4 Complications of diabetes

Introduction

Diabetes can result in a range of short- and long-term complications which are the major causes of associated morbidity and mortality in people with diabetes. These complications are responsible for loss of working ability, invalidism, shortened life expectancy and reduced quality of life among people with diabetes. The presence of complications also greatly increases the cost of managing diabetes.

Short-term complications include diabetic ketoacidosis which results from a severe lack of insulin and hypoglycaemia (low blood sugar) —a complication of insulin or sulphonylurea treatment. Other short-term complications include increased susceptibility to infections and poor wound healing when diabetes is poorly controlled (Flack & Colagiuri 2005).

Long-term complications include disease of the large blood vessels (macrovascular disease) such as coronary heart disease (CHD), stroke and peripheral vascular disease (PVD) as well as diseases of the small blood vessels (microvascular disease) such as retinopathy, kidney diseases and neuropathy (peripheral nerve disease) (Bate & Jerums 2003). Other complications of or conditions associated with diabetes include digestive diseases (ulcers, coeliac disease, cancer of the pancreas, constipation, diarrhoea, liver disease and gallstones), infections, oral diseases, mental problems (depression and anxiety) and problems in pregnancy (ADA 2007b, 2007c; AIHW 2002).

Complications arising from the treatment for diabetes can also occur. These include: hypoglycaemia from insulin or oral hypoglycaemic agents and side effects of hypoglycaemic agents (gastro-intestinal, liver toxicity, lactic acidosis and allergic skin reactions) (Hussein et al. 2004).

The underlying causes of diabetes complications remain controversial, although persistent high blood sugar is strongly implicated. The Diabetes Control and Complications Trial, involving participants with Type 1 diabetes, showed that keeping blood sugar levels as close to normal as possible slows the onset and progression of eye, kidney and nerve diseases (DCCT Research Group 1993). The United Kingdom Prospective Diabetes Study of people with Type 2 diabetes found that tight blood sugar control reduces the risk of major diabetic eye disorder by a quarter and early kidney damage by a third. Moreover, tight blood pressure control in people with high blood pressure reduces the risk of strokes, serious deterioration of vision and death from long term complications in diabetes, all by at least a third (UKPDS 1998).

Improving the management and care of diabetes, particularly the early identification and reduction of risk factors, can delay the onset or slow the progression of complications.

This chapter presents information on diabetes complications from many different data sources: self-reported and measured surveys and administrative collections. Data on a number of diabetes-related complications, including kidney, eye, nervous system and peripheral circulatory complications are available in hospital and deaths databases. However, other conditions such as CHD, stroke, PVD and ESKD are not available specifically identified as being related to diabetes. For these conditions, it was necessary to derive information assuming that the presence of diabetes may have contributed to them. The method of deriving such data is described in Box 4.1.

Cardiovascular disease

Cardiovascular disease (CVD) is a major complication of, and leading cause of death in, diabetes (Ali & Maron 2006). People with diabetes have twice the risk of CVD, including stroke and myocardial infarction (heart attack) compared with the general population. People with diabetes have higher mortality as a result of their first cardiovascular event (such as stroke or heart attack), and poorer outcomes in the months and years following such an event, compared with the general population (Buse et al. 2007). In people with diabetes, CVD has an earlier onset and is more resistant to treatment and therapies compared wutg those without diabetes (Weisfeldt & Zieman 2007).

This section focuses on coronary heart disease, stroke and peripheral vascular disease, as they are the most common cardiovascular complications associated with diabetes.

Box 4.1 Identifying diabetes complications in hospitalisations and deaths data

The method described below is used to identify diabetes hospitalisations and deaths that occurred with CVD, stroke, PVD, kidney complications of diabetes (including ESKD), oral, neurological and ophthalmic complications of diabetes and lower limb ulcers.

The first step in analysing the hospitalisations data was to identify people with diabetes: that is, hospitalisations where diabetes was mentioned as either the principal or an additional diagnosis (ICD 10 codes: E10-E14 and O24).

The next step was to identify which of these diabetes hospitalisations also had the selected complication listed as the principal or an additional diagnosis.

