Introduction

Diabetes mellitus is a growing health problem, particularly in developed countries. Global projections of diabetes estimate that by 2010 the total number of individuals with diabetes will be 239.3 million worldwide, with 23.7 million people with type 1 diabetes and 215.6 million with type 2 [1]. This is double the number estimated in 1994. In Australia, there were an estimated 700,000 people with diabetes in 1995, of which at least half were unaware they had the condition [2]. This figure is expected to rise to 950,000 by 2010.

Type 2 diabetes is the most common form of diabetes and constitutes the majority of cases worldwide. It comprises 85-90% of all diabetes cases, making it a significant public health issue in the majority of developed countries [3]. There is an increasing body of evidence to suggest that type 2 diabetes is a consequence of increasing levels of obesity, decreased levels of activity, and increased food availability – a result of ‘modernisation’. Societies undergoing transition to western lifestyles (such as hunter-gatherer societies) are potentially at the greatest risk for developing diabetes. In this context, the prevalence of diabetes among some Indigenous Australians is among the highest in the world. This has been attributed at least in part to lifestyle changes associated with transition from a traditional to western diet [4, 5].

What is diabetes?

Diabetes mellitus is defined as ‘a metabolic disorder of multiple aetiology characterised by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both’

More detailed information about kidney disease in Indigenous people can be found at:

http://www.healthinfonet.ecu.edu.au/diabetes_review
In simpler terms, diabetes is a condition where the body does not produce enough insulin. Insulin is a hormone produced by the pancreas that helps glucose (the main source of fuel for the body) move from the blood into the cells. In diabetics, the cells cannot use the glucose and this causes the blood glucose level to rise [6]. There are three main types of diabetes – type 1 diabetes (known also as insulin-dependent diabetes mellitus); type 2 diabetes (known also as non insulin-dependent diabetes mellitus); and gestational diabetes mellitus (GDM) [3].

Type 1 diabetes is predominantly a childhood disease and is more common in developed countries [1]. It is also known as ‘juvenile onset’ diabetes. Management principally involves the injection of insulin into the body, as the cells of the pancreas cannot produce enough insulin. It is incompletely understood as to how this form of diabetes is initiated, but it is believed that an auto-immune response that destroys the insulin-secreting cells of the pancreas (known as beta cells) may be triggered by a viral infection or by a physico-chemical agent. An individual may also be genetically predisposed to this development. Injections are necessary to provide insulin to cells [7]. The onset of type 1 diabetes is rapid and includes symptoms of increased thirst and hunger, excessive urination, dramatic weight loss, and overwhelming tiredness. There is also a range of minor symptoms.

Type 2 diabetes on the other-hand, is a ‘late onset’ diabetes, and develops more commonly in people over 40 years of age. It is primarily managed through diet and exercise [8]. Individuals with type 2 diabetes are not usually dependent on insulin injections. This is because impaired insulin secretion and cell resistance to insulin cause the condition – it is not caused by insulin shortage [9, 10]. Type 2 diabetes is often the result of an individual being overweight for many years. This leads to cells becoming insulin-resistant, as a result of increased levels of sugar being stored as fat and processed. Consequently, the function of the beta cells deteriorates, and this signals the progression of disease from a state of insulin resistance to clinical diabetes. Prolonged and continued beta cell exhaustion can result in reliance on insulin injections [10]. Complications are usually common in individuals with type 2 diabetes, largely because of the longer latent period of disease prior to diagnosis. The disease can go undetected for a number of years, during which time mild symptoms develop – these may become life-threatening.

Gestational diabetes mellitus (GDM) is less common than the other two forms. It is first diagnosed during pregnancy, and is primarily a temporary intolerance to carbohydrate, which returns to normal after the birth. More than 40% of women with GDM develop type 1 or type 2 diabetes in the following 10 years [11]. As well as having a greater risk of birth defects, babies of women with GDM are more likely to develop obesity and impaired glucose intolerance and/or diabetes in later life. Diabetic women who become pregnant are not included in this category [6].

Other types of diabetes include those associated with certain conditions or syndromes, such as malnutrition-related diabetes mellitus, pancreatic disease, diseases of hormonal aetiology, drug-induced or chemical-induced conditions, abnormalities of insulin or its receptors, genetic, and miscellaneous conditions [1].

### Diagnostic criteria

The diagnostic criterion for diabetes mellitus is a fasting blood sugar level of greater than 7.8 mmol/L (Table 1) [3]. An individual must exhibit this level on at least two tests. Random blood sugar levels of greater than 11.1 mmol/L are also suggestive of the diabetic state.

