.83	<0.0001
	RRMA3	987(93.0)	987(93.0)	991(93.4)	977(92.1)	979(92.3)	973(91.7)	981(92.5)	0.97	0.2
	RRMA4	55(93.2)	51(86.4)	50(84.7)	53(89.8)	55(93.2)	53(89.8)	55(93.2)	1.06	0.46
	P of diff	0.51	0.02	0.002	0.01	0.78	0.43	0.17		

Differences between groups: $^{\phi}\chi^2$ = is not significant, $^{*}\chi^2$ = is significant at p=0.05 level, $^{**}\chi^2$ = is significant at p=0.001 level, $^{***}\chi^2$ = is significant at p<0.0001

Table 9.3: GP attendances between 1993 and 1999 for cases and controls by RRMA, mean (sd)

					Year					
Geographic Isolation	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
RRMA 1	Case	4.6(6.7)***	5.1(7.0)***	5.3(6.9)***	5.9(7.7)***	6.0(7.6)***	6.6(7.9)***	7.2(8.0)***	0.99	<0.0001
	Control	9.9(10.1)	10.2(10.3)	10.7(11.0)	10.8(10.7)	11.1(10.4)	11.1(10.7)	11.02(10.6)	0.91	<0.0001
RRMA 2	Case	4.8(7.4)***	5.3(7.7)***	5.8(8.1)***	6.4(9.9)***	6.6(9.2)***	7.1(10.1)***	7.6(11.4)***	0.99	<0.0001
	Control	9.3(8.7)	10.1(10.8)	9.9(9.2)	10.1(8.5)	10.1(9.2)	9.8(8.5)	9.9(8.5)	0.99	<0.0001
RRMA 3	Case	3.5(8.2)***	3.9(9.7)***	4.4(9.9)***	4.5(10.2)***	4.8(10.5)***	5.3(10.9)***	5.8(10.8)***	0.99	<0.0001
	Control	8.4(11.4)	8.59.0)	9.3(9.9)	8.9(8.5)	9.0(8.7)	9.2(8.7)	9.2(8.1)	0.76	<0.0001
RRMA 4	Case	3.1(4.9)***	4.2(6.7)*	3.6(5.9)***	4.3(5.6)*	4.1(6.3)**	4.5(5.7)**	5.3(8.1)**	0.86	<0.0001
	Control	6.9(6.5)	6.4(5.8)	7.6(7.2)	6.3(6.1)	7.4(7.9)	7.7(6.8)	7.6(6.4)	0.58	<0.0001

Differences between groups: $^{\phi}$t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.01 level,*** t-test is significant at p<0.0001
Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years except 1994 (p=0.11) and 1996 (p=0.10).
Controls: Statistically significant difference between states in all years.

SPECIALIST AND CONSULTANT PHYSICIAN ATTENDANCES

Tables 9.4 and 9.5 show that there were significant differences in the proportions and frequencies of specialist attendances between cases and controls, and also between RRMA groups. Whilst the differences in the proportions of attendances between cases and controls were similar to those found in Chapters 4 and 5, there were major differences when RRMA groups were compared.

Tables 9.4 and 9.5 show that when RRMA groups were compared, a similar difference to that found in respect of GPs attendances was also reflected in the proportion and frequency of attendance at specialists and consultant physicians. A smaller proportion of cases from remote localities attended specialists than cases from more populous regions, and this was also true when the frequency of attendances was compared. However, unlike with GPs, this same pattern was observed among controls, although the difference between geographic areas was not as great as it was with cases. This suggests that people with diabetes from remote localities have significantly poorer access to specialists and consultant physicians than less isolated patients.[33]

Table 9.4 also shows that the proportion of subjects who attended specialist and consultant physicians increased in all RRMA groups over time, and this was also reflected in the frequencies in Table 9.5. This suggests that the level of access to specialist and consultant physicians improved over the study period.

When Tables 9.2 and 9.4 are compared, the findings suggest that there may have been a shift in participation in diabetes management from GPs to specialists and consultant physicians during the 1990s in some RRMA groups. This is indicated by the decline in the proportion of controls that attended GPs, and the simultaneous increase in the proportion that attended specialist and consultant physicians.

Table 9.4: Specialist and consultant physician attendances between 1993 and 1999 for cases and controls by RRMA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend (OR)	P
	RRMA 1	674(22.8)***	702(23.8)***	769(26.1)***	772(26.2)***	873(29.6)***	968(32.8)***	1156(39.2)***	1.13	<0.0001
	RRMA 2	115(29.0)***	106(26.7)***	120(30.2)***	119(30.0)***	124(31.2)***	115(29.0)***	159(40.6)***	1.07	0.002
	RRMA 3	198(16.9)***	222(18.9)***	216(18.4)***	247(21.1)***	243(20.7)***	280(23.9)***	361(30.8)***	1.12	<0.0001
	RRMA 4	9(8.1)***	9(8.1)***	12(10.8)*	13(11.7)***	13(11.7)***	16(14.4)*	21(18.9)***	1.17	0.005
	P of diff	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		
Controls										
	RRMA 1	1542(50.6)	1620(53.2)	1612(52.9)	1701(55.9)	1684(55.3)	1739(57.1)	1740(57.1)	1.04	<0.0001
	RRMA 2	244(52.2)	273(58.5)	269(57.6)	273(58.5)	267(57.2)	255(54.6)	259(55.5)	1.002	0.90
	RRMA 3	472(44.5)	504(47.5)	540(50.9)	548(51.6)	562(53.0)	560(52.8)	574(54.1)	1.06	<0.0001
	RRMA 4	25(42.4)	19(32.2)	17(28.8)	21(35.6)	26(44.1)	21(35.6)	29(49.2)	1.07	0.21
	P of diff	0.002	<0.0001	<0.0001	0.001	0.13	0.001	0.23		

Differences between groups: $^{\phi}\chi^2$ = is not significant,* χ^2 = is significant at p=0.05 level,** χ^2 = is significant at p=0.001 level,*** χ^2 = is significant at p<0.0001

Table 9.5: Specialist and consultant physician attendances between 1993 and 1999 for cases and controls by RRMA, mean (sd)

					Year					
Geographic isolation	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
RRMA 1	Case	0.69(2.2)***	0.68(2.1)***	0.84(3.1)***	0.86(5.4)***	1.0(3.4)***	1.2(4.2)***	1.5(6.6)***	0.95	<0.0001
	Control	2.1(3.7)	2.1(3.6)	2.3(4.9)	2.5(4.9)	2.4(4.2)	2.4(4.2)	2.6(5.4)	0.89	<0.0001
RRMA 2	Case	0.93(2.9)***	0.83(2.5)***	1.3(4.8)**	1.2(3.2)***	1.2(3.5)***	1.1(4.2)***	1.5(4.2)**	0.74	<0.0001
	Control	1.9(3.3)	2.3(3.9)	2.2(3.3)	2.4(4.2)	2.5(4.5)	2.5(5.1)	2.5(5.4)	0.87	<0.0001
RRMA 3	Case	0.46(1.6)***	0.59(2.3)***	0.45(1.5)***	0.50(1.7)***	0.59(2.4)***	0.72(2.9)***	0.92(2.6)***	0.82	<0.0001
	Control	1.53(2.9)	1.7(4.1)	1.9(4.8)	1.9(3.6)	1.9(3.3)	1.9(3.4)	2.3(5.5)	0.89	<0.0001
RRMA 4	Case	0.29(1.5)*	0.28(2.1)$^{\phi}$	0.67(3.4)$^{\phi}$	0.38(1.5)$^{\phi}$	0.19(0.63)***	0.63(3.1)$^{\phi}$	0.85(2.7)$^{\phi}$	0.59	<0.0001
	Control	0.83(1.3)	0.75(1.8)	0.74(1.4)	0.76(1.2)	1.3(2.1)	1.0(1.8)	1.9(4.9)	0.77	<0.0001

Differences between groups: $^{\phi}$t-test is not significant, * t-test is significant at p=0.05 level, ** t-test is significant at p=0.01 level, *** t-test is significant at p<0.0001
Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years.
Controls: Statistically significant difference between states in all years.

HbA1C TESTING

Tables 9.6 and 9.7 show that there were significant differences in the proportions and frequencies of HbA1c testing between cases and controls, and also between RRMA groups. Whilst the differences in the proportions of HbA1c testing for cases and controls were similar to those found in Chapters 4 and 5, there were major differences when remoteness groups were compared.

Tables 9.6 and 9.7 reflect differences in RRMA groups that were found in GP and specialist and consultant physician attendances in Tables 9.2 to 9.5. They also show that the proportion and frequency of HbA1c testing increased in all RRMA groups, suggesting that the quality of diabetes management may have improved across all regions.

Despite the lower level of access to GPs and other health care services in remote localities, the case group in the metropolitan areas had lower levels of testing than controls in remote localities. This indicates that diabetes complications were more strongly associated with the level of health care utilisation than with geographic isolation.

Table 9.6: HbA1c testing between 1993 and 1999 for cases and controls by RRMA, n (%)

					Year					
Cases		1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
	RRMA 1	244(8.3)***	327(11.1)***	402(13.6)***	368(12.5)***	411(13.9)***	441(14.9)***	523(17.7)***	1.12	<0.0001
	RRMA 2	33(8.3)***	35(8.8)***	55(13.9)***	41(10.3)***	65(16.4)***	71(17.9)***	74(18.6)***	1.17	<0.0001
	RRMA 3	61(5.2)***	90(7.7)***	114(9.7)***	132(11.3)***	154(13.1)***	172(14.7)***	186(15.9)***	1.20	<0.0001
	RRMA 4	7(6.3)*	6(5.4)$^{\phi}$	12(10.8)$^{\phi}$	11(9.9)*	9(8.1)*	14(12.6)*	8(7.2)***	1.07	0.31
	P of diff	0.007	0.003	0.006	0.43	0.13	0.37	0.01		
Controls										
	RRMA 1	643(21.1)	745(24.5)	853(28.0)	891(29.3)	1053(34.6)	1194(39.2)	1348(44.2)	1.19	<0.0001
	RRMA 2	93(19.9)	126(27.0)	129(27.6)	148(31.7)	150(32.1)	177(37.9)	201(43.0)	1.17	<0.0001
	RRMA 3	171(16.1)	210(19.8)	272(25.6)	279(26.3)	341(32.1)	437(41.2)	470(44.3)	1.27	<0.0001
	RRMA 4	10(16.9)	8(13.6)	10(16.9)	15(25.4)	14(23.7)	20(33.1)	24(40.7)	1.27	<0.0001
	P of diff	0.005	0.001	0.14	0.12	0.15	0.45	0.91		

Differences between groups: $^{\phi}\chi^2$ = is not significant,* χ^2 = is significant at p=0.05 level,$^{**}\chi^2$ = is significant at p=0.001 level,$^{***}\chi^2$ = is significant at p<0.0001

Table 9.7: HbA1c testing between 1993 and 1999 for cases and controls by RRMA, mean (sd)

					Year					
Geographic isolation	Group	1993	1994	1995	1996	1997	1998	1999	Annual trend(OR)	P
RRMA 1	Case	0.12(0.43)***	0.15(0.46)***	0.18(0.52)***	0.16(0.50)***	0.19(0.50)***	0.20(0.55)***	0.24(0.59)***	0.94	<0.0001
	Control	0.31(0.69)	0.37(0.77)	0.42(0.79)	0.46(0.83)	0.55(0.89)	0.62(0.92)	0.72(0.98)	0.99	<0.0001
RRMA 2	Case	0.11(0.42)***	0.11(0.39)***	0.17(0.48)***	0.13(0.44)***	0.21(0.54)***	0.22(0.53)***	0.26(0.59)***	.0.93	<0.0001
	Control	0.29(0.68)	0.39(0.76)	0.45(0.85)	0.52(0.89)	0.50(0.87)	0.59(0.90)	0.69(0.97)	0.97	<0.0001
RRMA 3	Case	0.06(0.29)***	0.09(0.37)***	0.11(0.39)***	0.14(0.44)***	0.17(0.48)***	0.18(0.50)***	0.19(0.50)***	0.99	<0.0001
	Control	0.22(0.58)	0.30(0.71)	0.36(0.71)	0.39(0.76)	0.51(0.87)	0.68(0.91)	0.68(0.91)	0.98	<0.0001
RRMA 4	Case	0.07(0.29)*	0.05(0.23)*	0.14 (0.5)$^{\phi}$	0.11(0.37)*	0.10(0.38)*	0.14(0.40)***	0.08(0.30)***	0.38	<0.0001
	Control	0.27(0.66)	0.15(0.41)	0.20(0.48)	0.25(0.44)	0.32(0.65)	0.56(0.93)	0.61(0.91)	0.85	<0.0001

Differences between groups: $^{\phi}$ t-test is not significant,* t-test is significant at p=0.05 level,** t-test is significant at p=0.01 level,*** t-test is significant at p<0.0001
Test for homogeneity of means (Oneway ANOVA): Cases: Statistically significant differences between states in all years.
Controls: Statistically significant difference between states in all years.

PATIENT CHARACTERISTICS AND HEALTH CARE UTILISATION OVER SEVEN YEARS FOR CASES VS CONTROLS

In Table 9.8 below, whether geographic isolation, patient characteristics and patterns of care predicted laser photocoagulation therapy was tested using a multivariate conditional logistic regression analysis. In addition, Tables 9.9 to 9.12 capture the relationship between patient characteristics, patterns of care and laser photocoagulation therapy within RRMA groups.

Table 9.8 shows a gradient in the risk of vision-threatening retinopathy by RRMA group, where the risk of complications increased as people with diabetes lived further away from metropolitan centres. The strongest predictors of vision-threatening retinopathy in remoteness groups were delayed diagnosis, low HDL-cholesterol testing and optometry attendances, which pointed to similar aspects of management of diabetes leading to the development of complications as was found in Tables 4.6 and others.

When remoteness groups were considered individually, they had similar patterns of risk factors to those presented in Table 9.8. Perhaps the most significant difference was in RRMA 3, where gender was a risk factor. This may be indicating that in regional localities there is some aspect of femaleness that increases the risk of complications, such as access to care or the severity of diabetes. In addition, in some years there were no significant differences between cases and controls in RRMA 4. However, this is unlikely to be an indication of different relationships between the patterns of care and diabetes complications in

these localities, and is more likely to reflect the small sample size used in the analysis.[342]

Table 9.8: Conditional logistic regression analysis predicting laser therapy in 2000 using geographic isolation characteristics, demographic characteristics, and health care utilisation between 1993 and 1999

YEAR Risk factor	OR	95% CI	P
RRMA 4 (remote) (ref)	1.0		
RRMA 3 (rural/ regional)	0.47	0.19 – 1.16	0.1
RRMA 2 (suburban)	0.51	0.19 – 1.34	0.17
RRMA 1 (urban/metro)	0.55	0.23 – 1.3	0.2
Gender*	0.76	0.60 – 0.95	0.02
Dx before 2000[Γ]	0.14	0.10 – 0.19	<0.0001
1993			
GP	0.96	0.94 – 0.98	<0.0001
S&CP[‡]	0.94	0.90 – 0.99	0.01
Optometry	0.25	0.17 – 0.38	<0.0001
HDL-c[†]	0.25	0.11 – 0.58	0.001
Retinal Ph[§]	1.9	0.64 – 6.20	0.23
1994			
S&CP	0.92	0.88 – 0.96	<0.0001
Optometry	0.12	0.07 – 0.21	<0.0001
HDL-c	0.16	0.07 – 0.38	<0.0001
Retinal Ph	3.4	0.82 – 14.4	0.09
1995			
GP	0.98	0.96 – 1.004	0.11
S&CP	0.95	0.91 – 0.98	0.004
Optometry	0.20	0.13 – 0.31	<0.0001
HDL-c	0.07	0.03 – 0.19	<0.0001
Retinal Ph	2.3	0.82 – 6.4	0.11
1996			
Optometry	0.37	0.26 – 0.54	<0.0001
HDL-c	0.11	0.04 – 0.27	<0.0001
Retinal Ph	5.6	1.20 – 26.0	0.03
1997			
Optometry	0.21	0.14 – 0.33	<0.0001
HDL-c	0.08	0.03 – 0.21	<0.0001
Retinal Ph	2.9	1.006 – 8.4	0.049
1998			
Optometry	0.19	0.12 – 0.30	<0.0001
HDL-c	0.11	0.05 – 0.23	<0.0001
Retinal Ph	2.6	0.98 – 6.8	0.05
1999			
GP	1.02	1.003 – 1.03	0.02
Optometry	0.21	0.14 – 0.33	<0.0001
HbA1c[±]	0.73	0.66 – 0.89	<0.0001
HDL-c	0.02	0.008 – 0.07	<0.0001
Retinal Ph	26.8	8.7 – 83.3	<0.0001
Microalbumin	2.6	1.9 – 3.5	<0.0001

Reference group = controls, *reference group = female
[Γ] reference group = not diagnosed.
Model overall $\chi^2 = 3104.4$, 34 df, $p < 0.0001$.
[±] Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§] Retinal photography.