Similarly, mortality analysis for diabetes complications for these conditions include any death where diabetes was mentioned along with the selected complication, either as the underlying or the additional cause of death.

It is possible for a single person with diabetes to have multiple complication types and consequently, there may be multiple complication types listed among the diagnoses for a single hospitalisation event or as a cause of death for an individual.

Coronary heart disease

Coronary heart disease (CHD) is the most common cause of sudden death in Australia. It consists mainly of acute myocardial infarction (heart attack) and angina. A heart attack occurs when a blood vessel supplying the heart itself is suddenly blocked completely, threatening to disrupt the heart and its functions, whereas angina is a temporary chest pain or discomfort caused by a reduced blood supply to the heart muscle.

Stroke

Cerebrovascular disease comprises disorders in which there is a disturbance of blood supply to the brain. Stroke is the most important manifestation of cerebrovascular disease. A stroke occurs when an artery supplying blood to a part of the brain suddenly becomes blocked (ischaemic stroke) or bleeds (haemorrhagic stroke), which account for about 85% and 15% of cases respectively. One in five people having a first-ever stroke die as a result within 1 month of its occurrence and one in three die within 12 months of their stroke (Thrift et al. 2000). Stroke also causes a large degree of disability and nearly all patients are disabled immediately following a stroke event. There may be permanent paralysis of one side of the body, speech or swallowing difficulties, problems with memory, personality changes or a range of other difficulties. Depression, anxiety and cognitive impairment are also common after stroke (Srikanth et al. 2004).

Peripheral vascular disease

Peripheral vascular disease (PVD) occurs due to a reduced arterial blood supply to the legs. It ranges from asymptomatic disease, through pain on walking, to pain at rest. It can also result in reduced blood supply that may lead to amputation if severe enough. While this is a significant cause of disability among people with PVD, the major cause of death in people with PVD is coronary heart disease.

How does diabetes increase the risk of developing cardiovascular disease?

The reasons why diabetes increases the risk of CVD are only partially understood. The prevailing explanation is that diabetes increases atherosclerosis (thickening of the walls of a blood vessel with deposits of plaque). Studies have shown that people with diabetes have a high prevalence of sub-clinical coronary heart disease (disease without symptoms) and it can be assumed that a person with diabetes would have some level of coronary pathology (Ali & Maron, 2006; Buse et al. 2007). Other factors possibly

contributing to the excess risk of cardiovascular disease in people with diabetes include high blood pressure and dyslipidaemia (low levels of HDL-cholesterol and high levels of LDL-cholesterol and triglycerides). Both are risk factors for cardiovascular disease and their prevalence is higher among people with diabetes (Wu et al. 1999).

Many aspects of the development of macrovascular complications such as cardiovascular disease in people with diabetes are not yet fully understood. It is not clear, for example, whether the development of the disease is the same in Type 1 and Type 2 diabetes, although both types are associated with an increased risk.

Risk factors

The risk of developing CVD increases when diabetes is present with other risk factors such as tobacco smoking, physical inactivity, high blood pressure, high blood cholesterol, and overweight and obesity.

Prevention and treatment of macrovascular complications in people with diabetes is not as well defined or as straight forward as microvascular disease (eye disease and kidney disease). A 'broad-based' regime involving weight reduction, increased physical activity, blood pressure control, blood lipid reduction, cessation of tobacco use and aspirin therapy have been shown to be effective primary preventative and treatment measures. Blood sugar control has also been shown to be effective in preventing microvascular disease, but there is no strong evidence suggesting that it lowers the risk of CVD in people with diabetes (Buse et al. 2007).

How many Australians with diabetes also have cardiovascular disease?

Coronary heart disease

The 1999–2000 AusDiab study showed that nearly 10% of Australians aged 25 years and over with diabetes had coronary heart disease compared with 6% of people without diabetes. In the same survey, 5% of people with diabetes had had a heart attack and 8% had angina while the corresponding rates for people without diabetes were 3% and 5%.

According to the 2004–05 NHS self-reports, an estimated 11% of people with diabetes had had a heart attack and 12% had angina. These proportions were greater among people with diabetes than among those without diabetes.