Fasting blood sugar levels of between 6.4 and 7.8 mmol/L indicate impaired glucose tolerance (IGT), which is often the precursor to diabetes [3]. The detection of IGT is a primary signal that diabetes may develop if good health management is not attained. For most people with IGT, this involves following a low-fat diet and maintaining a healthy body weight.

A further test, the oral glucose tolerance test (OGTT), may be performed to assess whether the patient is diabetic or has IGT. The OGTT consists of a glucose drink containing 75g of glucose. The patient’s blood sugar level is measured at one and two hours following administration of the drink. Diabetes is indicated if the two-hour blood sugar level is greater than 11.1 mmol/L and IGT is indicated if the blood sugar level is between 7.8 and 11.1 mmol/L [3].

### Table 1. World Health Organization diagnostic criteria for diabetes

<table>
<thead>
<tr>
<th>Blood sugar level (mmol/L)</th>
<th>Normal glucose tolerance</th>
<th>Impaired glucose tolerance (IGT)</th>
<th>Diabetes mellitus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>&lt; 6.5</td>
<td>n/a</td>
<td>&gt; 11.1</td>
</tr>
<tr>
<td>Fasting</td>
<td>&lt; 6.1</td>
<td>6.1-7.0</td>
<td>&gt; 7.0</td>
</tr>
<tr>
<td>2-hour post-prandial (after 75g glucose load)</td>
<td>&lt; 7.8</td>
<td>7.8-11.1</td>
<td>&gt; 11.1</td>
</tr>
</tbody>
</table>

Source: [9]

Symptoms for diabetes may include:

- frequent infections and boils
- urine infections and thrush
- frequent thirst
• frequent urination
• increased tiredness [12].

Factors contributing to the development of diabetes

Type 1 diabetes

Risk factors for type 1 diabetes are unclear, but intra-uterine nutrition and low birth-weight (small for gestational age) have been suggested as possible risk factors [13]. More than 80% of people with type 1 diabetes have no family history of the disease [2], but approximately half the lifetime risk of type 1 diabetes has been attributed to a familial link [13]. The remaining risk arises from viruses, chemical toxins, dietary components, and other environmental factors. Congenital rubella has been identified as having a causal link in type 1 diabetes development, but most environmental factors cannot be identified with any certainty in the majority of cases. Essentially, exposure to multiple factors, along with potentially long exposure time prior to symptom appearance, prevents their identification [14].

Type 2 diabetes

The development and onset of type 2 diabetes can be greatly influenced by a number of factors, which fall into two categories: non-modifiable (those that cannot be reduced) and modifiable (those that can be reduced).

Non-modifiable risk factors

The non-modifiable risk factors for type 2 diabetes include:
• family history;
• race/ethnicity;
• degree of modernisation/westernisation; and
• increasing age [1, 6].

Family history (or genetic predisposition) is a major risk factor for type 2 diabetes mellitus, and it is likely that multiple gene variations acting on various metabolic functions lead to the development of the disease [2].

Variations in the prevalence of type 2 diabetes between different populations suggest also an increased risk associated with race/ethnicity [1, 2, 15]. The groups with highest prevalences include: Indigenous Australians, Southern Europeans, Indigenous North Americans, African Americans, South Pacific Islanders, Indians and Chinese. The racial/ethnic risk factor is not a discrete one, however, and is strongly linked to westernisation.

The degree of modernisation, or westernisation, has been labelled increasingly as an important risk factor in the development of diabetes (particularly type 2). Populations previously free of diabetes exhibit prevalences that are significantly higher than their western counterparts [1]. This is evident particularly in populations who have changed from a so-called traditional lifestyle to a western lifestyle [16]. The common elements of westernisation include a lifestyle in which less energy is expended (due to use of motorised transport and other labour-saving devices), and, particularly, a diet higher in total kilojoules and fat, but lower in fibre [17].

It has been postulated also that the possible evolution of a ‘thrifty genotype’ may have occurred in some populations. This gene may have resulted as a selective survival advantage in times of fluctuating food abundance and famine, by allowing the efficient storage of kilojoules in times of abundant food supplies to take place [17, 18]. It is believed that this ‘thrifty genotype’ has become detrimental when food supplies are constant and abundant, leading to an increased prevalence of obesity and type 2 diabetes [17].

Increasing age is another risk factor for developing type 2 diabetes. Glucose tolerance deteriorates with increasing age, due to a combination of decreasing insulin secretion and increasing resistance to insulin [7]. As a result, increased life expectancy has contributed to the increase in overall prevalence of type 2 diabetes in many developed countries.

Modifiable risk factors

The modifiable risk factors for type 2 diabetes include:
• obesity;
• poor diet
• inactivity; and
• high blood pressure [1, 6].