Table 9.9 Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (RRMA 1)

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.17	0.14 – 0.21	<0.0001
1993			
GP	0.97	0.95 – 0.99	<0.0001
S&CP[‡]	0.91	0.88 – 0.94	<0.0001
Optometry	0.18	0.12 – 0.27	<0.0001
HDL-c[†]	0.39	0.22 – 0.68	0.001
Retinal Ph[§]	1.05	0.33 – 3.33	0.93
1994			
GP	1.002	0.98 – 1.02	0.86
S&CP	0.89	0.86 – 0.93	<0.0001
Optometry	0.09	0.05 – 0.14	<0.0001
HbA1c[±]	0.93	0.79 – 1.09	0.38
HDL-c	0.21	0.11 – 0.38	<0.0001
Retinal Ph	3.06	1.03 – 9.07	0.04
1995			
GP	0.97	0.96 – 0.99	0.001
Optometry	0.15	0.11 – 0.22	<0.0001
HbA1c	1.07	0.92 – 1.25	0.37
HDL-c	0.11	0.06 – 0.22	<0.0001
Retinal Ph	2.32	0.97 – 5.59	0.06
1996			
Optometry	0.26	0.18 – 0.36	<0.0001
HDL-c	0.19	0.10 – 0.35	<0.0001
Retinal Ph	4.47	1.55 – 12.9	0.006
1997			
Optometry	0.19	0.13 – 0.26	<0.0001
HDL-c	0.14	0.07 – 0.27	<0.0001
Retinal Ph	3.64	1.43 – 9.27	0.007
1998			
Optometry	0.16	0.11 – 0.22	<0.0001
HDL-c	0.15	0.08 – 0.28	<0.0001
Retinal Ph	5.65	2.22 – 14.3	<0.0001
1999			
GP	1.01	1.003 – 1.03	0.01
Optometry	0.30	0.22 – 0.41	<0.0001
HbA1c	0.75	0.66 – 0.86	<0.0001
HDL-c	0.08	0.04 – 0.16	<0.0001
Retinal Ph	61.6	20.2 – 187.6	<0.0001
Microalbumin	2.31	1.81 – 2.93	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 = 5086.9, 32 [df], p <0.0001.
[±]Haemoglobin A1c tests,
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§] retinal photography.

Table 9.10: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (RRMA 2)

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.20	0.11 – 0.37	<0.0001
1993			
GP	0.96	0.93 – 0.99	0.04
Optometry	0.081	0.02 – 0.33	<0.0001
HDL-c[†]	0.12	0.02 – 0.84	0.03
Retinal Ph[§]	9.13	0.34 – 241.7	0.19
1994			
S&CP	0.86	0.77 – 0.96	0.006
Optometry	0.19	0.07 – 0.49	0.001
HbA1c[±]	0.49	0.30 – 0.82	0.007
HDL-c	0.47	0.09 – 2.54	0.38
1995			
Optometry	0.17	0.06 – 0.45	<0.0001
HDL-c	0.27	0.07 – 1.05	0.06
Retinal Ph	718.3	0.000 – 1.3[16]	0.67
1996			
Optometry	0.15	0.05 – 0.41	<0.0001
Retinal Ph	0.13	0.02 – 0.87	0.03
1997			
Optometry	0.11	0.04 – 0.35	<0.0001
HDL-c	0.10	0.02 – 0.53	0.007
Retinal Ph	20.9	1.56 – 280.5	0.02
1998			
Optometry	0.23	0.11 – 0.51	0.01
HDL-c	0.12	0.02 – 0.62	0.01
1999			
S&CP	1.09	1.02 – 1.16	0.01
Optometry	0.29	0.14 – 0.60	0.001
HbA1c	0.72	0.49 – 1.03	0.07
HDL-c	0.21	0.07 – 0.59	0.003
Retinal Ph	62.3	4.1 – 935.3	0.003
Microalbumin	4.16	2.22 – 7.81	<0.0001

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall $\chi^2 = 742.7$, 25 df, $p < 0.0001$.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests,
[‡] Specialist and consultant physician attendances
[§] Retinal photography.

Table 9.11 Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (RRMA 3)

YEAR Risk factor	OR	95% CI	P
Gender*	0.48	0.36 – 0.65	<0.0001
Dx before 2000[Γ]	0.22	0.15 – 0.31	<0.0001
1993			
GP	0.92	0.90 – 0.95	<0.0001
S&CP[‡]	0.93	0.86 – 1.01	0.10
Optometry	0.36	0.23 – 0.55	<0.0001
HDL-c[†]	0.13	0.03 – 0.54	0.005
Retinal Ph[§]	3.65	0.88 – 15.1	0.07
1994			
S&CP	0.96	0.92 – 1.01	0.15
Optometry	0.19	0.11 – 0.33	<0.001
HDL-c	0.32	0.09 – 1.10	0.07
Retinal Ph	2.62	0.33 – 20.7	0.36
1995			
S&CP	0.88	0.82 – 0.95	0.002
Optometry	0.32	0.21 – 0.49	<0.0001
HDL-c	0.12	0.04 – 0.37	<0.0001
Retinal Ph	6.78	1.08 – 42.5	0.04
1996			
S&CP	0.89	0.83 – 0.95	0.001
Optometry	0.27	0.17 – 0.45	<0.0001
HDL-c	0.09	0.03 – 0.31	<0.0001
Retinal Ph	10.9	0.92 – 129.5	0.06
1997			
Optometry	0.29	0.19 – 0.46	<0.0001
HDL-c	0.09	0.04 – 0.26	<0.0001
Retinal Ph	3.77	0.86 – 16.6	
1998			
GP	1.02	0.99 – 1.05	0.08
S&CP	0.95	0.91 – 0.99	0.02
Optometry	1.29	0.19 – 0.44	<0.0001
HbA1c[±]	0.81	0.64 – 1.02	0.08
HDL-c	0.21	0.09 – 0.49	<0.0001
1999			
GP	1.03	1.001 – 1.05	0.04
Optometry	0.19	0.12 – 0.31	<0.0001
HbA1c	0.78	0.62 – 0.99	0.04
HDL-c	0.05	0.01 – 0.19	<0.001
Retinal Ph	24.8	4.72 – 130.6	<0.0001
Microalbumin	1.94	1.27 – 2.97	0.002

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 = 1850.9, 33 df, p <0.0001.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§]Retinal photography.

Table 9.12: Logistic regression analysis predicting laser therapy in 2000 using demographic characteristics, and health care utilisation between 1993 and 1999 (RRMA 4)

YEAR Risk factor	OR	95% CI	P
Dx before 2000[Γ]	0.16	0.01 – 1.7	0.12
1993			
GP	0.94	0.78 – 0.13	0.94
1995			
Optometry	0.006		0.99
1996			
Optometry	1.17[29]		0.99
HDL-c[†]	2.68[10]		0.99
1998			
S&CP[‡]	2.35[14]		0.97
1999			
S&CP	115328.8		0.98
Microalbumin	1.57[30]		0.98

Reference group = controls, *reference group = female
[Γ]reference group = not diagnosed.
Model overall χ^2 = 191.9, 7 df, p <0.0001.
[±]Haemoglobin A1c tests
[†] HDL cholesterol tests
[‡] Specialist and consultant physician attendances
[§] Retinal photography.

Discussion

There appear to be two distinct geographic populations in Australia with regard to diabetes: that is those who live in metropolitan areas and those who live in rural or remote localities. Whilst diabetes appears to be a greater problem in metropolitan areas it may be more severe in rural and remote localities. This could be a result of a greater concentration of people at high-risk of diabetes in urban populations along with poorer metabolic control and poorer access to health care services in non-metropolitan localities.[33]

Access to health care, which has been identified as a major health issue in rural and remote populations, was a complex phenomenon in this study. Whilst geographic remoteness was found to be an important factor in determining the level of health care utilisation, many individuals appeared to be able to overcome remoteness as a barrier. This is evident in that the timing of diagnosis was comparable between RRMA groups, as was the proportion of controls that attended GPs. In addition, the proportion and frequency of GP and specialist attendances and HbA1c testing was lower among metropolitan cases than it was among controls from remote areas. This suggests the level of health care utilisation was not solely determined by proximity to health care services, but also by factors that are more general across the population such as patients' self-efficacy and the organisation of the health care system.[151]

In addition to examining the factors that determine health care utilisation, the study also provided further insights into the changing nature of diabetes care. In

Chapter 4, it had been found that there had been a shift from GPs to specialists in the management of diabetes over the study period. However, the univariate analysis in the current study shows that this phenomenon may have been confined to metropolitan and outer metropolitan areas. This is evident in that in remote localities the utilisation of *both* GPs and specialists increased. Thus in metropolitan areas there may have been a greater specialisation of diabetes management, whilst in rural and remote localities both types of practitioners became more involved in diabetes.

Whilst the lower risk of diabetes complications found in metropolitan and outer metropolitan areas may be indicating the benefits of specialisation, there may be other factors at play where the higher use of specialists did not result in a lower risk of diabetes complications shown in other chapters. Hence, the advantage in metropolitan areas may relate to some aspect of health status, lifestyle or health care that is protective of complications in more populous localities.[279]

Table 9.8 reveals that the risk of complications increased as people with diabetes lived further away from metropolitan locations (although this relationship was not statistically significant). However, risk factors for diabetes complications did not appreciably change across RRMA groups (Tables 9.9 to 9.12). This suggests that the factors that increase the risk of diabetes complications in remote areas were similar to those that operated in metropolitan populations and that there may have been structural characteristics of the health care system that affected all groups.[354]

In conclusion, the study supports previous chapters findings that health care utilisation determined the risk of diabetes complications. However, in this study this relationship was found in all geographic locations. Thus despite the evidence concerning access to care in rural and remote localities, a consistent pattern of disadvantage associated with geographic isolation was not found. This suggests that access to health care is a problem that is uniform among rural and remote populations[33] but that other factors, such as patients' self- efficacy[151] and the characteristics of health care systems,[173] are stronger determinants of effective diabetes care than proximity to health care services.

Chapter 10

Do the characteristics of GPs determine the risk of complications?

Abstract

OBJECTIVES: There is substantial evidence that the characteristics and behaviour of GPs are important factors that determine the quality of care. However, few studies have been able to link these factors to the development of health outcomes such as diabetes complications. In this study, the relationship between provider characteristics and diabetes outcomes in patients is explored. The study aimed to determine whether the characteristics of GPs could explain the development of complications in their patients.

METHODS: 4256 GPs who had exclusively treated cases in 1999 were compared to 4499 GPs who had exclusively treated controls, and 3526 GPs who had treated both groups, in this same year. The factors examined included the demographic characteristics and skills of GPs, as well as the location of their principal practice. The information was obtained from the Australian Medicare database.

RESULTS: Close to 50% of Australian GPs were involved in the treatment of cases and controls. One-third exclusively treated cases, one-third exclusively treated controls and another third treated both groups. The average age of practitioners was 47.3 years (sd = 11.7), this did not differ by group, and the overwhelming majority were male. With regard to the location of principal practices, more GPs of cases served in lower socio-economic areas (19.1% of case GPs vs 17.7% of controls in SEIFA 1), however, the largest group was those who treated both cases and controls (24.1%), $P<0.0001$. In affluent areas (SEIFA 5), control practitioners dominated, with 22.4% vs 20.2% of case practitioners and 16.5% of those who treated both, $P<0.0001$. With regard to geographic isolation, case practitioners were more likely to serve in rural and remote localities (3.1% in RRMA 4 and 23.1% in RRMA 3), compared to controls (1.7% in RRMA 4 and 22.9% in RRMA 3), and those who treated both (1.7% in RRMA 4 and 21.2% in RRMA 3), $P<0.0001$. With regard to the quality of care, the lowest proportion of vocationally registered GPs was in the case group (83.8%), which compared to 85% of control practitioners and 87.0% of those who treated both, $P<0.0001$. To identify the factors that differentiate case from controls GPs, a logistic regression analysis was conducted. The strongest risk factors were vocational registration (less in cases), serving high socio-economic areas (less in cases), and serving in remote locations (more in cases). This model was highly significant ($P<0.0001$).

CONCLUSIONS: There were a number of factors that were found to differ between the GPs of cases and controls. In addition, these factors often reflected the risk factors for vision-threatening retinopathy in cases. However, data on the providers of diabetes care available in the Medicare system were limited. This meant that it was impossible to determine the significance of the provider characteristics for the development of diabetes complications.

Introduction

In the previous chapters the relationship between patterns of care and the risk of advanced diabetes complications has been extensively explored. This included investigations at the national level, within states, for high-risk groups, by socio-economic status and level of geographic isolation. In each of these studies it was found that people who developed diabetes complications had significantly lower levels of health care utilisation than those who remained free of the condition. They had also generally been diagnosed with diabetes later than unaffected controls.

In the literature review (Chapter 2) the role of the health care system in governing the standard of diabetes management was discussed. Part of this discussion referred to the characteristics of practitioners as important factors in quality of diabetes management.[41, 334, 338, 355] However, in the epidemiological evidence on which much of this argument was based, there has been a failure to link the characteristics of practitioners to the development of the health status of their patients. Thus little is known at present about the relationship between the characteristics of practitioners and the development of diabetes outcomes.

In this study, the GPs of cases are compared to those of controls to examine the seventh and final research question in the thesis: whether there were any characteristics of GPs that could be related to the development of vision-threatening retinopathy in patients.

Methods

To examine the relationship between GP characteristics and the development of diabetes complications, a population-based case-control study was used.[331] The study population consisted of GPs who had made a Medicare claim for a general practice service in 1999 (these were identified by whether practitioners had claimed for items in schedules A1 and A2 of the MBS).[206] Once these practitioners had been identified, GPs who had been attended by a subject included in the sample captured in Table 4.2 were selected to be included in the study. The linkage of GPs to patients was conducted through patient records as each Medicare claim includes information on both the patient and the provider.[206] Once the GP sample had been chosen, the demographic characteristics, accreditation status and the location of their principal practice were collected from the Medicare database. The data items used in the study are presented in Table 3.2.

In the univariate analyses, which compared case to control practitioners, as well as to those who treated both, proportions were compared using χ^2 tests and frequencies by analysis of variance (the Bonferroni adjustment was used to account for type 2 error).[342] The multivariate analysis in Table 10.2 was conducted using logistic regression, which used a stepwise process with backwards conditional as the variable selection method.[342] Socio-economic status was entered as four dummy variables and RRMA as three dummy variables in Table 10.2. All statistical analyses were performed using SPSS for Windows 11.5.[343]

Results

CHARACTERISTICS OF GPS AND THEIR PRACTICES

Table 10.1 shows that there were 12,283 GPs involved in the care of cases and controls in 1999. In 1998-99, it was estimated that there were 24,176 providers of general practice care who billed Medicare in those years.[d] Thus the sample consisted of about 50% of the providers of general practice services in Australia at that time.[254]

GPs were ascribed to one of three groups based on whether they had been attended by cases exclusively, controls exclusively or by both groups, with roughly one-third falling into each group (Table 10.1). When the groups were compared, case GPs were more likely to be male and to be overseas trained than control GPs, although, these factors were highest in GPs who had been attended by both cases and controls. However, case GPs were the least likely to have vocational registration.

With regard to the principal medical practice, case GPs were more likely to work in low socio-economic areas than those of controls, although this was highest in GPs who had been attended by both cases and controls. However, case GPs were the most likely to work in geographically remote locations (RRMA 4).

[d] Providers of general practice services include vocationally registered GPs and other medical practitioners (OMPs). OMPs include non-vocationally registered GPs as well as other medical practitioners who provide some general practice services (although they are not vocationally registered as GPs).

Table 10.1: Characteristics of GPs and their practices

	Case	Control	Both	P of differences
Age, mean (sd)	47.3(11.7)	46.9 (11.4)	47.1(11.0)	0.33
Gender n (% male)	3103(72.9)	3110(69.1)	2849(80.8)	<0.0001
Vocational registration, n (%)	3567 (83.8)	3850(85.6)	3067(87.0)	<0.0001
Overseas trained, n (%)	1192 (28.0)	1149(25.5)	1043(29.6)	<0.0001
SEIFA 1, n (%)	815 (19.1)	796(17.7)	850(24.1)	
SEIFA 2, n (%)	907(21.3)	863 (19.2)	682(19.3)	
SEIFA 3, n (%)	822(19.3)	892(19.8)	736(20.9)	
SEIFA 4, n (%)	853 (20.0)	939(20.9)	677(19.2)	
SEIFA 5, n (%)	861(20.2)	1009(22.4)	581(16.5)	<0.0001
RRMA 1, n (%)	2833 (66.5)	3019(67.1)	2375(67.4)	
RRMA 2, n (%)	310 (7.3)	360 (8.0)	345(9.8)	
RRMA 3, n (%)	983(23.1)	1030 (22.9)	747(21.2)	
RRMA 4, n (%)	132 (3.1)	90 (1.7)	59 (1.7)	<0.0001
Total, n (%)	4258(34.7)	4499(36.6)	3526(28.7)	12283

PREDICTING WHETHER GPS TREATED CASES OR CONTROLS

The relationship between GP characteristics, vocational registration, the location of the principal medical practice and the development of diabetes complications was examined using a multivariate logistic regression model. This is captured in Table 10.2. As the factors that differentiate case GPs from control GPs was the primary focus of the study, GPs who had been attended by both groups were excluded from the analysis.

In this model it was found that the strongest predictors of vision-threatening retinopathy were whether GPs were older, whether they had been vocationally registered, and whether their major medical practice was in a low socio-economic or a non-metropolitan locality.

Table 10.2: Logistic regression analysis comparing case to control GPs using demographic characteristics, vocational registration and characteristics of principal general practice (GPs who treated both groups excluded, n = 3184)

RISK FACTOR	OR	95% CI	P
Age	1.004	1.0 – 1.008	0.04
Vocational reg*	0.87	0.77 – 0.98	0.02
SEIFA 1†	1.0		0.18
SEIFA 2	1.08	0.94 – 1.24	0.27
SEIFA 3	0.93	0.81 – 1.07	0.29
SEIFA 4	0.92	0.80 – 1.06	0.26
SEIFA 5	0.85	0.74 – 0.98	0.03
RRMA 4 Remote‡	1.0		0.02
RRMA 3	0.67	0.50 – 0.89	0.009
RRMA 2	0.61	0.44 – 0.83	0.002
RRMA 1 Metropolitan	0.69	0.52 – 0.91	0.005

Reference group = controls, *reference group = not registered,
† reference group = lowest SEIFA,
‡ reference group = RRMA 4
Model overall $\chi^2 = 33.1$, 9 df, $p < 0.0001$.
N = 8469 (case practitioners = 4114, Control practitioners = 4355)

Discussion

The study examined the relationship between GP characteristics and the development of vision-threatening retinopathy using records contained in the Medicare database. A number of factors were found to differ between the GPs of cases and controls which may have been associated with the development of diabetes complications.