The age-standardised rate of heart attack among people with diabetes was more than twice as high as that among people without diabetes (3.1% and 1.5% respectively). The respective age-standardised rates of angina were 4.1% and 1.6% for people with and without diabetes.

A greater proportion of males with diabetes had suffered a heart attack (4%) than females (2.1%). The reverse was true for angina: 3.6% of males and 4.8% of females with diabetes had experienced the condition.

Stroke

Based on information from the 2003 Survey of Disability, Ageing and Carers, people aged over 50 had higher rates of stroke than younger people. In the 50 years and over age group, about 23,400 (7.2%) of males and 31,300 (10%) of females with diabetes had had a stroke. When the different age-structures of the male and female populations were taken into account, females with diabetes (10.2%) still had a higher rate of stroke than males with diabetes (7.7%). People with diabetes over 50 had a higher rate of stroke (7.8%) than people without diabetes (5.2%). Based on 1999–2000 AusDiab survey data, an estimated 5% of people aged 25 years and over with diabetes had had a stroke compared with 2% of people without diabetes.

Peripheral vascular disease

There are limited national data on the number of Australians who have diabetes and PVD. Data collected through the Australian National Diabetes Information Audit and Benchmarking (ANDIAB) in 2004 revealed that 12.4% of adults attending specialist diabetes services also had peripheral vascular disease (NADC 2005).

Hospitalisations

In 2004–05, there were over 81,000 hospitalisations where both diabetes and CHD were present and this accounted for 15.3% of all diabetes hospitalisations. Diabetes hospitalisations with stroke in 2004–05 amounted to 11,750 or 2.2% of all diabetes hospitalisations and PVD was present in more than 31,000 (5.9% of all diabetes hospitalisations. A greater proportion of males than females with diabetes also had CHD, PVD and stroke (Table 4.1).

The rate of diabetes hospitalisations with CHD, stroke and PVD increased progressively with age for both sexes, although more males than females across all age groups were hospitalised with diabetes and these complications. Diabetes hospitalisations with CHD started to accelerate for males at ages 45–49 years onwards, while for females the acceleration occurred from ages 60 to 64 years. For both males and females, diabetes hospitalisations with stroke did not start to increase until ages 70–74 years. Diabetes hospitalisations with PVD increased for males from ages 60–64 years of age and for females aged 65–69 years.

Deaths

In 2005, diabetes was mentioned as an underlying or an associated cause of death in nearly 11,900 deaths (9% of all deaths in that year). Almost half of these deaths also involved CHD (48%), while stroke was mentioned in 16%, and PVD in 6%of diabetes deaths (Table 4.2). Males had higher age-adjusted rates of mortality from diabetes with CHD, stroke and PVD compared with females.

During 1999–05, CVD was the underlying cause in approximately 3 in 10 (29%) deaths of people on the NDR. Of all CVD deaths, 68% were due

Table 4.1: Hospitalisations with diabetes and CHD, stroke or PVD, 2004–05

	Males		Females		Persons[(a)]	
	Number	Per cent	Number	Per cent	Number	Per cent
Coronary heart disease	49,802	17.3	31,551	13.0	81,360	15.3
Stroke	6,697	2.3	5,052	2.1	11,750	2.2
Peripheral vascular disease	20,684	7.2	10,755	4.4	31,439	5.9
Total diabetes hospitalisations	**288,444**		**242,614**		**531,069**	

(a) Includes sex not stated.

Notes

1. Diabetes and related complications are classified according to ICD-10-AM codes. See Appendix 1.
2. Hospitalisations include diabetes as a principal or additional diagnosis.

Source: AIHW National Hospital Morbidity Database.

Table 4.2: Diabetes deaths also involving CHD, stroke or PVD, 2005

	Males		Females		Persons	
	Number	Per cent	Number	Per cent	Number	Per cent
Coronary heart disease	3,216	50.8	2,499	45.1	5,715	48.2
Stroke	931	14.7	971	17.5	1,902	16.0
Peripheral vascular disease	352	5.6	326	5.9	678	5.7
Total diabetes deaths	**6,325**		**5,539**		**11,864**	

Notes

1. Diabetes and related complications are classified according to ICD-10 codes. See Appendix 1.
2. Diabetes deaths include diabetes as an underlying or associated cause of death where CHD, stroke and PVD are also mentioned as an underlying or additional cause of death.