Obesity, a condition in which the energy stores of the body (mainly fat) are too large, occurs when energy intake exceeds energy output over quite a long period of time [19]. Obesity may be the single most important risk factor for developing type 2 diabetes, and the risk escalates if body fat is centrally distributed around the abdomen [1, 10]. Around 40% of the adult population of Australia is overweight or obese (49% of adult men and 33% of adult women) [19]. Among people with a family history of diabetes, overweight and obesity are strong predictors of type 2 diabetes development, unmasking the underlying genetic disposition.

Poor nutrition is closely linked to obesity as well as to high blood pressure [20]. High blood pressure in turn is also closely linked to physical inactivity. People who are physically inactive, have poor nutrition habits, and are overweight or obese, also tend to have increased levels of high blood pressure [21]. The NHMRC recommends that a balanced diet should include a variety of fruit
and vegetables, reduced fat dairy foods, and a limited intake of fat
and salt saturated foods [22]. Poor nutrition has been described as
an increase in refined foods (containing high levels of sugars, fats,
and salts), and a decrease in the intake of dietary fibre. Reduced
physical activity coupled with poor nutritional factors, heightens
the risk of multiple chronic diseases, such as diabetes, obesity, and
heart disease [23].

Inactivity (low level of energy output) is often associated with a
person being overweight or obese. A sound diet and an adequate
level of exercise can have a beneficial impact on modifiable risk
factors. Exercise plays a gluco-regulatory role in the body, primarily
by its enhancement of the action of insulin and, to a lesser extent, by
its positive benefits in obtaining and maintaining a healthy weight.
For people who are insulin resistant due to weight problems, a
change in diet combined with increased physical activity may
allow their own body’s insulin to have a greater effect [7].

Possessing one or a combination of non-modifiable and modifiable
factors increases the likelihood of developing type 2 diabetes.
Some of these cannot be reduced (as in the case of non-modifiable
risk factors), but others (such as modifiable risks) can be reduced by
altering ‘unhealthy’ lifestyle habits.

### Diabetes-related complications

Type 2 diabetes has a large number of associated complications,
broadly classified as macrovascular and microvascular
complications (Table 2).

#### Table 2. Proportions of major complications associated with type 2 diabetes

<table>
<thead>
<tr>
<th>Complications</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macrovascular</strong></td>
<td></td>
</tr>
<tr>
<td>• Coronary heart disease (CHD)</td>
<td>75</td>
</tr>
<tr>
<td>• Peripheral vascular disease (PVD)</td>
<td>(which can lead to ulcers, gangrene and amputation)</td>
</tr>
<tr>
<td>• Cerebrovascular disease</td>
<td></td>
</tr>
<tr>
<td><strong>Microvascular</strong></td>
<td></td>
</tr>
<tr>
<td>Neuropathy (nerve damage)</td>
<td>50</td>
</tr>
<tr>
<td>• Distal symmetric polyneuropathy</td>
<td></td>
</tr>
<tr>
<td>• Autonomic neuropathy</td>
<td></td>
</tr>
<tr>
<td>• Cranial neuropathy</td>
<td></td>
</tr>
<tr>
<td>Nephropathy (kidney disease)</td>
<td>30-40</td>
</tr>
<tr>
<td>Vision disorders</td>
<td>20</td>
</tr>
<tr>
<td>• Diabetic retinopathy</td>
<td></td>
</tr>
<tr>
<td>• Glaucoma</td>
<td></td>
</tr>
<tr>
<td>• Cataract</td>
<td></td>
</tr>
<tr>
<td>• Corneal disease</td>
<td></td>
</tr>
<tr>
<td>Infections</td>
<td>5-20</td>
</tr>
<tr>
<td>Metabolic complications</td>
<td>10-30</td>
</tr>
<tr>
<td>Impotence</td>
<td>35-75</td>
</tr>
<tr>
<td>Complications during pregnancy</td>
<td>4-6</td>
</tr>
</tbody>
</table>

Source: Adapted from [1]

The duration of diabetes is associated with the progressive
development of all complications. Complications can become life-
threatening, in which case surgery may be necessary (for example,
kidney transplantation and lower limb amputations). People with
diabetes who develop complications of the disease are at increased
risk of premature death [1].