Perhaps the most clinically significant finding concerned the lower proportion of vocational registration among the GPs of cases compared to control GPs and those who treated both groups. Vocational registration is an accreditation scheme for GPs that aims to ensure certain standards of care.[254] These findings are consistent with studies that have compared register practitioners to non-register practitioners, and have found that registered practitioners provide higher quality care.[334]

In addition, Table 10.2 shows that the strongest predictor of vision-threatening retinopathy was whether GPs practised in remote or rural locations. This accords with the Australian and international literature that has found diabetes complications to be more common in geographically isolated areas.[33, 283] In addition, Table 10.2 shows that case GPs were also more likely to work in lower socio-economic areas. Again this is consistent with evidence linking social disadvantage with poorer health outcomes.[22, 265, 279]

When these findings are considered in the light of Chapters 4 to 9 there are a number of striking parallels between them, despite the very different methods used in the studies. When Table 10.2 is compared to 9.8 a similar differential in the risk of diabetes complications is apparent among isolated populations (although in Table 9.8, the relationship is non-significant). Similarly, when Table 10.2 is compared to Table 8.8, a gradient in risk of complications is associated with socio-economic status (again not significant). This supports the patient data that also found these social and geographic factors to be risk factors for diabetes complications.

With regard to vocational registration, which can be interpreted as a crude indicator of the knowledge and skills of GPs,[334] the lower level of vocational registration among case GPs may be linked to the pattern of under-referral and under testing that is the hallmark of poorer quality care evident among cases.

However, this study also contains a number of important limitations that must be considered when interpreting the findings. Firstly, the data did not identify the level of involvement of individual GPs in the care of patients: thus practitioners who were attended once were given equal weight to those attended multiple times. Whilst the care they provide may have ranged from a single episode to intense clinical involvement, the data did not allow this distinction to be made. Secondly, GPs were chosen only from 1999, whereas records from one year may be insufficient to represent how GPs provide diabetes care. Finally, there was a very limited number of risk factors available for examination in the study, so a large number of potential determinants could not be included in the analysis.[172]

This meant that the study could only provide a very crude account of the association between GPs and the development of diabetes complications and further research is needed to validate these findings.

In the context of these limitations, the findings indicate that the characteristics of practitioners may have played a role in the development of complications and this may relate to the nature of medical care provided to cases versus controls. However, because these data and methods were limited the significance of provider characteristics in the development of complications could not be determined. The major usefulness of the study to the thesis is that it confirms a number of findings in other chapters, namely the greater risk of advanced complications in lower socio-economic groups and in remote areas. In addition, the study also reinforces the contention of the importance of providing high quality of care in the management of diabetes.

Chapter 11

Discussion

Structure of the discussion

The studies in Chapters 4 to 10 represent a comprehensive examination of the capacity of the Australian health care system to manage diabetes, based on an analysis of the relationship between patients' patterns of care and the health outcome of vision-threatening retinopathy. The discussion brings together these findings and identifies the key messages of the thesis. The first section summarises the major findings of each of the seven studies. In Section 2 these findings are integrated and the key findings identified. Section 3 discusses the major implications of the thesis for the health care system to enable it to effectively and equitably manage diabetes.

Section 1: Major findings of research questions

RESEARCH QUESTION 1

To determine whether patterns of primary health care utilisation are a risk factor for the development of diabetes complications in the population with diabetes in Australia.

The first study in this thesis showed that diabetes patients who developed vision-threatening retinopathy had significantly lower levels of diabetes related health care utilisation across almost all of the aspects of primary and secondary care that were examined. Overall, those who developed vision-threatening retinopathy had a pattern of care that included delayed diagnosis, lower levels of medical care attendances, under-testing for diabetes related pathology tests and under-referral to specialists and optometrists over a seven-year period when compared to those who did not develop this complication.

A second major finding was the under-utilisation of GPs among those who developed vision-threatening retinopathy, and the study suggests both quantitative and qualitative dimensions to this risk factor. On the quantitative dimension, the number of attendances at GPs may have been critical in determining the quality of care and the progress of diabetes, as GP attendance enables access to most aspects of diabetes management.[39]

In addition, qualitative differences in care are suggested by the major disparities in testing for HDL cholesterol between cases and controls. The significance of this test lies in its specificity to glucose metabolism conditions and its rare use for other disorders.[22] However, HDL-cholesterol is a less commonly used

pathology test for identifying dyslipidaemia in diabetes. The most common tests used for this purpose are LDL or total cholesterol.[22] Therefore, its use can be regarded as a marker of a greater understanding of diabetes among the practitioners who use it. These findings suggest that there were deficiencies in provider behaviour perhaps explained by a lack of time or even poor competency, and that this may have contributed to the development of vision-threatening retinopathy.

RESEARCH QUESTION 2

To determine whether state and territory health care systems determine the effectiveness of diabetes management.

The second study found significant differences between cases and controls with regard to the timing of diagnosis and the patterns of care that were consistent across states and territories. This finding suggests that similar factors were involved in the development of advanced diabetes complications in all jurisdictions. This is despite the likelihood that patients had obtained some of their care in state and territory health care systems that may have had different methods for managing diabetes.[173]

Where differences between states and territories were identified, these were often difficult to relate to the risk of vision-threatening retinopathy. For example, differences in specialist attendances between jurisdictions, as well as in HbA1c testing were not associated with a higher risk of retinopathy. Again this suggests that despite differences in health care systems, the medical care provided may

have been of a very similar nature across all jurisdictions, although it may have been delivered by different combinations of health care practitioners.

Noteworthy differences in the combinations of health care practitioners were identified in the states and territories. For example, in states where specialists and consultant physicians played a greater role in patients' care, this was matched with higher levels of GP utilisation. Conversely, in jurisdictions where specialists played a lesser role, GPs were also utilised less. This suggests that the greater utilisation of one type of practitioner tends to increase the use of others (Tables 5.3 and 5.5). Nevertheless, higher levels of utilisation did not necessarily lead to fewer occurrences of vision-threatening retinopathy.

When states and territories were compared using logistic regression analysis, some differences in the risk of diabetes complications between jurisdictions became apparent. People with diabetes in Victoria, Queensland and Tasmania were found to be at a higher risk of developing complications. However, when major risk factors for complications were compared between jurisdictions (GP, specialist attendances as well as HbA1c testing), no marked differences were evident. This suggests that risk factors for complications were very similar in each state and territory and that the factors that determined the effectiveness of diabetes management related to the health care system at the national level.[173]

RESEARCH QUESTION 3

To determine whether patterns of care or delayed diagnosis is the more significant risk factor for the development of diabetes complications in the population with diabetes in Australia.

Significant differences were found in the patterns of care for cases and controls in this third study. Selection of subjects on the basis of having been diagnosed with diabetes prior to 1995 allowed for an investigation of the impact of diabetes management in an early-diagnosed group. That patterns of care were found to be a risk factor for advanced complications points to the importance of the quality of diabetes management in preventing these conditions. The study showed that whilst early diagnosis was desirable, it was only beneficial if it initiated appropriate diabetes management over time. Where this did not occur, patients remained at risk of developing advanced complications such as vision-threatening retinopathy.

RESEARCH QUESTION 4

To determine whether patterns of care prior to the diagnosis of diabetes is a risk factor for the development of diabetes complications in Australia.

The fourth study showed that patterns of care predicted the development of complications in patients with a delayed diagnosis. This suggests that health care utilisation prior to the diagnosis of diabetes may have been a significant risk factor for the development of advanced diabetes complications.[36]

The difference between cases and controls was similar to that found in the previous study. This suggests that similar factors may be involved in determining health care utilisation both preceding and following diagnosis. This points to the

utilisation of health care being a somewhat stable characteristic of patients, and not totally determined on the basis of need.[354]

In an attempt to explain differences between case and control groups in this study, socio-economic status was entered as a risk factor into the logistic regression model in Table 7.4. These findings indicated that of people with diabetes who do not have a diagnosis, those who are of low socio-economic status are at higher risk of developing advanced complications.

RESEARCH QUESTION 5

To determine whether socio-economic status is a risk factor for diabetes complications in Australia

The fifth study showed that there was a greater risk of complications in lower as compared to higher socio-economic groups. This was evident in the univariate analysis and the logistic regression model, although in the latter, socio-economic status was not significant. This accords with a large body of evidence concerning the association between socio-economic status and diabetes.[270, 272, 273]

When the findings are considered in the light of the studies reported in Chapters 6 and 7, they may be explained by socio-economic status being influential in the late diagnosed group, but not in the early diagnosed population. Thus in investigating the relationship between socio-economic status and advanced diabetes complications across the diabetes population, the strong relationship evident in Chapter 7 in the late diagnosed group was diluted as socio-economic status was not related to complications in other populations.

However, the nature of this greater risk in lower socio-economic groups is difficult to determine as low status patients made more use of GPs than higher status groups and were tested for HbA1c more often. The major difference between the groups concerned the higher use of specialists by higher status patients. This suggests that greater specialisation in diabetes care could lead to the reduced risk of advanced complications.[349]

On the other hand, the benefits of specialisation were not borne out by the other studies that were able to investigate this aspect of care. For example, the greater use of specialists in particular states did not reduce the risk of complications in Chapter 5. This suggests that the lower risk of advanced complications in high socio-economic groups may be related to some other factor or factors that were not included in the study. For example, it may be that diabetes was less severe in high status groups or that they had a greater capacity to manage the condition. Whilst higher status groups could have had better self-management, this is not supported by the broader epidemiological literature.[154]

RESEARCH QUESTION 6

To determine whether geographic isolation is a risk factor for diabetes complications in Australia.

There appear to be two distinct populations in Australia with regard to geographic isolation and diabetes: those who live in metropolitan areas and those who live in rural or remote localities, as these two groups face different levels of risk of developing diabetes complications.[33] In this study a greater proportion of controls were found in more populous areas and more cases were found in

comparatively isolated localities. This suggests that diabetes may be more prevalent in metropolitan areas, but more severe in rural and remote localities. Hence, people with diabetes in more isolated localities may be at higher risk of developing advanced diabetes complications (although in the multivariate analysis the relationship was found not to be significant).[33]

A principal concern with regard to geographic isolation relates to poor access to health care. Whilst geographic isolation was identified as a major risk factor in the study, its relationship to the development of advanced complications was complex. While rural and remote populations had lower levels of health care utilisation, this was not true for other risk factors included in the study. This suggests the level of health care utilisation was not solely determined by proximity to health care services, but also by factors that are more general across the diabetes population, such as low self-efficacy and poor self-management.[151] It is probable that the factors that determine the development of advanced diabetes complications in rural and remote localities are very similar to those of the broader Australian population.

Whilst the lower risk of diabetes complications found in metropolitan, outer metropolitan and rural areas may be indicating the benefits of specialist care, similar to the findings above, higher levels of such care do not automatically lead to a reduction in the risk of complications, as was discussed above. Hence, the advantage for people with diabetes who live in metropolitan areas may not just lie in having the greater utilisation of more knowledgeable practitioners, it may

also be explained by better overall health status, or perhaps some element of lifestyle that is protective of complications in more populous localities.[279]

RESEARCH QUESTION 7

To determine whether the characteristics of GPs are associated with the risk of complications in Australia.

The study in Chapter 10 represents a substantial departure from the preceding six studies in that it used provider data to examine risk factors for the development of advanced diabetes complications. It sought to examine, whether, and if so which, GP characteristics determine the risk of developing vision-threatening retinopathy.

The study found that there were many similarities between the GPs of cases and those of controls. Indeed in many cases, the greatest difference in GPs concerned practitioners who had treated both types of patient. Whilst the data used in this study were limited, a number of significant factors emerged in the statistical analyses that could be related to the development of advanced diabetes complications in patients.

Perhaps the most significant factors related to the geographic location of the principal general practice: the GPs of cases were more likely to practise in low socio-economic and rural and remote localities than the GPs of controls. This accords with the patient findings in studies in Chapters 6 to 9, which found that people with diabetes of lower socio-economic status, as well as those who lived in rural areas, were at a higher risk of developing advanced complications.

Another notable characteristic that could be related to the development of advanced complications was vocational registration. As vocational registration is potentially an indicator of the level of skills and knowledge of GPs with regard to the provision of primary health care, the GPs of cases may have been less skilled or knowledgeable than those of controls.[334] Whilst a more comprehensive indicator of the knowledge and skills of GPs would be needed to validate this finding, they accord with some of the findings in the patient studies, which also included a proxy indicator for the skills and knowledge of GPs, HDL-cholesterol testing as was discussed in Chapter 3. Together, these findings suggest that case GPs were less skilled and knowledgeable than control GPs and that this may have led to an increased risk of advanced diabetes complications.

Section 2: Key messages and implications

Together the studies comprising this thesis represent an evaluation of the capacity of the Australian health care system to manage diabetes. Major differences between cases and controls were found in respect of this capacity. These related to patients' patterns of care, the timing of diagnosis and equity. Key messages and implications in respect of the findings are explored below.

PATTERNS OF CARE AND THE RISK OF ADVANCED DIABETES COMPLICATIONS

The consistency of the relationship between patterns of care and diabetes complications found in the studies suggests that people who develop advanced complications are a distinctive group with long-term and sustained problems associated with diabetes management and health care utilisation. These difficulties transcend state and territory borders as well as socio-economic status and level of geographic isolation, and suggest the need for a national and consistent approach to the management of diabetes so that the system can be both equitable and effective.

The differences in the patterns of care between those that developed an advanced complication and those that did not were reflected in cases' under-utilisation of GPs, specialists and pathology tests over a seven-year period, and these differences were common across each of the studies comprising the thesis. As well as revealing stark quantitative differences in levels of care, the findings also point to qualitative differences in the nature of care as important. Qualitative

differences were suggested by the lower level of HDL-cholesterol testing among cases in Chapters 4 to 9, and the lower level of vocational registration among the practitioners of cases found in Chapter 10. The qualitative differences suggest that even where patients have adequate access to health care they may still be disadvantaged with regard to diabetes management.[353]

When the logistic regression analyses are considered the most important aspects of diabetes care for the prevention of complications become apparent. In the majority of these analyses, the smallest odds ratios belong to optometry attendances and HDL-cholesterol attendances, indicating that these measures are most strongly associated with the prevention of advanced diabetes complications.

The significance of optometry attendances is likely to be pointing to the importance of screening for retinopathy,[79] and this was reinforced by the odds ratios for specialist attendances in the models, which were also higher in controls and include visits to ophthalmologists. Whilst the significance of HDL-cholesterol testing may lie in its relative obscurity as an aspect of diabetes management, use of this test suggests a more sophisticated understanding and approach to diabetes management on the part of practitioners.[353] As patients who received this test may also have been more likely to obtain other testing and monitoring included in the guidelines, it may be an indicator of overall better diabetes care.

However, the clinical literature suggests that HbA1c testing is the most important test, as it is directly related to hyperglycaemia.[207] But the differences in HbA1c

testing between cases and controls were not as great as between the two previous risk factors. This suggests that most doctors understand the significance of HbA1c, but fail to understand the importance of the other elements included in the clinical management guidelines such as HDL-cholesterol testing.

Another important finding was captured in Tables 6.3 and 7.3, which presented the univariate analyses of health care utilisation of two different sub-groups. Table 6.3 presented results from the early-diagnosed group, and Table 7.3, results from patients whose diagnosis had been delayed. These studies could be considered to be comparing two different phases in the development of diabetes.

These analyses showed that the differential in the frequency of GP attendances between cases and controls was of a similar magnitude in both the pre-diagnosis (Chapter 7) and post-diagnosis periods (Chapter 6), with cases attending between a half and a third less often than controls. In addition, there were consistent differences in specialist attendances.

When the pre-and post-diagnosis periods are compared, the findings suggest that the disadvantage experienced by cases in respect of diabetes management may have its origins in the earlier period.[25, 36] This suggests that cases may belong to a group that is generally disadvantaged with regard to the utilisation of health care and that the development of advanced diabetes complications is largely due to pre-diagnosis experiences.

Whilst it is difficult to determine the factors that separated cases from controls in respect of patterns of care, Pringle et al. have argued that the management of chronic disease is determined by a number of sets of factors: those related to practitioners, to patients and to the health care system. While there is some evidence that all three are at play in the findings of the studies comprising the thesis, in the literature review it was argued that the most significant factor that determined the standard of diabetes care across the population is the nature of the health care system.[172] This is supported by the literature that formed the basis for Wagner et al.'s Chronic Care Model and which provided sound evidence that where the health care system has a greater focus on acute conditions, the standard of diabetes management is poor.[196] However, where greater structure is provided, the standard of diabetes care is much improved.[197]

Wagner et al.'s Chronic Care Model, detailed in the literature review, emphasises the need for infrastructure to support planned and systematic care.[38] The infrastructure that has been found to be most effective in this regard are diabetes registers, reminder and recall systems. Whilst this type of infrastructure has only been introduced in a very limited way in Australia,[190] other less tangible factors that are linked to the structure of the system may also play a role in the effectiveness of diabetes management. For example the value of continuity of care in the management of diabetes has been well demonstrated,[364] and controls may have been more likely to have a regular diabetes doctor.

The findings indicate the need for measures to improve health care utilisation in patients who are disadvantaged in this regard, as well as both the quantity and

quality of health care for people with diabetes. With regard to the former, factors that have been found to lead to lower levels of health care utilisation include socio-economic, gender and ethnicity characteristics, as well as the poor supply of GPs.[354] The Australian and international literature demonstrates the importance of addressing these and other barriers to care.[365]

Perhaps the primary contribution of this thesis is in illuminating the differences and consequences of the patterns of care. Whilst low levels of health care utilisation have been identified before in studies of diabetes,[22, 183] few have been able to link actual health care utilisation to the development of an advanced complication. As cases were found to have significantly lower levels of health care utilisation and pathology testing, the thesis provides a strong argument for the development of strategies to increase their engagement with the health care system.