Source: AIHW National Mortality Database.

to coronary heart disease and 14% were from cerebrovascular diseases. Diabetes itself was the underlying cause in 14% of deaths of NDR registrants. The NDR contains information on people who started using insulin to treat their diabetes after 1 January 1999 (AIHW: Catanzariti et al. 2007).

Trends

Over the period 1997 to 2005, the contribution of CHD and PVD to diabetes deaths has declined while the contribution of stroke has remained steady. The proportion of diabetes deaths where CHD was also present declined by 5% and for PVD by 27% between 1997 and 2005. Over this period the proportion of diabetes deaths with CHD was consistently higher among males than females whereas diabetes deaths with PVD or stroke were higher among females.

Eye disease

People with diabetes are at an increased risk of developing diabetic retinopathy (retinal disease), cataract and glaucoma—leading to a loss of vision or blindness—than people without diabetes (Williams et al. 2004). Diabetic retinopathy is the leading cause of blindness in adults aged 20–74 years (Aylward 2005; Fong et al. 2004). Cataracts and glaucoma are also major causes of vision impairment and blindness among adults.

Diabetic retinopathy

Diabetic retinopathy is a microvascular complication of diabetes caused by damage to the capillaries of the retina (the light-sensitive tissues at the back of the eye). In the early stages, the retinal capillaries swell and leak fluid. At this stage there is usually no visual impairment. As the disease progresses, abnormal new capillaries grow on the surface of the retina. Without treatment, these capillaries can bleed causing cloudy vision or blindness. Abnormal fibrous tissue can also develop, leading to retinal detachment with severe vision loss.

Diabetic retinopathy is symptomless in its early phases, and can be treated successfully by laser surgery if identified early. Although it cannot be cured completely, it is estimated that early detection and timely treatment can prevent nearly 100% of severe vision loss and blindness due to diabetic retinopathy (Lee et al. 2001). Despite this, the disease is estimated to account for 17% of all blindness and vision impairment in Australia (Resnikoff et al. 2004).

Cataracts and glaucoma

Cataracts and glaucoma, along with diabetic retinopathy, are the leading causes of blindness and visual impairment in people with diabetes (Williams et al. 2004).

A cataract is a clouding of the normally clear lens of the eye leading to vision loss. A cloudy lens prevents light from entering the eye. Cataracts are more common and progress more rapidly in people with diabetes (Klein & Klein 1995).

Glaucoma is a condition where pressure builds up in the eye, pinching the capillaries that carry blood to the retina and optic nerve. Over time, the retina and optic nerve become damaged and vision is lost. People with diabetes are significantly more likely to develop glaucoma than people without diabetes (Klein & Klein 1995).

Timely identification and treatment can prevent serious vision loss due to cataracts and glaucoma.

Risk factors

Age at onset and duration of diabetes are key factors influencing the development of diabetic retinopathy. In young people with diabetes (aged <30 years at diagnosis), the prevalence is as high as 25% during the first 5 years after diagnosis, increasing to 50% after 15 years since diagnosis. In older people (aged 30 years or more at diabetes diagnosis), up to 20% may have signs of retinopathy, rising to 60% after 15 years with diabetes (Mensah & Kohner 2002).

In addition to duration of diabetes, the risk of developing eye complications and visual impairment increases with coexisting medical problems or complications (such as high blood pressure and nephropathy), poor blood sugar

control, pregnancy, elevated blood lipids and smoking (Cohen et al. 1998; NHMRC 1997). Consequently, good glycaemic control, blood pressure control, management of kidney impairment, blood lipid reduction and increased screening before conception and during pregnancy are key preventative measures and treatment options for reducing the prevalence and serious consequences of diabetic retinopathy (Fong et al. 2004; Williams et al. 2004).

How many Australians with diabetes also have eye disease?

Diabetic retinopathy

In the 1999–2000 AusDiab study, 22% of people with known diabetes and 6.2% of people with new diabetes had retinopathy (Tapp et al. 2003b).