Macrovascular complications are primarily those affecting the
circulatory system. Individuals with diabetes have increased rates
of coronary heart disease (CHD; known also as ischaemic heart
disease), stroke (cerebrovascular disease), and peripheral vascular
disease (PVD), and are two to three times more likely to develop
cardiovascular disease than the general population [2]. These risks
are increased if an individual smokes, has high cholesterol, and
high blood pressure [24, 25].
Diabetes is considered to be an independent risk factor for CHD, and macrovascular diseases are responsible for over half of all diabetic deaths [2]. Macrovascular complications usually lead to microvascular complications, such as nerve damage. Nerve damage is a major cause of morbidity among people with diabetes, primarily because of the loss of sensation in lower limbs [1]. For example, trauma to the foot may go unnoticed due to foot numbness, increasing the severity of chronic foot ulcers and infections, sometimes leading to gangrene and amputations. In westernised societies, lower extremity amputations are 15 times more common among people with diabetes, accounting for approximately half of all amputations [26]. Diabetic foot problems are, in fact, a combination of macrovascular (PVD) and microvascular (neuropathy) complications, as well as increased susceptibility to bacterial infections [27]. As a result of PVD, blood supply is decreased to the foot, with consequent necrosis (death) of foot tissues. Other factors – such as poor hygiene, ill-fitting footwear, orthopaedic problems, presence of calluses and pressure areas, and poor glycaemic control – contribute to diabetic foot problems. Dietary deficiencies (particularly of zinc, protein and vitamins A and C) may also play a part by impeding healing, thus compounding foot problems [28].

Nerve damage (primarily autonomic neuropathy) can also be responsible for the development of impotence and gastrointestinal problems, and can lead also to severe limb pain, loss of muscle strength and lack of bladder and bowel control. Studies conducted in Western Australia and South Australia have found that 14% to 20% of people with diabetes developed neuropathy [2, 29, 30]. A Swedish study also reported that signs of autonomic neuropathy were present in almost half the study subjects [31].

Kidney disease primarily results from damage to the small blood vessels of the kidney. It is first diagnosed by the detection of protein in the urine (albuminuria), and is associated with hypertension [1, 32]. Over time, nephropathy can develop into end-stage renal disease, which requires dialysis or kidney transplantation. This complication is more common in individuals with type 1 diabetes than those with type 2 diabetes [1]. Microalbuminuria (small amounts of protein in the urine) is usually the first indication of damage to the glomerular filtration barrier, and may predict imminent proteinuria. Proteinuria (detectable by dipstick) usually develops five to ten years after the onset of microalbuminuria, or about 10-15 years after the onset of diabetes [1]. Renal failure caused by diabetes is common among Indigenous Australians. In central Australia, it has been estimated that renal disease is the direct cause of death in 22% of Indigenous diabetics [30].

Diabetic retinopathy, like nephropathy, is also caused by damage to the small blood vessels – in this case, to small vessels in the retina of the eye. In Australia, it is the most common cause of visual loss in adult Australians under the age of 60 years [2]. Diabetic retinopathy is more common in people who have poor blood sugar control and has been associated with insulin and oral hypoglycaemic treatment, duration of diabetes and microalbuminuria. It is readily treatable by laser therapy if identified early. Other eye disorders associated with diabetes that can lead to loss of vision include glaucoma and cataracts [32].

Diabetes affects almost every system in the body – due to the metabolic nature of the disease. As a result of the development of complications, people with type 2 diabetes have higher hospitalisation and health service use than the general population – for treatment of infections, amputations, kidney dialysis and transplants, laser therapy for retinopathy, and other specialist care [1, 27]. Premature death is the most serious result of diabetes, usually caused by one or more of the associated complications. Excess mortality in diabetics is approximately twice that of non-diabetics in Australia – similar to figures from the United Kingdom and Denmark [1].
References


The Australian Indigenous HealthInfoNet is an innovative Internet resource that contributes to ‘closing the gap’ in health between Indigenous and other Australians by informing practice and policy in Indigenous health.

Two concepts underpin the HealthInfoNet’s work. The first is evidence-informed decision-making, whereby practitioners and policy-makers have access to the best available research and other information. This concept is linked with that of translational research (TR), which involves making research and other information available in a form that has immediate, practical utility. Implementation of these two concepts involves synthesis, exchange and ethical application of knowledge through ongoing interaction with key stakeholders.

The HealthInfoNet’s work in TR at a population-health level, in which it is at the forefront internationally, addresses the knowledge needs of a wide range of potential users, including policy-makers, health service providers, program managers, clinicians, Indigenous health workers, and other health professionals. The HealthInfoNet also provides easy-to-read and summarised material for students and the general community.

The HealthInfoNet encourages and supports information-sharing among practitioners, policy-makers and others working to improve Indigenous health – its free on line yarning places enable people across the country to share information, knowledge and experience. The HealthInfoNet is funded mainly by the Australian Department of Health and Ageing. Its award-winning web resource (www.healthinfonet.ecu.edu.au) is free and available to everyone.