Since the period selected for the present analysis, measures have been introduced to improve diabetes management in Australia. Use of the clinical management guidelines is now supported by their formal incorporation into Medicare schedules under the Practice Incentive Program and Service Improvement Programs,[174] where GPs are now paid to manage diabetes on an annual basis. However, this initiative has not yet been evaluated in terms of its capacity to prevent diabetes complications. The studies comprising this thesis would provide a useful baseline for the evaluation of these measures.

DELAYED DIAGNOSIS AND THE RISK OF ADVANCED DIABETES COMPLICATIONS

Over fifty-percent of patients in this thesis who developed vision-threatening retinopathy may not have been diagnosed with diabetes prior to the development of their advanced complication. This suggests that a significant proportion of people with diabetes received delayed diagnosis.

The risk associated with delayed diagnosis stems from the nature of medical care in the period prior to diagnosis, as during this period patients would not have been having their diabetes managed. The association between delayed diagnosis and advanced complications observed in this thesis is consistent with the clinical evidence presented in the literature review that shows that the benefits of screening and monitoring, as represented in the clinical management guidelines, are only forthcoming when the preventive interventions are initiated early and sustained over the duration of diabetes.[12] In the absence of diagnosis there is no means by which diabetes management and the prevention of complications can occur.

With regard to the factors associated with delayed diagnosis, the study points to a number of possible explanations. Firstly, the level of health care utilisation among cases was much lower than that of controls, pointing to a reduced opportunity for cases to obtain a diagnosis. In addition, practitioner related factors such as the characteristics of GPs may have played a role. In the studies in Chapters 4 to 10, there were signs that the practitioners of cases were less knowledgeable and skilled with regard to diabetes.[41, 353] In addition, they may

have had limited incentives to identify diabetes especially where this condition is not the presenting problem.[38] In conventional medicine, where the system is structured around acute illnesses, GPs tend to deal with the problem at hand thus limiting opportunities for more holistic or preventive health care.[38] The thesis also points to the significance of lower socio-economic status being a factor in delaying diagnosis, which is discussed below.

Whilst the majority of people with diabetes in Australia received timely diagnosis, as indicated by the more even spread of earliest HbA1c testing in control subjects across the study years in Table 4.2, there appears to be a sizeable minority of patients who are disadvantaged because their diagnosis was delayed. This group would potentially benefit from strategies to bring forward the time of diagnosis, thus enabling diabetes management to be initiated earlier.[357, 360]

This is the first time a population-based study has shown a link between delayed diagnosis, health care utilisation and the development of an advanced diabetes complication in Australia. Whilst the study shows that delayed diagnosis represents a considerable threat to the health of people with diabetes, it also shows that it is not a general problem across the diabetes population. This suggests that programs promoting early diagnosis could be targeted at high-risk populations.

EQUITY AND DIABETES MANAGEMENT

This thesis examined in detail two important dimensions of equity in respect of the development of advanced diabetes complications: socio-economic status and geographic isolation. A third aspect of equity, Aboriginal and Torres Strait Islander health was also investigated, although in a more limited way.

A number of studies in the thesis investigated the relationship between socio-economic status and the development of advanced diabetes complications, but perhaps the most significant findings occurred in Chapters 6 and 7.

In these chapters socio-economic status was entered into a logistic regression analysis in order to explore its significance as a risk factor for advanced diabetes complications. In the study in Chapter 7, which examined patients whose diagnosis had been delayed, lower socio-economic status was found to be an important risk factor for the development of advanced complications. Indeed, patients of lower socio-economic status and who received a delayed diagnosis were almost twice as likely to develop advanced diabetes complications than similar patients of higher socio-economic status.

Some of the factors that may account for socio-economic differences in the risk of advanced complications include the quality of care, as lower socio-economic groups have been found to attend specialists less often,[22] to rely more on conventional doctor-patient relationships[305] and are less likely to attend for preventive care.[317, 318] In addition, there are class based cultural and value

differences between GPs and socially deprived patients that can also impact on the quality of care.[41] By contrast, in Chapter 6, which investigated an early-diagnosed group, the risk of advanced complications was found not to be related to socio-economic status.

This suggests that much of the greater burden of diabetes complications in low socio-economic groups may be related to delayed diagnosis, and points to the need for the implementation of early diagnosis strategies among low socio-economic groups.[357] Moreover, and perhaps surprisingly, it indicates that the management of diabetes as it was conducted in the 1990s was able to overcome important social inequalities in diabetes once diabetes had been diagnosed.

The lack of significance of socio-economic status in Table 6.4 suggests that among those who had been diagnosed early, both higher and lower socio-economic groups were able to obtain similar levels of health care for the management of diabetes. It seems likely that the Medicare system, with its goal of equal access to care for equal need, was at work here.[258] As lower socio-economic groups can be vulnerable to high health care costs the subsidies provided by the Medicare system allowed poorer patients access to health care.[366] That this has resulted in comparable levels of risk of advanced diabetes complications across socio-economic groups, points to the value of maintaining the Medicare system as the basis of diabetes management.

With regard to addressing socio-economic disadvantage and diabetes, strategies to improve timely diagnosis should be prioritised. Whilst population screening

for diabetes is often seen as an inappropriate strategy for identifying diabetes,[357] there is some evidence that it may be effective in high-risk groups, such as the low socio-economic patients studied here. Pro-active case finding could be encouraged through programs targeting medical practitioners to get them to more effectively diagnose diabetes.[360]

Even though the thesis may be showing that socio-economic differentials in the risk of vision-threatening retinopathy were addressed by the Australian health care system, the level of diabetes management in the population still appeared to be below that recommended by the clinical management guidelines.[74] This suggests that the population remained at risk of developing advanced diabetes complications, even though for most vision-threatening retinopathy had been avoided in 2000.[12]

Whilst a number of studies have shown that low socio-economic groups have a higher risk of diabetes complications,[32, 161] as well as lower levels of health care utilisation,[22] this is the first study to show that these two factors are linked. Further research on the specific factors at play in preventing people of low socio-economic status being diagnosed with diabetes should inform the development of appropriate strategies to address this inequality in diabetes care.

The second aspect of equity examined in the thesis concerns geographic isolation. The role of geographic isolation as a risk factor for the development of advanced diabetes complications was investigated in Chapter 9, where people with diabetes who lived in remote localities were found to be at twice the risk of

complications than patients who lived in metropolitan or other localities. In addition, the analyses showed that differences between cases and controls found in the earlier studies in this thesis were broadly consistent across all geographic areas. This suggests that the factors leading to the development of complications in remote localities were similar to those that account for complications in metropolitan areas.

However, the study also found that some aspects of health care utilisation, such as delayed diagnosis, were not determined by geographic isolation. This suggests that whilst highly significant, proximity to health care services may not be the absolute barrier to health care that it is often assumed to be.[367, 368]

The introduction of the Chronic Care Model within geographically remote areas represents a significant challenge to the health care system, but if advanced diabetes complications are to be prevented equitably, ways in which to introduce at least some of the model must be found. In the literature review the significance of information technology for improving the quality of care in remote or disadvantaged localities was suggested as one way in which the management of diabetes could be improved in these settings.[249]

Whilst only a relatively opaque examination of the role of patterns of care and the development of complications among Aboriginals and Torres Strait Islanders was able to be conducted due to limitations in the Medicare data, the findings reaffirm that this population is particularly disadvantaged with regard to diabetes.[30] Of most concern was the younger age of people with diabetes in the

Northern Territory, as well as the lower level of health care utilisation in cases in this jurisdiction.

Section 3: Conclusion: How the studies add to the understanding of diabetes management

Having examined such issues as whether diabetes management was adequate during the 1990s, whether the health care system should focus on the management of diabetes or on screening, whether interventions should be concentrated on primary or tertiary care, whether programs should be introduced to promote equity in how diabetes is addressed, and whether medical practitioners need to be better skilled in diabetes care, the studies comprising this thesis have important implications for the management of diabetes in Australia,

Since the findings of the DCCT were published in 1993,[3] the evidence concerning the efficacy of clinical interventions to prevent advanced complications has been very strong.[12] However, because population-based studies of diabetes interventions are rare, it has not been established whether clinical interventions when provided across a population, can be effective in preventing diabetes complications in a national population.[11] This thesis has addressed that gap by showing an association between clinically effective interventions and the prevention of complications.

In addition, in conducting a public health analysis of the effectiveness of clinical interventions, the thesis was able to identify problems with the management of diabetes across the Australia health care system. These problems were found to be related to the standard of diabetes management, as indicated by the patterns of care. In addition, significant equity issues in respect of diabetes care and

outcomes were identified, suggesting the need for particular segments of the population to be prioritised in the provision of diabetes care. Further, in identifying these problems, the studies also pointed to potential strategies by which they could be addressed, such as early diagnosis strategies in lower-socio-economic groups.

Perhaps the strongest finding was the broad need for improvements in the implementation of diabetes management in Australia. The findings were clear that improvements are required in both the quality and quantity of diabetes care. Those subjects that did not develop complications were more likely to utilise care more and to show indicators of having received better quality care. Importantly, whilst cases were shown to be a particularly disadvantaged group in respect of care, the level of health care utilisation in controls indicated that they also received inadequate diabetes management. Whilst the thesis suggested ways in which the diabetes management for cases could be improved, at least to the level of controls, it was not able to determine how the level of management could be optimised across the diabetes population. However, it did demonstrate a need for such improvement.

Some of the most significant factors to consider with regard to reducing the risk of complications concerned low socio-economic status. With regard to addressing this risk factor, the studies suggested that there may be a need for early intervention programs, with a particular focus on low socio-economic groups to ensure more equitable diabetes outcomes in Australia.

In addition, the pre-diagnosis period was found to be highly significant in the development of advanced complications, and two types of strategies were suggested by the findings. For people with diabetes, strategies that promoted timely diagnosis were supported. For the general population, health promotion programs focused on cardiovascular risk factors were also supported as being of potential benefit to people with diabetes.

Some implications also emerged in relation to GP characteristics. While findings suggest that the practitioners of cases may have been less able to manage diabetes than the practitioners of controls, this analysis was not definitive. Moreover, the consistent differences in the patterns of care shown in the studies suggest that the major problem in Australia lies with the health care system and not with the characteristics of practitioners. These findings accord with overseas studies showing that when the health care system is re-oriented towards the provision of chronic disease, the quality of care improves.[277] They also suggest that practitioners are generally capable of providing effective diabetes management if the appropriate structures and incentives are put in place.[197]

Having provided strong epidemiological evidence in support of the need for effective and equitable diabetes management, the task now turns to how the Chronic Care Model can be implemented in Australia. In the literature review, it was argued that the scope of the reform required would represent a significant barrier to the introduction of the model.[258] However, given the findings of these studies, it may have become a bit easier to advocate for its introduction to health care policy makers and professionals.

With regard to addressing diabetes in Australia and the need to focus on particular risk groups, the literature review identified potential problems associated with the implementation of the Chronic Care Model in disadvantaged populations.[237] However, the findings of the studies in this thesis suggest that a focus on socio-economic status may not be necessary with regard to diabetes management (except in respect of promoting earlier diagnosis) as long as access to health care remains comparably equal across socio-economic groups, as is currently enabled through the Medicare system. Whilst establishing the Chronic Care Model in isolated populations will remain a substantial challenge, the findings point to proximity to health services not being an absolute barrier to access to diabetes care that it often assumed to be. This may mean that there is considerable scope for improving the management of diabetes in isolated populations through the health care system as it currently operates.

There is a great opportunity to use diabetes and its related microvascular and macrovascular complications as a vehicle to establish integrated health care models of care. By their very nature these systems would incorporate Commonwealth and state governments and create chronic disease centres that would link the activities of primary and secondary care settings. These centres would also provide the key IT infrastructure that would facilitate communication, information transfer, scheduling and recall systems. A necessary component of these centres would be the provision of training in chronic disease self-management for patients as well as allied health staff that would assist general practice. Finally, this approach would allow for innovative funding models that

would enable and provide incentives to optimise best practice care. If there is no structural reform then the cost of diabetes, secondary to complications of blindness, kidney disease, stroke and heart disease will continue to rise inexorably.

References

[1] Commonwealth Department of Health and Aged Care and Australian Institute of Health and Welfare. National health priority report: diabetes mellitus 1998. AIHW Cat No. PHE 10. Canberra: Commonwealth Department of Health and Aged Care and the Australian Institute of Health and Welfare, 1999.

[2] Bowman BA, Gregg EW, Williams DE, Engelgau MM, Jack L Jr. Translating the science of primary, secondary and tertiary prevention to inform the public health response to diabetes. *Journal of Public Health Management and Practice* 2003; Nov (Suppl): S8-14.

[3] The Diabetes Control and Complications Trial (DCCT) Research Group. Lifetime benefits and costs of intensive therapy as practiced in the Diabetes Control and Complications Trial. *Journal of the American Medical Association* 1996; 276(17): 1409-15.

[4] Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM. Diabetes Prevention Program Research Group. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine* 2002; 346(6): 393-403.

[5] UK Prospective Diabetes Study Group. The efficacy of atenolol and captopril in reducing risk of macrovascular and microvascular complications in type 2 diabetes (UKPDS 39). *British Medical Journal* 1998; 317(7160): 713-20.

[6] Renders CM, Valk GD, Griffin SJ, Wagner EH, van Eijk JT, Assendelft WJ. Interventions to improve the management of diabetes mellitus in primary care, outpatient and community settings. *Cochrane Database Systematic Reviews* 2001; (1): CD001481.

[7] Amos AF, McCarty DJ, Zimmet PZ. The rising global burden of diabetes and its complications: estimates and projections to the year 2010. *Diabetic Medicine* 1997; 14(Suppl 5): S1-85.

[8] Glasgow RE, Toobert DJ, Gillette CD. Psychosocial barriers to diabetes self-management and quality of life. *Diabetes Spectrum* 2001; 14(1): 33-41.

[9] Cramer JA. A systematic review of adherence with medications for diabetes. *Diabetes Care* 2004; 27(5): 1218-24.

[10] Glasgow RE, Lichtenstein E, Marcus AC. Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to-effectiveness transition. *American Journal of Public Health* 2003; 93(8): 1261-67.

[11]Glasgow RE, McKay HG, Piette JD, Reynolds KD. The RE-AIM framework for evaluating interventions: what can it tell us about approaches to chronic illness management? *Patient Education and Counseling* 2001; 44(2): 119-27.

[12] New South Wales Department of Health. Evidence for the NSW Health Department Guidelines for the Clinical Management of Diabetes Mellitus in Adults: Part 1. Sydney: New South Wales Health Department, 1996.

[13] Last JM (ed). A dictionary of epidemiology (2 ed). New York; Oxford University Press, 1988: 107.

[14] Rushforth NB, Miller M, Bennett PH. Fasting and two-hour post-load glucose levels for the diagnosis of diabetes. The relationship between glucose levels and complications of diabetes in the Pima Indians. *Diabetologia* 1979; 16(6): 373-79.

[15] Borch-Johnsen K, Deckert T. Complications of diabetes: the changing scene. In: Alberti KGMM, Zimmet P, DeFronzo RA; honorary editor, Keen H. International textbook of diabetes mellitus (2 ed). Chichester: John Wiley and Sons Ltd, 1997: 1283-92.

[16] Glasgow RE. Translating research to practice: lessons learned, areas for improvement, and future directions. *Diabetes Care* 2003; 26(8): 2451-6.

[17] Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *American Journal of Public Health* 1999; 89(9): 1322-7.

[18] Last JM (ed). A dictionary of epidemiology (2 ed). Oxford University Press, New York, 1988: 20.

[19] Wacholder S, McLaughlin JK, Silverman DT, Mandel JS. Selection of controls in case-control studies: 1. Principles. *American Journal of Epidemiology* 1992; 135(9): 1019-28.

[20] Powell-Davies G, Fry D. General practice in the health system. In: Department of Health and Ageing. General Practice in Australia: 2004. Canberra: Commonwealth of Australia, 2005: 421-64.

[21] Australian Institute of Health and Welfare. Australia's health 2004. Canberra: Australian Institute of Health and Welfare, 2004: 1-9.

[22] Overland J, Hayes L, Yue DK. Social disadvantage: its impact on the use of Medicare services related to diabetes in NSW. *Australian and New Zealand Journal of Public Health* 2002; 26(3): 262-5.

[23] Backlund LB, Algvee PV, Rosenqvist U. New blindness in diabetes reduced by more than one-third in Stockholm County. *Diabetic Medicine* 1997; 14(9): 732-40.

[24] Aiello LP, Gardner TW, King GL, Blankenship G, Cavallerano JD, Ferris FL 3rd, Klein R. Diabetic retinopathy (technical review). *Diabetes Care* 1998; 21(1): 143-56.

[25] Harris MI. Undiagnosed NIDDM: clinical and public health issues. *Diabetes Care* 1993; 16(4): 642-52.

[26] Murata GH, Shah JH, Wendel CS, Hoffman RM, Adam KD, Bokhari SU, Solvas PA, Duckworth WC. Risk factor management in stable, insulin-treated patients with Type 2 diabetes: The Diabetes Outcomes in Veterans Study. *Journal of Diabetes and Its Complications* 2003; 17(4): 186-91.

[27] de Courten M, Bennett PH, Tuomilehto J, Zimmet P. Epidemiology of NIDDM in non-Europids. In: Alberti KGMM, Zimmet P, DeFronzo RA; honorary editor, Keen H. International textbook of diabetes mellitus (2 ed). Chichester: John Wiley and Sons Ltd, 1997: 143- 70.

[28] Hart CL, Hole DJ, Smith GD. The contribution of risk factors to stroke differentials, by socioeconomic position in adulthood: the Renfew/Paisley Study. *American Journal of Public Health* 2000; 90(11): 1788-91.