The National Divisions Diabetes Program (NDDP) Data Collation Project found that approximately 11% of patients examined in 2000, 10% in 2001 and 9% in 2002 had retinopathy detected in at least one eye.

Data on the prevalence of diabetic retinopathy among patients attending diabetes clinics are also available from the ANDIAB data. According to ANDIAB, of those patients who had a retinal assessment in 2004, approximately 30% had a diabetes-related abnormality at least one eye (NADC 2005). ANDIAB data report on people with diabetes requiring specialist clinical management, in particular those who have had poor control of their diabetes, so ANDIAB figures are likely to be higher than the rate of this condition among all people with diabetes.

Cataracts and glaucoma

From self-reports in the 2004–05 NHS, about 12% of people with diabetes had sight problems due to diabetes. Overall, 9% of people with diabetes (7% males and 11% females) had cataracts as a long-term condition while 6% (4% males and 7% females) had glaucoma.

The age-standardised rates showed that compared with people without diabetes, those with diabetes were over twice as likely to have glaucoma and nearly two times as likely to have cataracts.

The prevalence of cataracts and glaucoma were high in older ages: over 80% and 52% of people with diabetes aged 65 years and above were estimated to have cataracts and glaucoma, respectively, in 2004–05.

Blindness and visual problems

In 2004–05, 7% of people (7% males and 8% females) with diabetes had visual disturbances or loss of vision, or complete or partial blindness in one or both eyes, based on self-reported data. Of these, 2% had complete or partial blindness and 5% had visual disturbances or loss of vision.

People with diabetes were 1.3 times as likely to be blind or have visual disturbances as people without diabetes according to age-standardised rates.

In 2004–05, among people with diabetes, blindness or visual disturbance was most prevalent among those aged 65 years and over: over 60% of blindness occurred in this age group. A greater proportion of females than males aged 65 years and above was blind or had visual disturbances.

Based on ANDIAB data for 2006, the incidence rate for blindness was 0.7% of all people with clinically diagnosed diabetes (NADC 2007).

Hospitalisations

In 2004–05, there were around 38,700 hospitalisations for diabetes-related eye complications (including retinopathy, glaucoma and cataract) which accounted for approximately 7% of all hospitalisations with diabetes.

Hospitalisations for diabetes-related eye complications were higher for females than for males (8.2% and 7%, respectively). These hospitalisations increased with age: people with diabetes aged 65 years and over accounted for 78% of diabetes hospitalisations with eye complications (Figure 4.1).

Note: Diabetes and related complications are classified according to ICD-10-AM codes. See Appendix 1.

Source: AIHW National Hospital Morbidity Database.

Figure 4.1: Number of hospitalisations for diabetes with ophthalmic complications, 2004–05

Kidney disease

Diabetes can affect the kidneys in a variety of ways, leading to serious and even life-threatening conditions. This section focuses on diabetic nephropathy and chronic kidney failure including ESKD, as these are the most common kidney complications associated with diabetes.

Diabetic nephropathy

Diabetic nephropathy results from high blood sugar levels damaging the blood-filtering capillaries in the kidneys. As a result the filtering efficiency of these capillaries declines and blood proteins such as albumin leak into the urine (albuminuria).

In the early stages of diabetic nephropathy, small quantities of albumin leak into the urine (this is known as microalbuminuria). As diabetic nephropathy progresses, the kidneys leak larger amounts of albumin — this is known as macroalbuminuria or proteinuria. Microalbuminuria is a strong predictor of developing proteinuria, ESKD, high blood pressure and cardiovascular disease. Proteinuria is usually associated with kidney damage (Chadban et al. 2003). Diabetic nephropathy is often asymptomatic until late in the disease when therapeutic interventions are less effective. If detected early, intervention may slow or halt its progression.

Chronic kidney failure (end-stage kidney disease)

In severe cases of diabetic nephropathy, kidney function may deteriorate to the extent that it is no longer sufficient to sustain life and if left untreated is fatal within weeks. This terminal condition is called end-stage kidney disease (ESKD) —a type of chronic kidney failure. Diabetic nephropathy is the most common cause of ESKD in Australia (McDonald et al. 2006).

Risk factors

Factors that may determine whether diabetic nephropathy develops and progresses to ESKD include long duration of diabetes, poor blood sugar control, high blood pressure, anaemia, genetic susceptibility to diabetic kidney disease and smoking (Rossing et al. 2004).

How many Australians with diabetes also have kidney disease?

The most recent available data on the prevalence of kidney disease among people with diabetes is from the 1999–2000 AusDiab study. According to self-reported data from this study, approximately 6.3% of Australians aged 45 or over with diabetes were treated for, or suffering, from kidney disease. Significantly more women with diabetes reported being treated for, or suffering from, kidney disease than men (11% compared with 3%).

Diabetic nephropathy

Examining the prevalence of diabetic nephropathy is problematic due to different methodologies. In this report we have used albuminuria and proteinuria (protein in the urine) as a proxy measures for diabetic nephropathy. These are indicators of kidney damage, which may be caused by high blood sugar in people with diabetes.

Data on the prevalence of diabetic nephropathy based on urinary albumin measurements is available from the 1999–2000 AusDiab study. The prevalence of proteinuria in those with diabetes was over 4 times as high as in those without diabetes (8.7% versus 1.9% respectively) (Chadban et al. 2003).

Data on the prevalence of albuminuria among patients attending diabetes clinics is available from the ANDIAB data. Two thirds of these patients had a urinary albumin assessment in 2006. Of them, 58.9% had normal albumin levels, 31.1% had microalbuminuria and 10.0% had macroalbuminuria (NADC 2007).

Similar data are also available from the National Divisions Diabetes Program (NDDP) Data Collation Project. In 2002, 3,548 of the 13,325 registered NDDP patients had albuminuria assessed. Of those, 76.9% had normal albumin levels, 19.9% had microalbuminuria and 3.1% had macroalbuminuria.

End-stage kidney disease (ESKD)

Evidence of the burden of ESKD caused by diabetes is available from the Australia and New Zealand Dialysis and Transplant (ANZDATA) Registry — a registry of people receiving kidney dialysis or a kidney transplant. New cases of ESKD with diabetic nephropathy as the primary cause have increased dramatically over the past decade. This increase has been most evident among patients with Type 2 diabetes.

In Australia during 2006, diabetic nephropathy was the most common cause of primary kidney disease among ANZDATA patients, which accounted for one third (32%) of new patients (McDonald et al. 2007). This represents an increase in the proportion of new ESKD cases with diabetes—from 25%, in 2001. The burden of ESKD from diabetes, particularly Type 2 diabetes, is likely to increase further as both the age of the population and prevalence of diabetes are projected to rise.

Hospitalisations

Kidney complications

In 2004–05, there were nearly 112,100 diabetes hospitalisations with kidney complications (excludes hospitalisations for dialysis) which accounted for 21% of all diabetes hospitalisations. Nearly 58% of those hospitalisations were for males. Hospitalisations for diabetes with kidney complications increased with age for both men and women (Figure 4.2).

Note: Diabetes and related complications are classified according to ICD-10-AM codes. See Appendix 1.

Source: AIHW National Hospital Morbidity Database.

Figure 4.2: Number of hospitalisations for diabetes with kidney complications, 2004–05

Hospitalisation rates for diabetes with kidney complications increased 3-fold over the period 2000–01 to 2004–05 from about 37,400 to 112,100. Part of this increase may be the result of changes made to the way complications are coded in hospitalisations data (see Appendix 1).

The average length of stay in hospital for diabetes with a principal diagnosis of kidney complication was 11 days for both males and females (this excludes day stay for regular dialysis). The average length of stay was 5 days for males and females for hospitalisations involving any diagnosis of kidney complications.

Chronic kidney failure

In 2004–05 there were over 102,000 hospitalisations with diabetes and chronic kidney failure (this excludes day admissions for dialysis, but includes admissions for ESKD) and 57% of these were for males. These represented 19% of all diabetes hospitalisations in that year.