[29] Leiter LA, Barr A, Belanger A, Lubin S, Ross BA, Tildesley HD, Fontaine N. Diabetes Screening in Canada (DIASCAN) Study: Prevalence of undiagnosed diabetes and glucose intolerance in family physician offices. *Diabetes Care* 2001; 24(6): 1038-43

[30] de Courten M, Hodge A, Dowse G, King I, Vickery J, Zimmet P. Review of the epidemiology, aetiology, pathogenesis and preventability of diabetes in Aboriginal and Torres Strait Islander populations. Canberra: Office of Aboriginal and Torres Strait Islander Health Services and Commonwealth Department of Health and Family Services, 1998.

[31] Cameron AJ, Welborn TA, Zimmet PZ, Dunstan DW, Owen N, Salmon J, Dalton M, Jolley D, Shaw JE. Overweight and obesity in Australia: the 1999-2000 Australian Diabetes Obesity and Lifestyle Study (AusDiab). *Medical Journal of Australia* 2003; 178(9): 427-32.

[32] Chaturvedi N, Jarrett J, Shipley MJ, Fuller JH. Socio-economic gradient in morbidity and mortality in people with diabetes: cohort study findings from the Whitehall study and the WHO multinational study of vascular disease in diabetes. *British Medical Journal* 1998; 316(7125): 100-5.

[33] Strong K, Trickett P, Titulaer I, Bhatia K. Health in rural and remote Australia. AIHW Cat No. PHE 6. Canberra: Australian Institute of Health and Welfare, 1998.

[34] Guest C, O'Dea K, Hopper J, Nankervis AJ, Larkins RG. The prevalence of glucose intolerance in Aborigines and Europids of south-eastern Australia. *Diabetes Research and Clinical Practice* 1992; 15(3): 227-35.

[35] Klein R, Klein BEK, Moss SE, Davis MD, DeMets DL. The Wisconsin Epidemiologic Study of Diabetic Retinopathy X. Four-year incidence and progression of diabetic retinopathy when age at diagnosis is 30 years or more. *Archives of Ophthalmology* 1989; 107(2): 244-9.

[36] Gulliford MC, Charlton J, Latinovic R. Increased utilisation of primary care 5 years before diagnosis of type 2 diabetes: a matched cohort study. *Diabetes Care* 2005; 28(1): 47-52.

[37] Williams GC, McGregor HA, King D, Nelson CC, Glasgow RE. Variation in perceived competence, glycemic control, and patient satisfaction: relationship to autonomy support from physicians. *Patient Education and Counseling* 2005; 57(1): 39-45.

[38] Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. *The Milbank Quarterly* 1996; 74(4): 511-44.

[39] Starfield B. Is primary care essential? *Lancet* 1994; 344(8930): 1229-33.

[40] Knottnerus JA. Medical decision making by general practitioners and specialists. *Family Practice* 1991; 8(4): 305-7.

[41] Weinberger M, Cohen SJ, Mazzuca SA. The role of physicans knowledge and attitudes in effective diabetes management. *Social Science and Medicine* 1984; 19(9): 965-9.

[42] Colagiuri S, Colagiuri R, Ward J. National Diabetes Strategy and Implementation Plan. Canberra: Diabetes Australia, 1998.

[43] Jarrett RJ, Keen H. Hyperglycaemia and diabetes mellitus. *Lancet* 1976; 2(7993): 1009-12.

[44] American Diabetes Association. Standards of medical care for patients with diabetes mellitus. *Diabetes Care* 2003; 26(Suppl 1): S33-50.

[45] Cockram CS. The epidemiology of diabetes mellitus in the Asia-Pacific Region. *Hong Kong Medical Journal* 2000; 6(1): 43-52.

[46] Welborn TA, Reid CM, Marriott G. Australian Diabetes Screening Study: impaired glucose tolerance and non-insulin dependent diabetes mellitus. *Metabolism: Clinical and Experimental* 1997; 46(12 Suppl 1): 35-9.

[47] Ewald D, Patel M, Hall G. Hospital separations indicate increasing need for prevention of diabetic foot complications in Central Australia. *Australian Journal of Rural Health* 2001; 9(6): 275-9.

[48] McCulloch B, McDermott R, Miller G, Leeward D, Elwell M, Muller R. Self-reported diabetes and health behaviours in remote indigenous communities in Northern Queensland, Australia. *Diabetes Care* 2003; 26(2): 397-403.

[49] Colagiuri S, Colagiuri R, Conway B, Grainger D, Davey P. DiabCo$t Australia: assessing the burden of type 2 diabetes in Australia. Canberra: Diabetes Australia, 2003.

[50] Fukushima M, Suzuki H, Seino Y. Insulin secretion capacity in the development from normal glucose tolerance to type 2 diabetes. *Diabetes Research and Clinical Practice* 2004; 66(Suppl 1): S37-43.

[51] Ruderman N, Williamson J, Brownlee M. Hyperglycaemia, diabetes and vascular disease. Oxford University Press: Oxford, 1992: 3-20.

[52] Konen JC, Curtis LG, Summerson JH. Symptoms and complications of adult diabetic patients in a family practice. *Archives of Family Medicine* 1996; 5(3): 135-45.

[53] World Health Organisation. Definition, diagnoses and classification of diabetes mellitus and its complications – part 1: diagnosis and classification of diabetes mellitus. Geneva: World Health Organization, 1999

[54] Wang S-L, Head J, Stevens L, Fuller JH. Excess mortality and its relation to hypertension and proteinuria in diabetic patients: the WHO Multinational Study of Vascular Disease in Diabetes. *Diabetes Care* 1996; 19(4): 305-12.

[55] Sever PS, Poulter NR, Dahlof B, Wedel H, Collins R, Beevers G, Caulfield M, Kjeldsen SE, Kristinsson A, McInnes GT, Mehlsen J, Markku N, O'Brien E, Ostergren J. Reduction in cardiovascular events with atorvastatin in 2532 patients with type 2 diabetes: Anglo-Scandinavian Cardiac Outcomes Trial – Lipid Lowering Arm (ASCOT-LLA). *Diabetes Care* 2005; 28(5): 1151-7.

[56] Jarrett RJ. Epidemiology and public health aspects of non-insulin-dependent diabetes mellitus. *Epidemiologic Reviews* 1989; 11: 151-71.

[57] UK Prospective Diabetes Study Group. Quality of life in type 2 diabetic patients is affected by complications but not by intensive policies to improve blood glucose or blood pressure control (UKPDS 37). *Diabetes Care* 1999; 22(7): 1125 – 36.

[58] DeWitt DE, Hirsch IB. Outpatient insulin therapy in type 1 and type 2 diabetes mellitus: scientific review. *Journal of the American Medical Association* 2003; 289(17): 2254-64.

[59] Atkinson MA, Maclaren NK. The pathogenesis of insulin-dependent diabetes mellitus. *New England Journal of Medicine* 1994; 331(21): 1428-36.

[60] Australian Institute of Health and Welfare and National Centre for Monitoring Diabetes. Diabetes: Australian facts 2002. Canberra: Australian Institute of Health and Welfare, 2002.

[61] Harris MI, Zimmet P. Classification of diabetes mellitus and other categories of glucose intolerance. In: Alberti KGMM, Zimmet P, DeFronzo RA; honorary editor, Keen H. International textbook of diabetes mellitus (2 ed). Chichester: John Wiley and Sons Ltd, 1997: 9-23.

[62] Serrano-Rios M, Perez A, Saban-Ruiz J. Cardiac complications in diabetes. In: Krall LP, Alberti KGMM, Serrano-Rios M. World book of diabetes in practice, vol 2. New York: Elsevier, 1986-1988: 169-78.

[63] Edelstein SL, Knowler WC, Bain RP, Andres R, Barrett-Connor EL, Dowse GK, Haffner SM, Pettitt DJ, Sorkin JD, Muller DC, Collins VR, Hamman RF. Predictors of progression from impaired glucose tolerance to NIDDM: an analysis of six prospective studies. *Diabetes* 1997; 46(4): 701-10.

[64] Pi-Sunyer FX. Weight and non-insulin-dependent diabetes mellitus. *American Journal of Clinical Nutrition* 1996; 63(3): 426S-9S.

[65] Klein S, Sheard NF, Pi-Sunyer FX, Daly A, Wylie-Rosett J, Kulkarni K, Clark NG. American Diabetes Association, North American Association for the Study of Obesity, American Society for Clinical Nutrition. Weight management through lifestyle modification for the prevention and management of type 2 diabetes: rationale and strategies: A statement of the American Diabetes Association, the North American Association for the Study of Obesity, American Society for Clinical Nutrition. *Diabetes Care* 2004; 27(8): 2067-73.

[66] Buse JB. Overview of current therapeutic options of type 2 diabetes: rationale for combining oral agents with insulin therapy. *Diabetes Care* 1999; 22(Suppl 3): C65-70.

[67] Haffner SM. Epidemiology of type 2 diabetes: risk factors. *Diabetes Care* 1998; 21(Suppl 3): C3-6.

[68] Pierce M, Hayworth J, Warburton F, Keen H, Bradley C. Diabetes mellitus in the family: perceptions of offspring's risk. *Diabetic Medicine* 1999; 16(5): 431-6.

[69] Blair SN, Horton E, Leon AS, Lee IM, Drinkwater BL, Dishman RK, Mackey M, Keinholz ML. Physical activity, nutrition and chronic disease. *Medical Science and Sports Exercise* 1996; 28(3): 335-49.

[70] Feskens EJ, Loeber JG, Kromhout D. Diet and physical activity as determinants of hyperinsulinemia: the Zutphen Elderly Study. *American Journal of Epidemiology* 1994; 140(4): 350-60.

[71] Gress TW, Nieto FJ, Shahar E, Wofford MR, Brancati FL (Atherosclerosis Risk in Communities Study Investigators). Hypertension and antihypertensive therapy as risk factors for type 2 diabetes mellitus. *New England Journal of Medicine* 2000; 342(13): 905 –12.

[72] Kannel WB, McGee DL. Diabetes and cardiovascular risk factors: the Framingham Study. *Circulation* 1979; 59(1): 8-13.

[73] Harris MI. Diabetes in America: epidemiology and scope of the problem. *Diabetes Care* 1998; 21(Suppl 3): C11-14.

[74] New South Wales Department of Health. Guidelines for the clinical management of diabetes mellitus in adults. Sydney: New South Wales Department of Health, 1996

[75] Bartnik M, Malmberg K, Hamsten A, Efendic S, Norhammar A, Silveira A, Tenerz A, Ohrvik J, Ryden L. Abnormal glucose tolerance – a common risk factor in patients with acute myocardial infarction in comparison with population-based controls. *Journal of Internal Medicine* 2004; 256(4): 288-97.

[76] Buchanan TA, Xiang AH. Gestational diabetes mellitus. *Journal of Clinical Investigation* 2005; 115(3): 485-91.

[77] Jang HC, Yim CH, Han KO, Yoon HK, Han IK, Kim MY, Yang JH, Cho NH. Gestational diabetes mellitus in Korea: prevalence and prediction of glucose intolerance at early post-partum. *Diabetes Research and Clinical Practice* 2003; 61(2): 117-24.

[78] Peters RK, Kjos SL, Xiang A, Buchanan TA. Long-term diabetogenic effect of single pregnancy in women with previous gestational diabetes mellitus. *Lancet* 1996; 347(8996): 227-30.

[79] Skrha J. Pathogenesis of angiopathy in diabetes. *Acta Diabetologia* 2003; 40(Suppl 2): S234-9.

[80] Howard BV, Ruotolo G, Robbins DC. Obesity and dyslipidemia. *Endocrinology and Metabolic Clinics of North America* 2003; 32(4): 855-67.

[81] Mancia G. The association of hypertension and diabetes: prevalence, cardiovascular risk and protection by blood pressure reduction. *Acta Diabetologia* 2005; 42(Suppl 1): S17-25.

[82] Izkahov E, Meltzer E, Rubinstein A. Pathogenesis and management of diabetic dyslipidemia. *Treatments in Endocrinology* 2003; 2(4): 231-45.

[83] Brownlee M. Glycation of macromolecules. In: Alberti KGMM, Zimmett P, DeFronzo RA; honorary editor, Keen H. International textbook of diabetes mellitus (2 ed). Chichester: John Wiley and Sons Ltd, 1997: 745-53.

[84] Greene DA, Lattimer SA, Sima AA. Sorbitol, phosphoinositides and sodium-potassium-ATPase in the pathogenesis of diabetic complications. *New England Journal of Medicine* 1987; 316(10): 599-606.

[85] Winegrad AI. Banting lecture 1986: does a common mechanism induce the diverse complications of diabetes? *Diabetes* 1987; 36(3): 396-406.

[86] Lee TS, Saltsman KA, Ohashi H, King GL. Activation of protein C kinase by elevation of glucose concentration: proposal for a mechanism in the development of diabetic vascular complications. *Proceedings of the National Academy of Sciences: USA* 1989; 86(13): 5141-5.

[87] Klein R, Klein BE, Moss SE, Davis MD, DeMets DL. The Wisconsin epidemiologic study of diabetic retinopathy II. Prevalence and risk of diabetic retinopathy when age of diagnosis is less than 30 years. *Archives of Ophthalmology* 1984; 102(4): 520-6.

[88] Klein R, Klein BE, Moss SE, Davis MD, DeMets DL. The Wisconsin epidemiologic study of diabetic retinopathy III. Prevalence and risk of diabetic retinopathy when age of diagnosis is 30 or more years. *Archives of Ophthalmology* 1984; 102(4): 527-32.

[89] Early Treatment of Diabetic Retinopathy Study Group. Grading diabetic retinopathy from stereoscopic color fundus photographs – an extension of the modified Airlie House Classification. ETDRS Report No. 10. *Ophthalmology* 1991; 98(5 Suppl): 786-806.

[90] Delcourt C, Villatte-Cathelineau B, Vauzelle-Kerveroedan F, Cathelineau G, Papoz L. Visual impairment in type 2 diabetic patients. A multicentre study in France. CODIAB-INSERM-ZENECA-Pharma Study Group. *Acta Ophthalomogica Scandinavica* 1995; 73(4): 293-8.

[91] Ferris FL. How effective are treatments for diabetic retinopathy? *Journal of the American Medical Association*1993; 269(10):1290-1.

[92] Gross JL, de Azevedo MJ, Silveiro SP, Canani H, Caramori ML, Zelmanovitz T. Diabetic nephropathy: diagnosis, prevention and treatment. *Diabetes Care* 2005; 28(1): 164-76.

[93] Cooper ME, Frauman A, O'Brien RC, Seeman E, Murray RM, Jerums G. Progression of diabetic nephropathy in type 1 and type 2 diabetics. *Diabetic Medicine* 1988; 5(4): 361-8.

[94] Simmons D. The epidemiology of diabetes and its complications in New Zealand. *Diabetic Medicine* 1996; 13(4): 371-5.

[95] Young BA, Maynard C, Boyko EJ. Racial differences in diabetic nephropathy, cardiovascular disease, and mortality in a national population of veterans. *Diabetes Care* 2003; 26(7): 2392-9.

[96] Nzerue CM, Demissochew H, Tucker JK. Race and kidney disease: role of social and environmental factors. *Journal of the National Medical Association* 2002; 94(8 Suppl): 28S-38S.

[97] Hovind P, Tarnow L, Rossing P, Jensen BR, Graae M, Torp I, Binder C, Parving HH. Predictors of the development of microalbuminuria and macroalbuminuria in patients with type 1 diabetes: inception cohort study. *British Medical Journal* 2004; 328(7448): 1105-8.

[98] Wong TY, Shankar A, Klein R, Klein BE. Retinal vessel diameters and the incidence of gross proteinuria and renal insufficiency in people with type 1 diabetes. *Diabetes* 2004; 53(1): 179-84.

[99] Valmadrid CT, Klein R, Moss SE, Klein BE. The risk of cardiovascular disease mortality associated with microalbuminuria and gross proteinuria in persons with older-onset diabetes mellitus. *Archives of Internal Medicine* 2000; 160(8): 1093-100.

[100] Adler AI, Stevens RJ, Manley SE, Bilous RW, Cull CA, Holman RR. Development and progression of nephropathy in type 2 diabetes: the UK Prospective Diabetes Study (UKPDS 64). *Kidney International* 2003; 63(1): 225-32.

[101] The Diabetes Control and Complications Trial/ Epidemiology of Diabetes Interventions and Complications Research Group. Sustained effect of intensive treatment of type 1 diabetes mellitus on development and progression of diabetic nephropathy: the Epidemiology of Diabetes Interventions and Complications (EDIC) study. *Journal of the American Medical Association* 2003; 290(16): 2159-67.

[102] UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet* 1998; 352(9131): 837-53.

[103] Gross JL, Zelmanovitz T, Moulin CC, De Mello V, Perassolo M, Leitao C, Hoefel A, Paggi A, Azevedo MJ. Effect of a chicken-based diet on renal function and lipid profile in patients with type 2 diabetes: a randomised crossover trial. *Diabetes Care* 2002; 25(4): 645-51.

[104] Pedrini MT, Levey AS, Lau J, Chalmers TC, Wang PH. The effect of dietary protein restriction on the progression of diabetic and nondiabetic renal diseases: a meta-analysis. *Annals of Internal Medicine* 1996; 124(7): 627-32.

[105] Jacobsen P, Rossing K, Parving HH. Single versus dual blockade of the renin-angiotensin system (angiotensin-converting enzyme inhibitors and/ or angiotensin II receptor blockers) in diabetic nephropathy. *Current Opinion on Nephrology and Hypertension* 2004; 13(3): 319-24.

[106] Working Party of the International Diabetes Federation (European Region). Hypertension in people with type 2 diabetes: knowledge-based diabetes-specific guidelines. *Diabetic Medicine* 2003; 20(12): 972-87.

[107] The Diabetes Control and Complications Trial/ Epidemiology of Diabetes Interventions and Complications Research Group. Retinopathy and nephropathy in patients with type 1 diabetes four years after a trial of intensive therapy. *New England Journal of Medicine* 2000; 342(6): 381-89.

[108] Krolewski AS, Barzilay J, Warram JH, Martin BC, Pfeifer M, Rand LI. Risk of early-onset proliferative retinopathy in IDDM is closely related to cardiovascular autonomic neuropathy. *Diabetes* 1992; 41(4): 430-7.

[109] Knowler WC, Bennett PH, Ballintine EJ. Increased incidence of retinopathy in diabetes with elevated blood pressure: a six year follow-up study in Pima Indians. *New England Journal of Medicine* 1980; 302(12): 645-50.

[110] Feldman EL, Russell JW, Sullivan KA, Golovoy D. New insights into the pathogenesis of diabetic neuropathy. *Current Opinion in Neurology* 1999; 12(5): 553-63.

[111] Thomas PK, Tomlinson DR. Diabetic and hypoglycemic neuropathy. In: Dyck PJ, Thomas PK, Griffin JW, Low PA, Pudoslo JF (eds). Peripheral neuropathy. Philadelphia; WB Saunders, 1993: 1219-50.

[112] Bruyn GW, Garland H. Neuropathies of endocrine origin. In Vinken PJ, Bruyn GW (eds). Handbook of clinical neurology, vol 8. Amsterdam: North-Holland 1970: 29.

[113] Most RS, Sinnock P. The epidemiology of lower-extremity amputations in diabetic individuals. *Diabetes Care* 1983; 6(1): 87-91.

[114] Dyck PJ, Kratz KM, Karnes JL, Litchy WJ, Klein R, Pach JM, Wilson DM, O'Brien PC, Melton III LJ, Service FJ. The prevalence by staged severity of various types of diabetic retinopathy, retinopathy and nephropathy in a population-based cohort: The Rochester Diabetic Neuropathy Study. *Neurology* 1993; 43(4): 817-24.

[115] The Diabetes Control and Complications Trial Research Group. Factors in development of diabetic neuropathy. *Diabetes* 1988; 37(4): 476-81.

[116] Mayfield JA, Reiber GE, Sanders LJ, Janisse D, Pogach LM. Preventive foot care in people with diabetes. *Diabetes Care* 1998; 21(12): 2161-77.

[117] Cohen KL, Harris S. Efficacy and safety of nonsterioidal anti-inflammatory drugs in the therapy of diabetic neuropathy. *Archives of Internal Medicine* 1987; 147(8): 1442-4.

[118] Joss JD. Tricyclic antidepressant use in diabetic neuropathy. *Annals of Pharmacotherapy* 1999; 33(9): 996-1000.

[119] Simmons Z, Feldman EL. Treatment of diabetic neuropathy. In Williams R, Herman W, Kinmonth A-L, Wareham NJ. The evidence base for diabetes care. John Wiley and Sons, Chichester, 2002: 555-75.

[120] Watkins PJ, Drury PL, Howell SL. Diabetes and its management (5 ed). London: Blackwell Science, 1996: 143-50.

[121] American Diabetes Association. Consensus statement: role of cardiovascular risk factors in prevention and treatment of macrovascular disease in diabetes. *Diabetes Care* 1989; 12(8): 573-9.

[122] Wilson PW. Diabetes mellitus and coronary heart disease. *American Journal of Kidney Disorders* 1998; 32(5 Suppl 3): S89-100.

[123] Davies M, Thomas A. Plaque fissuring – the cause of acute myocardial infarction, sudden ischaemic death and crescendo angina. *British Heart Journal* 1985; 53(4): 363-73.

[124] Folsom AR, Rasmussen ML, Chambless LE, Howard G, Cooper LS, Schmidt MI, Heiss G. Prospective associations of fasting insulin, body fat distribution, and diabetes with risk of ischaemic stroke. The Atherosclerosis Risk in Communities Study Investigators. *Diabetes Care* 1999; 22(7): 1077-83.

[125] Roehmholdt ME, Palumbo PJ, Whisnant JP, Elveback LR. Transient ischaemic attack and stroke in a community-based diabetic cohort. *Mayo Clinic Proceedings* 1983; 58(1): 56-8.

[126] Rubins HB, Robins SJ, Collins D, Fye CL, Anderson JW, Elam MB, Faas FH, Linares E, Schaefer EJ, Schectman G, Wilt TJ, Wittes J. Gemfibrozil for the secondary prevention of coronary heart disease in men with low level of high-density lipoprotein cholesterol. Veterans Affairs High-Density Lipoprotein Cholesterol Intervention Trial Study Group. *New England Journal of Medicine* 1999; 341(6): 410-8.

[127] Tatti P, Pahor M, Byington RP, Di Mauro O, Guarisco R, Strollo G, Strollo F. Outcome results of the Fosinopril Versus Amlodipine Cardiovascular Events Randomized Trial (FACET) in patients with hypertension and NIDDM. *Diabetes Care* 1998; 21(4): 597-603.

[128] Tanasescu M, Leitzmann MF, Rimm EB, Hu FB. Physical activity in relations to cardiovascular disease and total mortality among men with type 2 diabetes. *Circulation* 2003; 107(19): 2435-9.

[129] Malmberg K, Ryden L, Efendic S, Herlitz J, Nicol P, Waldenstrom A, Wedel H, Welin L, on behalf of the DIGAMI Study Group. Randomized trial of insulin-glucose infusion followed by subcutaneous insulin treatment in diabetic patients with acute myocardial infarction (DIGAMI Study): effects on mortality at 1 year. *Journal of the American College of Cardiology* 1995; 26(1): 57-65.

[130] UK Prospective Diabetes Study Group. Effect of intensive blood glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). UK Prospective Diabetes Study Group. *Lancet* 1998; 352(9131): 854-65.

[131] Goldberg RB, Mellies MJ, Sacks FM, Moye LA, Howard BV, Howard WJ, Davis BR, Cole TG, Pfeffer MA, Braunwald E. Cardiovascular events and their reduction with pravastatin in diabetic and glucose intolerant myocardial infarction survivors with average cholesterol levels: subgroup analysis in the Cholesterol and Recurrent Events (CARE) trial. The CARE investigators. *Circulation* 1998; 98(23): 2513-9.

[132] Sacks FM, Tonkin AM, Craven T, Pfeffer MA, Shepherd J, Keech A, Furberg CD, Braunwald E. Coronary heart disease patients with low LDL-cholesterol: benefit of pravastatin in diabetics and enhanced role for HDL-cholesterol and triglycerides as risk factors. *Circulation* 2002; 105(12): 1424-8.

[133] Diabetes Atherosclerosis Intervention Study. Effect of fenofibrate on progression of coronary-artery disease in type 2 diabetes: the Diabetes Atherosclerosis Intervention Study, a randomised study. *Lancet* 2001; 357(9260): 905-10.

[134] Scandinavian Simvastatin Survival Study Group. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simastatin Survival Study (4S). *Lancet* 1994; 344(8934): 1383-9.

[135] The Heart Outcomes Prevention Evaluation Study Investigators. Effects of ramipril on cardiovascular and mocrovascular outcomes in people with diabetes mellitus: results of the HOPE study and MICRO-HOPE substudy. *Lancet* 2000; 355(9200): 253-9.

[136] Ghazzi MN, Perez JE, Antoucci TK, Driscoll JH, Huang SM, Faja BW, Whitcomb RW. Cardiac and glycaemic benefits of troglitazone treatment in NIDDM. The Troglitazone Study Group. *Diabetes* 1997; 46(3): 433-9.

[137] Freed MI, Ratner R, Marcovina SM, Kreider MM, Biswas N, Cohen BR, Brunzell JD, Roziglitazone Study 108 investigators. Effects of rosiglitazone alone and in combination with atorvastatin on the metabolic abnormalities in type 2 diabetes mellitus. *American Journal of Cardiology* 2002; 90(9): 947-52.

[138] Holmes DR, Vliestra RE, Smith HC, Vetrovec GW, Kent KM, Cowley MJ, Faxon DP, Gruentzig AR, Kelsey SF, Detre KM, et al. Restenosis after percutaneous transluminal coronary angioplasty (PTCA): A report from PTCA Registry of National Heart Lung and Blood Institute. *American Journal of Cardiology* 1984; 53(12): 77C-81C.

[139] Hiatt WR, Marshall JA, Baxter J, Sandoval R, Hildebrandt W, Kahn LR, Hamman RF. Diagnostic methods for peripheral arterial disease in the San Luis Valley Diabetes Study. *Journal of Clinical Epidemiology* 1990; 43(6): 597-606.

[140] Apelqvist J, Larsson J, Agardh CD. The influence of external precipitating factors and peripheral neuropathy on the development and outcome of diabetic foot ulcers. *Journal of Diabetes Complications* 1990; 4(1): 21-5.

[141] Pecoraro RE, Reiber GE, Burgess EM. Pathways to diabetic limb amputation: basis for prevention. *Diabetes Care* 1990; 13(5): 513-21.

[142] Frykberg RG, Mendeszoon E. Management of the diabetic Charcot foot. *Diabetes/Metabolism Research and Reviews* 2000; 16(Suppl 1): S59-65.

[143] Harris M, Eastman R, Cowie C. Symptoms of sensory neuropathy in adults with NIDDM in the US population. *Diabetes Care* 1993; 16(11): 1446-52.

[144] Orchard TJ, Strandness DE Jr. Assessment of peripheral vascular disease in diabetes. Report and recommendations of an international workshop sponsored by the American Diabetes Association and the American Heart Association, September 18-20, 1992 New Orleans, Louisiana. *Circulation* 1993; 88(2): 819-28.

[145] Gavin LA, Stress RM, Goldstone J. Prevention and treatment of foot problems in diabetes mellitus: a comprehensive program. *Western Journal of Medicine* 1993; 158(1): 47-53.

[146] Rohan T, Frost C, Wald N. Prevention of blindness by screening for diabetic retinopathy: a quantitative assessment. *British Medical Journal* 1989; 299(6709): 1198 201

[147] Valk GM, Renders CM, Kriegsman DM, Newton KM, Twisk JW, van Eijk JT, van der Wal G, Wagner EH. Quality of care for patients with type 2 diabetes mellitus in the Netherlands and the United States: a comparison. *Health Services Research* 2004; 39(4Pt 1): 709-25.

[148] Golin CE, DiMatteo MR, Gelberg L. The role of patient participation in the doctor visit: Implications for adherence to diabetes care. *Diabetes Care* 1996; 19(10): 1153-64.

[149] Glasgow RE. Compliance to diabetes regimens: conceptualization, complexity and determinants. In: Cramer JA, Spiker B. Patient compliance in medical practice and clinical trials. New York, Raven Press, 1991.

[150] Davies M. The reality of glycaemic control in insulin treated diabetes: defining the clinical challenges. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 2004; 28(Suppl 2): S14-22.

[151] Bodenheimer T, Lorig K, Holman H, Grumbach K. Patient self-management of chronic disease in primary care. *Journal of the American Medical Association* 2002; 288(19): 2469-75.

[152] Holman H, Lorig K. Patient self-management: a key to effectiveness and efficiency in care of chronic disease. *Public Health Reports* 2004; 119(3): 239-43.

[153] Williams GC, McGregor H, Zeldman A, Freedman ZR, Deci EL, Elder D. Promoting glycemic control through diabetes self-management: evaluating a patient activation intervention. *Patient Education and Counseling* 2005; 56(1): 28-34.

[154] Roter D, Kinmonth A-L. What is the evidence that increasing participation of individuals in self-management improves the processes and outcomes of care? In: Williams R, Herman W, Kinmonth A-L. The evidence base for diabetes care. Chichester, John Wiley and sons, 2002: 681-700.

[155] Clark NM, Becker MH, Janz NK, Lorig K, Rakowski W, Anderson L. Self-management of chronic disease by older adults: a review and questions for research. *Journal of Aging Health* 1991; 3(1): 3-27.

[156] van den Arend IJ, Stolk RP, Krans HM, Grobbee DE, Schrijvers AJ. Management of type 2 diabetes: a challenge for patient and physician. *Patient Education and Counseling* 2000; 40(2): 187-94.

[157] Pill R, Scott NCH, Rollnick SR, Rees M. A randomised controlled trial of an intervention designed to improve the care given in general practice to type II diabetic patients: patient outcomes and professional ability to change behaviour. *Family Practice* 1998; 15(3): 229-35.

[158] Aljasem LI, Peyrot M, Wissow L, Rubin RR. The impact of barriers and self-efficacy on self-care behaviours in type 2 diabetes. *Diabetes Educator* 2001; 27(3): 393-404.

[159] Bradley C, Brewin CR, Gamsu DS, Moses JL. Development of scales to measure perceived control of diabetes mellitus and diabetes related health beliefs. *Diabetic Medicine* 1984; 1(3): 213-8.

[160] van Dam HA, var der Horst FG, Knoops L, Ryckman RM, Crebolder HFJM, van den Borne BHW. Social support in diabetes: a systematic review of controlled intervention studies. *Patient Education and Counseling* 2004; DOI: 10.1016/j.pec.2004.11.001

[161] Klein R, Klein BEK, Jensen SC, Moss SE. The relation of socio-economic factors to the incidence of proliferative diabetic retinopathy and loss of vision. *Ophthalmology* 1994; 101(1): 68-76.

[162] Sobal J, Stunkard AJ. Socio-economic status and obesity: a review of the literature. *Psychological Bulletin* 1989; 105(2): 260-75.

[163] Nathanson CA, Sex, illness and medical care: a review of the data, theory and method. *Social Science and Medicine* 1977; 11(1): 13-25

[164] Lynch JW, Kaplan GA, Salonen JT. Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socio-economic life course. *Social Science and Medicine* 1997; 44(6): 809-19

[165] Glasgow RE, Fisher EB, Anderson BJ, LaGreca A, Marrero D, Johnson SB, Rubin RR, Cox DJ. Behavioural science in diabetes: contributions and opportunities *Diabetes Care* 1999; 22(5): 832-43.

[166] Heilbronn LK, Noakes M, Clifton PM. Effect of energy restriction, weight loss and diet composition on plasma lipids and glucose in patients with type 2 diabetes. *Diabetes Care* 1999; 22(6): 889-95.

[167] Markovic PT, Campbell LV, Balasubramanian S, Jenkins BA, Fleury AC, Simons LA, Chisholm DJ. Beneficial effect of average lipid levels from energy restriction and fat loss in obese individuals with or without type 2 diabetes. *Diabetes Care* 1998; 21(5): 695-700.

[168] Peterson KA. Diabetes management in the primary care setting: summary. *American Journal of Medicine* 2002; 113(Suppl 6A): 36S-40.

[169] O'Connor PJ, Desai J, Rush WA, Cherney LM, Solberg LI, Bishop DB. Is having a regular provider of diabetes care related to intensity of care and glycemic control? *The Journal of Family Practice* 1998; 47(4): 290-7.

[170] Armstrong D. Clinical autonomy, individual and collective: the problem of changing doctors' behaviour. *Social Science and Medicine* 2002; 55(10): 1771-7.

[171] Task Force on Community Preventive Services. Recommendations for healthcare system and self-management education interventions to reduce morbidity and mortality from diabetes. *American Journal of Preventive Medicine* 2002; 22(Suppl 4S): 10-4.

[172] Pringle M, Stewart-Evans C, Coupland C, Williams I, Allison S, Sterland J. Influence on control in diabetes mellitus: patient, doctor, practice or delivery of care? *British Medical Journal* 1993; 306(6878): 630-34.

[173] Duckett SJ. The Australian health care system. South Melbourne: Oxford University Press, 2000: 22-45.

[174] Commonwealth Department of Health and Aged Care. The Australian health care system: an outline. Canberra: Commonwealth Department of Health and Aged Care, 2000.

[175] Starfield B. William Pickles lecture: primary and specialty care interfaces: the imperative of disease continuity. *British Journal of General Practice* 2003; 53(494): 723-9.

[176] Katon W, Von Korff MV, Lin E, Simon G. Rethinking practitioner roles in chronic illness: the specialist, primary care physician, and the practice nurse. *General Hospital Psychiatry* 2001; 23(3): 138-44.

[177] Australian Bureau of Statistics. National health survey 1989-90. ABS Cat No. 4112.0. Canberra: Australian Bureau of Statistics, 1991.

[178] Young AF, Dobson AJ, Byles JE. Determinants of general practitioner use among women in Australia. *Social Science and Medicine* 2001; 53(12): 1641-51.

[179] Starfield B. Primary Care: Concept, evaluation and policy. Oxford University Press, New York and Oxford, 1992: 25-55.

[180] Doyal L, Doyal L. The British National Health Service: a tarnished vision. *Health Care Analysis* 1999; 7(4): 363-76.

[181] Holm S, Liss P-E, Northeim OF. Access to health care in the Scandinavian countries: ethical aspects. *Health Care Analysis* 1999; 7(4): 321-30.

[182] Sale MM, Hazelwood K, Zimmet PZ, Shaw JE, Stankovich JM, Greenaway TM, Dwyer T. Trends in diabetes management practices of patients from an Australian insulin-treated diabetes register. *Diabetic Medicine* 2004; 21(2): 165-70.

[183] Overland J, Yue DK, Mira M. The pattern of diabetes care in New South Wales: a five year analysis using Medicare occasions of service data. *Australian and New Zealand Journal of Public Health* 2000; 24(4): 391-5.

[184] National Association of Diabetes Centres. National Clinical Diabetes Data Collection Project 1998: final report. Canberra: National Association of Diabetes Centres, 1999.

[185] Diabetes Ambulatory Care Centre, Royal Prince Alfred Hospital. Services at the diabetes centre. www.usyd.edu.au/services.html (accessed 20/8/05).

[186] Knuiman MW, Welborn TA, Bartholomew HC. Self-reported health and use of health services: a comparison of diabetic and nondiabetic persons from a national sample. *Australian and New Zealand Journal of Public Health* 1996; 20(3): 241- 7.

[187] Brooks PM. The impact of chronic illness: partnerships with other health care professionals. *Medical Journal of Australia* 2003; 179(5): 260-2.

[188] Stewart M, Brown JB, Donner A, McWhinney IR, Oates J, Weston WW, Jordan J. The impact of patient centred care on outcomes. *Journal of Family Practice* 2000; 49(9): 796-804.