Between 2000–01 and 2004–05, there has been a 4-fold increase in the number of diabetes hospitalisations with chronic kidney failure (about 23,600 and 102,000, respectively). The proportion of male hospitalisations with diabetes and a diagnosis of chronic kidney failure has always been higher than that of females.

The average length of stay in hospital for people with chronic kidney failure as the principal and diabetes as an additional diagnosis was 9 days. Length of stay in hospital was generally higher for females than for males (11 days compared with 7 days).

Deaths

In 2005, chronic kidney diseases were responsible for 13% (1,557 deaths) of all diabetes deaths and ESKD was mentioned in the majority (90%) of these deaths.

The rate of kidney-related diabetes mortality was higher for males compared with females in 2005 (10 and 6 deaths per 100,000, respectively).

Between 1997 and 2005, the kidney-related diabetes death rate increased by nearly 70% from 5 to 8 per 100,000 people. Males experienced a slightly higher increase than females between the two periods (71% and 62%, respectively).

Nerve damage

Nerve damage (neuropathy) is a frequent complication of diabetes (Boulton et al. 2005). It is not certain how nerve damage occurs. However, there is some evidence suggesting that diabetic neuropathy may be the result of chronically high blood sugar levels, which affect the metabolism of nerves, causing reduced blood flow to the nerve. This, in turn, causes the accumulation of toxins which damage nerve structure and function.

Diabetic neuropathy affects both peripheral (peripheral neuropathy) and autonomic (autonomic neuropathy) nervous systems and is associated with reduced quality of life and increased mortality (Boulton et al. 2005; Vinik et al. 2003).

Peripheral neuropathy

Peripheral neuropathy is 'the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes' (Boulton et al. 2005). The condition commonly causes damage to the nerves in the toes, feet and legs; however, damage can also occur in the hands and arms. Peripheral neuropathy can cause a diverse range of symptoms, depending on the nerve(s) affected, although some people will experience no obvious symptoms.

There are two broad types of peripheral neuropathy:

- Sensory neuropathy—affects the nerves that carry information to the brain about sensations from various parts of the body. Symptoms may include pain, tingling in the limbs, extreme sensitivity to touch, or absence of feeling in the feet (which predisposes people with diabetes to foot trauma).
- Motor neuropathy—affects the nerves that carry signals to muscles to allow the muscles to move and is characterised by loss of strength and inability to control movement. Motor neuropathy can lead to muscle weakness, particularly in the feet, which may become deformed as a result.

Autonomic neuropathy

Autonomic neuropathy is manifested by dysfunction of one or more organ systems, and

affects the nerves controlling the heart and blood vessels, digestive system, urinary tract, sex organs, sweat glands and eyes (Boulton et al. 2005; Vinik et al. 2003). Symptoms may include dizziness and fainting, nausea, vomiting and diarrhoea, constipation, loss of bladder control, sexual dysfunction in women and erectile dysfunction in men (see Box 4.2).

Risk factors

The risk of developing neuropathy increases with duration of diabetes, poor blood sugar control, and age. Strict glycaemic control has been shown to reduce or prevent the development of neuropathy, and may alleviate neuropathic symptoms. Early identification is essential, especially in people with no obvious symptoms, to prevent the late sequelae of neuropathy. A combination of clinical observations and complex nerve function tests are often required to confirm the presence of diabetic neuropathy.

How many Australians with diabetes also have neuropathy?

According to the 1999–2000 AusDiab study, 10.3% of males and 8.6% of females with diabetes had clinical signs of neuropathy.

Box 4.2: Erectile dysfunction

What is erectile dysfunction?

Erectile dysfunction is the inability to achieve and/or sustain an erection sufficient for sexual intercourse. Research indicates that the prevalence of erectile dysfunction is significantly higher among men with diabetes than men without diabetes, with prevalence estimates ranging from 35–75% and age of onset occurring 10–15 years earlier in men with diabetes.

Risk factors for erectile dysfunction

Neuropathy is a major risk factor for developing erectile dysfunction among men with diabetes. Other risk factors include poor glycaemic control, vascular disease, nutrition, psychogenic factors and anti-diabetes medication.

Sources: Chu & Edelmanl 2001; Vinik et al. 2003; Brown et al. 2005a.