[189] Bauman AE, Fardy HJ, Harris PG. Getting it right: why bother with patient centred care. *Medical Journal of Australia* 2003; 179(5): 253-6.

[190] Harris M, Priddin D, Ruscoe W, Infante FA, O'Toole BI. Quality of care provided by GPs using and not using Division-based diabetes registers. *Medical Journal of Australia* 2002; 177(5): 250-2.

[191] Phillips P, Wilson D, Beilby J, Taylor A, Rosenfeld E, Hill W, Parsons J. Diabetes complications and risk factors in an Australian population. How well are they managed? *International Journal of Epidemiology* 1998; 27(5): 853-9.

[192] Ward J, Lin M, Heron G, Lajoie V. Comprehensive audit of quality-of-care and quality-of-life for patients with diabetes. *Journal of Quality in Clinical Practice* 1997; 17(2): 91-100.

[193] Kamien M, Ward AM, Mansfield F, Fatovich B, Mather C, Anstey K. Management of type 2 diabetes in Western Australian metropolitan general practice. *Diabetes Research and Clinical Practice* 1994; 26(3): 197-208.

[194] Rothman AA, Wagner EH. Chronic illness management: what is the role of primary care? *Annals of Internal Medicine* 2003; 138(3): 256-61.

[195] Griffin SJ, Kinmonth AL. The management of diabetes by general practitioners and shared care. In: Pickup JC, Williams G (eds). Textbook of diabetes, vol 2, (2 ed). Oxford; Blackwell Science, 1997: 801-2.

[196] Wagner EH. Meeting the needs of chronically ill people. *British Medical Journal* 2001; 323(7319): 945-6.

[197] Griffin S. Diabetes care in general practice: meta-analysis of randomised control trials. *British Medical Journal* 1998; 317(7155): 390-6.

[198] Kinmonth A, Woodcock A, Griffin S, Speigal N, Campbell MJ. Randomised controlled trial of patient-centred care of diabetes in general practice: impact on current well-being and future disease risk. The Diabetes Care From Diagnosis Research Team. *British Medical Journal* 1998; 317(7167): 1202-8

[199] Eddy DM. A Manual for assessing health practices and designing practice policies. The explicit approach. Philadelphia: American College of Physicians 1992.

[200] National Health and Medical Research Council (NHMRC). Management of diabetic retinopathy: clinical practice guidelines. Canberra: Commonwealth of Australia, 1997.

[201] American Diabetes Association. Standards of medical care for patients with diabetes mellitus. *Diabetes Care* 2001; 24(1 Suppl): S33-43.

[202] Weiner JP, Parente ST, Garnick DW, Fowles J, Lawthers AG, Palmer RH. Variation in office-based quality: a claims based profile of care provided to Medicare patients with diabetes. *Journal of the American Medical Association* 1995; 273(19): 1503-8.

[203] Tapp RJ, Zimmet PZ, Harper CA, de Courten MP, Baklau B, McCarty DJ, Taylor HR, Welborn TA, Shaw JE. Australian Diabetes, Obesity and Lifestyle Study Group. Diabetes care in an Australian population: frequency of screening examinations for eye and foot complications of diabetes. Australian Diabetes Obesity and Lifestyle Study Group. *Diabetes Care* 2004; 27(3): 688-93

[204] The New South Wales Department of Health. The New South Wales Health Survey 1997. http://health.nsw.gov.au/public-health/hs97/dia_dhp.htm, (accessed 27/10/99).

[205] Commonwealth Department of Health and Aged Care. An outline of the practice incentives program, July 2001. Canberra: Commonwealth Department of Health and Aged Care, 2001

[206] Commonwealth Department of Health and Family Services. Medicare benefits schedule book 1996. Canberra: Australian Government Publishing Service, 1996.

[207] Goldstein DE, Little RR, Lorenz RA, Malone JI, Nathan D, Peterson CM. Tests of glycemia in diabetes [technical review]. *Diabetes Care* 1995: 18(6): 896-909.

[208] UK Prospective Diabetes Study Group. United Kingdom Prospective Diabetes Study 24: a 6-year, randomized controlled trial comparing sulfonylurea, insulin and metformin therapy in patients with newly diagnosed type 2 diabetes that could not be controlled by diet therapy. United Kingdom Prospective Diabetes Study Group. *Annals of Internal Medicine* 1998; 128(3): 165-75.

[209] Singer DE, Nathan DM, Fogel HA, Schachat AP. Screening for diabetic retinopathy. *Annals of Internal Medicine* 1992; 116(8): 660-71.

[210] Moss S, Klein R, Kessler S, Richie KA. Comparison between ophthalmoscopy and fundus photography in determining severity of diabetic retinopathy. *Ophthalmology* 1985; 92(1):62-7.

[211] Klein BE, Davis MD, Segal P, Long JA, Harris WA, Huang GA, Magli YL, Syrjala S. Diabetic retinopathy: assessment of severity and progression. *Ophthalmology* 1984; 91(1): 10-7.

[212] Buxton MJ, Sculpher MT, Ferguson BA, Humphreys JE, Altman JF, Spiegelhalter DJ, Kirby AJ, Jacob JS, Bacon H, Dudbridge SB, et al. Screening for treatable diabetic retinopathy: a comparison of different methods. *Diabetic Medicine* 1991; 8(4): 371-77.

[213] Jung RT. Obesity as a disease. *British Medical Bulletin* 1997; 53(2): 307-21.

[214] Assmann G, Schulte H. The prospective Munster (PROCAM) study: prevalence of hyperlipidemia in persons with hypertension and/or diabetes mellitus and the relationship to coronary heart disease. *American Heart Journal* 1988; 116(6 Pt 2): 1713-24.

[215] Caputo GM, Cavanagh PR, Ulbrecht JS, Gibbons GW, Karchmer AW. Assessment and management of foot disease in patients with diabetes. *New England Journal of Medicine* 1994; 331(13): 854-60.

[216] Krauss RM. Relationship of intermediate and low-density lipoprotein subspecies to risk of coronary artery disease. *American Heart Journal* 1987; 113(2 Pt 2): 578-82.

[217] Ellis SE, Speroff T, Dittus RS, Brown A, Pichert JW, Elasy TA. Diabetes patient education: a meta-analysis and meta-regression. *Patient Education and Counseling* 2004; 52(1): 97-105.

[218] McCarty DJ, Greenaway TM, Kamp MC, Dwyer T, Zimmet PZ. Management of insulin-treated diabetes in Tasmania. *Medical Journal of Australia* 1999; 170(7): 312-5.

[219] Bonney M, Carter S, Burns J, Powell-Davies PG, Harris MF. National Divisions Diabetes Program Data Collation Project. Volume 3: divisions of general practice – diabetes profiles. Quality of care and health outcomes - collated divisions data. Sydney: Centre for General Practice Integration Studies, School of Community Medicine, University of New South Wales, 2000.

[220] McCabe CJ, Stevenson RC, Dolan AM. Evaluation of a diabetic foot screening and protection programme. *Diabetic Medicine* 1998; 15(1): 80-4.

[221] Wolpert HA, Anderson BJ. Management of diabetes: are doctors framing the benefits from the wrong perspective? *British Medical Journal* 2001; 323(7319): 994-6.

[222] Hypertension Detection and Follow-up Program Cooperative Group. Five-year findings of the Hypertension Detection and Follow-up Program 1: Reduction in mortality of persons with high blood pressure, including mild hypertension. *Journal of the American Medical Association* 1979; 242(23): 2562-71.

[223] McCarty DJ, Fu CL, Harper CA, Talyor HR, McCarty CA. Five-year incidence of diabetic retinopathy in the Melbourne Visual Impairment Project. *Clinical and Experimental Ophthalmology* 2003; 31(5): 397-402

[224] Vinicor F, Cohen SJ, Mazzuca SA, Moorman N, Wheeler M, Kuebler T, Swanson S, Ours P, Fineberg SE, Gordon EE, et al. DIABEDS: A randomized trial of the effects of physician and/or patient education on diabetes patient outcomes. *Journal of Chronic Disease* 1987; 40(4): 345-56.

[225] Carlson A, Rosenqvist U. Diabetes control program implementation: on the importance of staff involvement. *Scandinavian Journal of Primary Health Care* 1988; (Suppl 1): 105-12.

[226] Carlson A, Rosenqvist U. Diabetes care organization: process and patient outcomes: effects of a diabetes control program. *Diabetes Educator* 1991; 17(1): 42-8.

[227] New JP, Mason JM, Freemantle N, Teasdale S, Wong LM, Bruce NJ, Burns JA, Gibson JM. Specialist nurse-led intervention to treat and control hypertension and hyperlipidemia in diabetes (SPLINT): a randomised controlled trial. *Diabetes Care* 2003; 26(8): 2250-5.

[228] Denver EA, Barnard M, Woolfson RG, Earle KA. Management of uncontrolled hypertension in a nurse-led clinic compared with conventional care for patients with type 2 diabetes. *Diabetes Care* 2003; 26(8): 2256-60.

[229] Harris MI. Racial and ethnic differences in health care access and health outcomes for adults with type 2 diabetes. *Diabetes Care* 2001; 24(3): 454-9.

[230] Veale B. Meeting the challenge of chronic illness in general practice. *Medical Journal of Australia* 2003; 179(5): 247-9.

[231] Keen H. Management of non-insulin-dependent diabetes mellitus: The United Kingdom experience. *Annals of Internal Medicine* 1996; 124(Suppl 1 pt 2): 156-9.

[232] Stason WB, Shepard DS, HM Perry Jr, Carmen BM, Nagurney JT, Rosner B, Meyer G. Effectiveness and costs of Veterans Affairs hypertension clinic. *Medical Care* 1994; 32(12): 1197-215.

[233] Schulz JF, Sheps SG. Management of patients with hypertension: a hypertension clinic model. *Mayo Clinic Proceedings* 1994. 69(10): 997-9.

[234] Thorne PA, Watkins P. Organisation of diabetic care. *British Medical Journal* 1982; 285(6344): 787-9.

[235] Nocon A, Rhodes PJ, Wright JP, Eastham J, Williams DR, Harrison SR, Young RJ. Specialist general practitioners and diabetes clinic in primary care: a qualitative and descriptive evaluation. *Diabetic Medicine* 2004; 21(1): 32-8.

[236] Ariyaratne CV, Harris M. The use of diabetes registers in an urban division of general practice. *Australian Family Physician* 2004; 33(4): 287-8.

[237] Wagner EH, Austin BT, Davis C, Hindmarsh M , Schaefer J, Bonomi A. Improving chronic illness care: translating evidence into action. *Health Affairs* 2001; 20(6): 64-79.

[238] Parsons T. The Social System. Glencoe, IL: The Free Press: 1951.

[239] Institute of Medicine. Crossing the quality chasm: a new health system for the twenty-first century. Washington: National Academy Press, 2001.

[240] Koperski M. How effective is systematic care of diabetic patients? a study in one general practice. *British Journal of General Practice* 1992; 42(365): 508-11.

[241] Wagner EH. The role of patient care teams in chronic disease management. *British Medical Journal* 2000; 320(7234): 569-72.

[242] Wagner EH, Glasgow RE, Davis C, Bonomi AE, Provost L, McCulloch D, Carver P, Sixta C. Quality improvement in chronic illness care: a collaborative approach. *Joint Commission Journal on Quality Improvement* 2001; 27(2): 63-80.

[243] Aubert RE, Herman WH, Waters J, Moore W, Sutton D, Peterson BL, Bailey CM, Koplan JP. Nurse case management to improve glycemic control in diabetic patients in a health maintenance organization: a randomised controlled trial. *Annals of Internal Medicine* 1998; 129(8): 605-12.

[244] Stewart MA. Effective physician-patient communication and health outcomes: a review. *CMAJ: Canadian Medical Association Journal* 1995; 152(9):1423-33.

[245] Anderson RM, Funnell MM, Butler PM, Arnold MS, Fitzgerald JT, Feste CC. Patient empowerment: results of a randomised controlled trial. *Diabetes Care* 1995; 18(7): 943-9.

[246] Clement S. Diabetes self-management education. *Diabetes Care* 1995; 18(8): 1204-14.

[247] McCulloch D, Glasgow RE, Hampson SE, Wagner E. A systematic approach to diabetes management in the post-DCCT era. *Diabetes Care* 1994; 17(7): 765-9.

[248] Johnson ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome: a critical appraisal of research. *Annals of Internal Medicine* 1994; 120(2): 135-42.

[249] Feifer C, Ornstein SM, Nietert PT, Jenkins RG. System supports for chronic illness and their relationship to clinical outcomes. *Topics in Health Information Management* 2001; 22(2): 65-72.

[250] Hurwitz B, Goodman C, Yudkin J. Prompting the clinical care of non-insulin dependent (type II) diabetic patients in an inner city area: one model of community care. *British Medical Journal* 1993; 306(6878): 5624-30.

[251] Simon GE, Ludman EJ, Tutty S, Operskalski B, Von Korff M. Telephone psychotherapy and telephone case management for primary care patients starting antidepressant treatment: a randomised controlled trial. *Journal of the American Medical Association* 2004; 292(8): 935-42.

[252] Brooks PM. Organisation of healthcare: challenging the "ego systems" *Medical Journal of Australia* 2000; 172(9): 445-7.

[253] McCarty CA, Lloyd-Smith CW, Lee SE, Livingston PM, Stanislavsky YL, Taylor HR. Use of eye care services by people with diabetes: the Melbourne Visual Impairment Project. *British Journal of Ophthalmology* 1998; 82(4): 410-4.

[254] Bolton P, Mira M. Characteristics of services provided by GPs. In: Department of Health and Aged Care. General practice in Australia 2000. Canberra: Department of Health and Aged Care, 2000: 105-56.

[255] Beilby J, Steven ID, Coffey G, Litt JC, Marley JC. Reported diabetes management among South Australian general practitioners. *Australian Family Physician* 1994; 23(4): 611- 3, 618-21 *passim*.

[256] Wilkinson D, McElroy H, Beilby J, Mott K, Morey S, Best J. Variation in levels of uptake of enhanced primary care item numbers between rural and urban settings, November 1999 to October 2001. *Australian Health Review* 2002; 25(6): 123-30.

[257] Keating NL, Landrum MB, Landon BE, Ayanian JZ, Borbas C, Wolf R, Guadagnoli E. The influence of physicians' practice management strategies and financial arrangements on quality of care among patients with diabetes. *Medical Care* 2004; 42(9): 829-39.

[258] Deeble J. Medicare: Where have we been? Where are we going? *Australian and New Zealand Journal of Public Health* 1999; 23(6): 563-70.

[259] Mooney G. Key Issues in Health Economics. London: Harvester/ Wheatsheaf, 1994: 65-86.

[260] Australian Bureau of Statistics. Information paper: Socio-economic indexes for areas (SIEFA), Australia 2001. ABS Cat No. 2039.0. Canberra: Australian Bureau of Statistics, 2001.

[261] Townsend P, Whitehead M, Davidson N (eds). Inequalities in health: the Black Report and the Health Divide (2 ed). London: Penguin, 1992.

[262] Evans JM, Newton RW, Ruta DA, Macdonald TM, Morris AD. Socio-economic status, obesity and prevalence of type 1 and type 2 diabetes mellitus. *Diabetic Medicine* 2000; 17(6):478-80.

[263] Turrell G, Mathers C. Socio-economic inequalities in all-cause and specific-cause mortality in Australia: 1985-1987 and 1995-1997. *International Journal of Epidemiology* 2001; 30(2): 231-9.

[264] Bhopal R, Hayes L, White M, Unwin N, Harland J, Ayis S, Alberti G. Ethnic and socio-economic inequalities in coronary heart disease, diabetes and risk factors in Europeans and South Asians. *Journal of Public Health Medicine* 2002; 24(2): 95-105.

[265] West SK, Munoz B, Klein R, Broman AT, Sanchez R, Roriguez J, Snyder R. Risk factors for type II diabetes and diabetic retinopathy in a Mexican-American population: Proyecto VER. *American Journal of Ophthalmology* 2002; 134 (3): 390-98.

[266] Paeratakul S, Lovejoy JC, Ryan DH, Bray GA. The relation of gender, race and socioeconomic status to obesity and obesity comorbidities in a sample of US adults. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 2002; 26(9): 1205-10.

[267] Green C, Hoppa RD, Young KT, Blanchard JF. Geographic analysis of diabetes prevalence in an urban area. *Social Science and Medicine* 2003; 57(3): 551-60.

[268] Tang M, Chen Y, Krewski D. Gender-related differences in the association between socio-economic status and self-reported diabetes. *International Journal of Epidemiology* 2003; 32: 381-5.

[269] Connolly V, Unwin N, Sherriff P, Bilous R, Kelly W. Diabetes prevalence and socio-economic status: a population-based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. *Journal of Epidemiology and Community Health* 2000; 54(3):173-7.

[270] Roper NA, Bilous RW, Kelly WF, Unwin NC, Connolly VM. Excess mortality in a population with diabetes and the impact of material deprivation: longitudinal, population based study. *British Medical Journal* 2001; 322(7299): 1389-93.

[271] Koskinen SV, Martelin TP, Valkonen T. Socio-economic differences among diabetic people in Finland: five year follow up. *British Medical Journal* 1996; 313(7063): 375-8.

[272] Larsson D, Lager I, Nilsson PM. Socio-economic characteristics and quality of life in diabetes mellitus - relation to metabolic control. *Scandinavian Journal of Public Health* 1999; 27(2): 101-5.

[273] Bachmann MO, Eachus J, Hopper CD, Davey Smith G, Propper C, Pearson NJ, Williams S, Tallon D, Frankel S. Socio-economic inequalities in diabetes complications, control, attitudes and health service use: a cross-sectional study. *Diabetic Medicine* 2003; 20(11): 921-9.

[274] Brunner E, Shipley MJ, Blane D, Smith GD, Marmot MG. When does cardiovascular risk start? Past and present socio-economic circumstances and risk factors in adulthood. *Journal of Epidemiology and Community Health* 1999; 53(12): 757-64.

[275] Bartley M, Martikainen P, Shipley M, Marmot M. Gender differences in the relationship of partners social class to behavioural risk factors and social support in the Whitehall II study. *Social Science and Medicine* 2004; 59(9): 1925-36.

[276] Goyder EC, McNally PG, Botha JL. Inequalities in access to diabetes care: evidence from a historical cohort study. *Quality in Health Care* 2000; 9(2): 85-9.

[277] Edwards R, Burns JA, McElduff P, Young RJ, New JP. Variations in the process and outcomes of diabetes care by socio-economic status in Salford, UK. *Diabetologia* 2003; 46(6): 750-9.

[278] Australian Bureau of Statistics. National health survey 2001: summary report. ABS Cat No. 4364.0. Canberra: Australian Bureau of Statistics, 2002.

[279] Taylor R, Chey T, Bauman A, Webster I. Socio-economic, migrant and geographic differentials in coronary heart disease occurrence in New South Wales. *Australian and New Zealand Journal of Public Health* 1999; 23(1): 20-6.

[280] Bennett S. Cardiovascular risk factors in Australia: trends in socio-economic inequalities. *Journal of Epidemiology and Community Health* 1995; 49(4): 363-72.

[281] Salmon J, Owen N, Bauman A, Schmitz MK, Booth M. Leisure-time, occupational, and household physical activity among professional, skilled and less-skilled workers and homemakers. *Preventive Medicine* 2000; 30(3): 191-9.

[282] Mainous AG, King DE, Garr DR, Pearson WS. Race, rural residence and control of diabetes and hypertension. *Annals of Family Medicine* 2004; 2(6): 563-8.

[283] Ramsay PW, Glenn LL. Obesity and health status in rural, urban, suburban southern women. *Southern Medical Journal* 2002; 95(7): 666-71.

[284] Laaksonen M, Lahelma E, Prattala R. Associations among health-related behaviours: sociodemographic variation in Finland. *Sozial-und Praventivmedizin* 2002; 47(4): 225-32.

[285] Australian Bureau of Statistics. National Health Survey 1995: Cardiovascular and related conditions. ABS Cat No. 4368.0. Canberra: Australian Bureau of Statistics, 1997.

[286] Beilby J, Furler J. General practitioner services in Australia. In: Department of Health and Ageing. General Practice in Australia 2004. Canberra: Department of Health and Ageing, 2005: 129-213.

[287] McLennan W, Madden R. The health and welfare of Australia's Aboriginal and Torres Strait islander peoples. Canberra: Australian Bureau of Statistics and Australian Institute of Health and Welfare, 1997.

[288] International Diabetes Institute. Diabesity and associated disorders in Australia: 2000. Melbourne: Australia, International Diabetes Institute, 2001

[289] Cunningham J, Condon JR. Premature mortality in Aboriginal adults in the Northern Territory, 1979-1991. *Medical Journal of Australia* 1996; 165(6): 309-12.

[290] Hoy WE, Mathews JD, McCredie DA, Pugsley DJ, Hayhurst BG, Rees M, Kile E, Walker KA, Wang Z. The multidimensional nature of renal diseases: rates and associations of albuminuria in an Australian Aboriginal Community. *Kidney International* 1998; 54(4): 1296-304.

[291] Hoy WE, Pugsley DJ, Hayhurst B, Mathews JD. Treatment of end-stage renal disease in the Top End of the Northern Territory, 1978-1993. *Nephrology* 1995; 1: 307-313.

[292] Philips CB, Patel MS, Cabaron Y. Utilisation of health services by Aboriginal Australians with diabetes. *Diabetes Research and Clinical Practice* 1993; 20(3): 231-9.

[293] Hoy WE. Renal disease in Australian Aboriginals. *Medical Journal of Australia* 1996; 165(3): 126-7.

[294] Edwards FM, Wise PH, Craig RJ, Thomas DW, Murchland JB. Visual acuity and retinal changes in South Australian Aborigines. *Australia and New Zealand Journal of Medicine* 1976; 6(3): 205-9.

[295] Stanton K, McCann V, Knuiman M, Constable I, Welborn T. Diabetes in part-Aborigines of Western Australia. *Diabetologia* 1985; 28(1): 16-21.

[296] World Health Organisation. Diabetes mellitus: report of a WHO Study Group. Geneva: World Health Organization, 1985.

[297] Bastian P. Coronary heart disease in tribal Aborigines – The West Kimberly Survey. *Australia and New Zealand Journal of Medicine* 1979; 9(3): 284-92.

[298] Smith RM, Spargo RM, Hunter EM, King RA, Correll RL, Craig IH, Nestel PJ. Prevalence of hypertension in Kimberley Aborigines and its relationship to ischaemic heart disease. An age-stratified random survey. *Medical Journal of Australia* 1992; 156(8): 557-62.

[299] Gracey M, Veroni M. Comparative hospitalisation and mortality rates of Aboriginal and non-Aboriginal Western Australians in their sixth and seventh decades. *Australia and New Zealand Journal of Medicine* 1995; 25(1): 27-31.

[300] Van Buynder PG, Gaggin JA, Mathews JD. Renal disease patterns in Aboriginal Australians: a family based study in a high incidence community. *Medical Journal of Australia* 1993; 159(2): 82-7.

[301] Rowley KG, Iser DM, Best JD, O'Dea K, Leonard D, McDermott. Albuminuria in Australian Aboriginal people: prevalence and associations with components of the metabolic syndrome. *Diabetologia* 2000; 43(11): 1397-403.

[302] O'Dea K, Spargo RM, Akerman K. The effect of transition from traditional to urban life-style on the insulin secretory response in Australian Aborigines. *Diabetes Care* 1980; 3(1): 31-7.

[303] Lee AJ, Bonson AP, Powers JR. The effect of retail store managers on Aboriginal diet in remote communities. *Australian and New Zealand Journal of Public Health* 1996; 20(2): 212-4.

[304] Lee AJ, O'Dea K, Mathews JD. Apparent dietary intake in remote Aboriginal communities. *Australian Journal of Public Health* 1994; 18(2): 190-7.

[305] Willems S, De Masschalck S, Deveugele M, Derese A, De Maesenee J. Socio-economic status of the patient and doctor-patient communication: does it make a difference. *Patient Education and Counseling* 2004; 56(2): 139-46

[306] Dowse GK, Gareeboo H, Zimmet PZ, Alberti KG, Tuomilehto J, Fareed D, Brissonnette LG, Finch CF. High prevalence of NIDDM and glucose intolerance in Indian, Creole and Chinese Mauritians. *Diabetes* 1990; 39(3): 390-6.

[307] Collins V, Dowse G, Plehwe W, Imo TT, Toelupe PM, Taylor HR, Zimmet PZ. High prevalence of diabetic retinopathy and nephropathy in Polynesians of Western Samoa. *Diabetes Care* 1995; 18(8): 1140-9.

[308] Sievers ML, Nelson RG, Knowler WC, Bennett PH. Impact of NIDDM on mortality and causes of death in Pima Indians. *Diabetes Care* 1992; 15(11): 1541-9.

[309] Turrell G. Structural, material and economic influences on the food purchasing choices of socioeconomic groups. *Australian and New Zealand Journal of Public Health* 1996; 20(6): 611-7.

[310] O'Dea K. Diabetes in Australian Aborigines: impact of the Western diet and lifestyle. *Journal of Internal Medicine* 1992; 232(2): 103-17.

[311] Kunitz SJ. Globalization, states and the health of indigenous peoples. *American Journal of Public Health* 2000; 90(10): 1531-1539.

[312] Centres for Disease Control and Prevention (CDC). Injury mortality among American Indian and Alaska Native children and youth – United States, 1989-1998. *MMWR. Morbidity and Mortality Weekly Reports* 2003; 52(30): 697-701.

[313] Gurri FD, Balam Pereira G, Moran EF. Well-being changes in response to 30 years of regional integration in Maya populations from Yucatan, Mexico. *American Journal of Human Biology* 2001; 13(5): 590-602.

[314] Beveridge W. Social insurance and allied services. London: HMSO 1942.

[315] Blewitt N. Healthy public policy. *New Doctor* 1987; 44:17.

[316] Acheson D, Barker D, Chambers J, Graham H, Marmot M. Independent inquiry into inequalities in health: report. London: Stationery Office, 1998.

[317] Shelly JM, Irwig LM, Simpson JM, Macaskill P. Who had pap smears in New South Wales? Patterns of screening across sociodemographic groups. *Australian Journal of Public Health* 1994; 18(4): 406-11.

[318] Hill DJ, White VM, Borland R, Cockburn J. Cancer-related beliefs and behaviours in Australia. *Australian Journal of Public Health* 1991; 15(1): 14-23.

[319] Wiggers JH, Sanson-Fisher R. Practitioner provision of preventive care in general practice consultations: Association with patient educational and occupational status. *Social Science and Medicine* 1997; 44(2): 137-46.

[320] Sims G, Bolton P. The supply and distribution of general practitioners. Department of Health and Ageing. General Practice in Australia: 2004. Commonwealth of Australia, Canberra, 2005: 95-127.

[321] Turrell G, Oldenburg B, McGuffog ID, Dent R. Socio-economic determinants of health: towards a national research program and a policy intervention agenda. Canberra: Queensland University of Technology, School of Public Health and Ausinfo, 1999.

[322] McDermott R, Tulip F, Sinha A. Sustaining better diabetes care in remote indigenous communities. *Quality and Safety in Health Care* 2004; 13(4): 295-8.

[323] Mak DB, Plant AJ, McAllister I. Screening for diabetic retinopathy in remote Australia: a program description and evolution of a devolved model. *Australian Journal of Rural Health* 2003; 11(5): 224-30.

[324] Grant RW, Hamrick HE, Sullivan CM, Dubey AK, Chueh HC, Cagliero E, Meigs JB. Impact of population management with direct physician feedback on care of patients with type 2 diabetes. *Diabetes Care* 2003: 26(8): 2275-80.

[325] Clark CM Jr. How should we respond to the worldwide diabetes epidemic? *Diabetes Care* 1998; 21(4): 475-6.

[326] Engelgau MM, Aubert RE, Thompson TJ, Herman WH. Screening for NIDDM in nonpregnant adults. A review of principles, screening tests, and recommendations. *Diabetes Care* 1995; 18(12): 1606-18.

[327] Coon P, Zulkowski K. Adherence to American Diabetes Association Standards of Care by rural health care providers. *Diabetes Care* 2002; 25(12): 2224-9.

[328]Commonwealth Department of Human Services and Health. Medicare Benefits Schedule Book (Operating from 1 November 1995). Australian Government Publishing Service, Canberra, 1995.

[329] Wong O. Use of administrative databases in occupational and environmental epidemiological research. *Annals of Epidemiology* 2001; 11(5): 281-5.

[330] Bailey CC, Sparrow JM, Grey RH, Cheng H. The National Diabetic Retinopathy Laser Treatment Audit. *Eye* 1998; 12 (Pt 1): 69-76.

[331] Rothman KJ, Greenland S. Modern epidemiology (2 ed). Philadelphia: Lippincott-Raven, 1998: 93-114.

[332] Department of Health and Ageing. General Practice in Australia: 2004. Commonwealth of Australia, Canberra, 2005: 597.

[333] Australian Bureau of Statistics. Outcomes of ABS views on remoteness classification, Australia. Information Paper. ABS Cat No. 1244.0.001. ABS, Canberra 2001.

[334] Miller G, Britt H, Pan Y, Knox S. Relationship between general practitioner certification and characteristics of care. *Medical Care* 2004; 42(8): 770-8.

[335] Massing MW, Henley NS, Carter-Edwards L, Schenck AP, Simpson RJ Jr. Lipid testing among patients with diabetes: care from primary care physicians. *Diabetes Care* 2003; 26(5): 1369-73.

[336] Kristinsson JK. Diabetic retinopathy: screening and prevention of blindness. *Acta Ophthalmologica Scandinavica* 1997; 223(Suppl): 1-76.

[337] Costanza MC. Theoretical epidemiology: matching. *Preventive Medicine* 1995; 24(5): 425-33.

[338] Britt H, Valenti L, Miller G. Time for care – length of consultations in Australia. *Australian Family Physician* 2002; 31(9): 876-80.

[339] Roter D, Lipkin M Jr, Korsgaard A. Sex differences in patients' and physicians' communication during primary care medical visits. *Medical Care* 1991; 29(11): 1083-93.

[340] Saha S, Komaromy M, Koepsell TD, Bindman AB. Patient – physician racial concordance and the perceived quality and use of health care. *Archives of Internal Medicine* 1999; 159(9): 1015-1016.

[341] Australian Bureau of Statistics. ASGC Remoteness classification: purpose and use. Census Paper No. 03/01. Canberra: Australian Bureau of Statistics, 2001.

[342] Kleinbaum DG, Kupper LL, Muller KE, Nizam A. Applied regression analysis and other multivariable methods. Pacific Grove, CA: Duxbury Press, 1998: 656-87.

[343] SPSS Inc. Version 11.5 for Windows (Computer software package). Chicago, 2001.

[344] Orr N, Boyages S. Patterns of care as a risk factor for the development of vision-threatening retinopathy: a population-based matched case control study using insurance claims (Medicare) data. *Diabetic Medicine* 2005; 22(8): 1083-90.

[345] Britt H, Sayer G, Miller G, Charles J, Scahill S, Horn F et al. General practice activity in Australia 1998-1999. AIHW Cat. No. GEP2. Canberra: Australian Institute of Health and Welfare, 1999.

[346] King H, Aubert RE, Herman WH. Global burden of diabetes, 1995-2025: prevalence, numerical estimates and projections. *Diabetes Care* 1998; 21(9): 1414-31.

[347] Tapp RJ, Shaw JE, Harper CA, de Courten MP, Balkau B, McCarty DJ, Taylor HR, Welborn TA, Zimmet PZ. Ausdiab Study Group. The prevalence of and factors associated with diabetic retinopathy in the Australian population. *Diabetes Care* 2003; 26(6): 1731-37.

[348] Orchard TJ. Dyslipoproteinemia and diabetes. *Endocrinology and Metabolism Clinics of North America* 1990; 19(2): 361-80.

[349] Harrold LR, Field TS, Gurwitz JH. Knowledge, patterns of care, and outcomes of care for generalists and specialists. *Journal of General Internal Medicine* 1999; 14(8): 499-511.

[350] Gruen RL. Variations in procedure rates: a need for 'population-based' surgical research. *Australian and New Zealand Journal of Surgery* 2004; 74(6): 404-5.

[351] Australian Bureau of Statistics. Australian historical population statistics – 2. population distribution. ABS Cat No. 3105.0.65.001. Canberra: Australian Bureau of Statistics, 2004.

[352] McCarty CA, McKay R, Keefe JE. Management of diabetic retinopathy by Australian Optometrists. *Australian and New Zealand Journal of Ophthalmology* 1999; 27(6): 404-9.

[353] Larme AC, Pugh JA. Attitudes of primary care providers towards diabetes: barriers to guideline implementation. *Diabetes Care* 1998; 21(9): 1391-6.

[354] Hulka BS, Wheat JR. Patterns of utilization: the patient perspective. *Medical Care* 1985; 23(5): 438-460.

[355] Verstappen WH, ter Riet G, Dubois WI, Winkens R, Grol RP, van der Weijden T. Variation in test ordering behaviour of GPs: professional or context-related factors? *Family Practice* 2004; 21(4): 387-95.

[356] Weiner JP, Parente ST, Garnick DW, Fowles J, Lawthers AG, Palmer H. Variation in office-based quality: a claims based profile of care provided to Medicare patients with diabetes. *Journal of the American Medical Association* 1995; 273(19): 1503-8.

[357] Engelgau MM, Narayan KMV, Herman WH. Screening for type 2 diabetes mellitus. *Diabetes Care* 2000; 23(10): 1563-80.

[358] Morrison AS. Screening in Chronic Disease (2 ed). New York: Oxford University Press, 1992.

[359] Santrach PJ, Burritt MF. Point of care testing. *Mayo Clinic Proceedings* 1995; 70(5): 493-4.

[360] Ealovega MW, Tabaei BP, Brandle M, Burke R, Herman WH. Opportunistic screening for diabetes in routine clinical practice. *Diabetes Care* 2004; 27(1): 9-12.

[361] Glasgow RE, Wagner EH, Kaplan RM, Vinicor F, Smith L, Norman J. If Diabetes is a public health problem, why not treat it as one? A population-based approach to chronic illness. *Annals of Behavioural Medicine* 1999; 21(2): 159-70.

[362] Campbell MK, Tessaro I, DeVellis B, Benedict S, Kelsey K, Belton L, Sanhueza A. Effects of a tailored health promotion program for female blue-collar workers: health works for women. *Preventive Medicine* 2002; 34(3): 313-23.

[363] Overland J, Yue DK, Mira M. Use of Medicare services related to diabetes care: the impact of rural isolation. *Australian Journal of Rural Health* 2001; 9(6): 311-6.

[364] O'Connor PJ, Desai J, Rush WA, Cherney LM, Solberg LI, Bishop DB. Is having a regular provider of diabetes care related to intensity of care and glycemic control? *The Journal of Family Practice* 1998; 47(4): 290-7.

[365] Aday LA, Andersen R. Equity of access to medical care: a conceptual and empirical overview. *Medical Care* 1981; 19(12 Suppl): 4-27.

[366] Young AF, Dobson AJ. The decline in bulk-billing and increase in out-of-pocket costs for general practice consultations in rural areas of Australia, 1995-2001. *Medical Journal of Australia* 2003; 178(3): 122-6.

[367] Christie S, Fone D. Equity of access to tertiary hospitals in Wales: a travel time analysis. *Journal of Public Health Medicine* 2003; 25(4) 344-50.

[368] Haynes R, Bentham G, Lovett A, Gale S. Effects of distances to hospital and GP surgery on hospital inpatient episodes, controlling for needs and provision. *Social Science and Medicine* 1999; 49(3): 425-33.