In the 2004 ANDIAB study, approximately one quarter (25.5%) of adults attending specialist diabetes clinics were recorded as having peripheral neuropathy following clinical assessment (NADC 2005). However, it should be noted that ANDIAB data are obtained from specialist diabetes clinics that are likely to see more patients with complications.

In the 1999–2000 AusDiab study, 30.2% of men with diabetes suffered from or received treatment for impotence (difficulty getting or sustaining an erection). This is probably due to neuropathy, but could be due to other factors (see Box 4.2). According to the ANDIAB Study, 2.2% of all males attending specialist diabetes clinics in 2006 had erectile dysfunction in the previous 12 months and 26.7% had erectile dysfunction before the previous 12 months (NADC 2007).

Hospitalisations

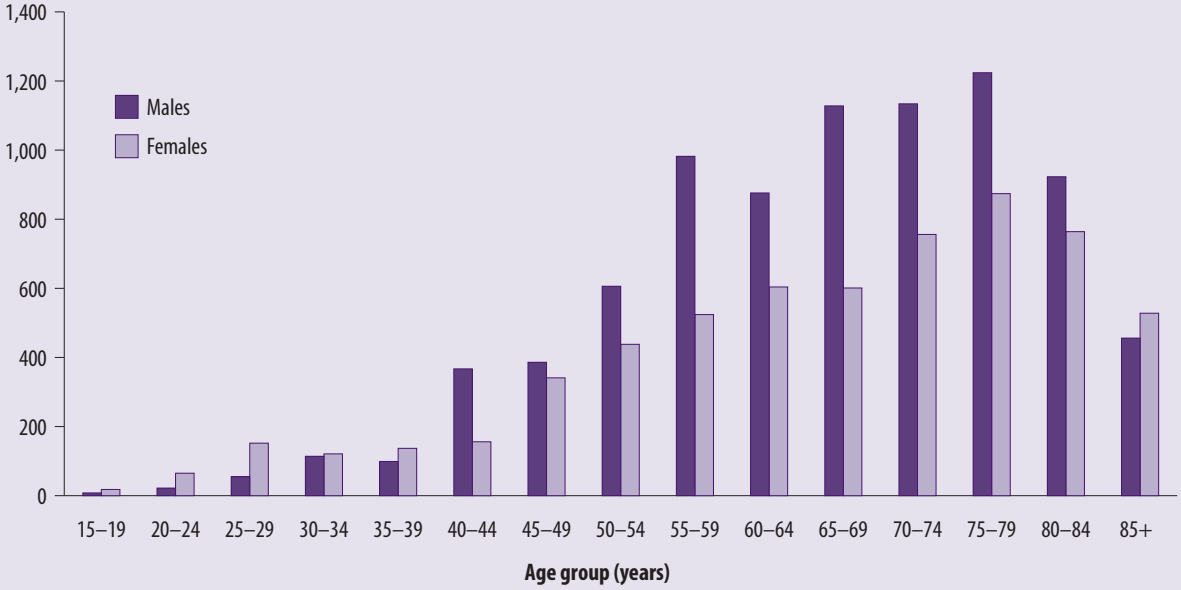
In 2004–05, there were around 14,500 diabetes hospitalisations where nervous system complications were also mentioned. These complications accounted for nearly 3% of all diabetes hospitalisations.

More males than females with diabetes had nervous system complications (58% of these hospitalisations were for males). For both males and females, diabetes hospitalisations with nervous system complications increased with age until 75–79 years and declined thereafter (Figure 4.3).

During 2004–05 the average length of stay in hospital for people with diabetes and a principal diagnosis of nervous system complication was 5 days. When nervous system complication was considered as a principal or additional diagnosis the average length of stay was 9 days for males and females.

Deaths

In 2005, nervous system complications were mentioned in 26 deaths where diabetes was an underlying or an associated cause of death.



Note: Diabetes and related complications are classified according to ICD-10-AM codes. See Appendix 1.

Source: AIHW National Hospital Morbidity Database.

Figure 4.3: Number of hospitalisations for diabetes with neurological complications, 2004–05

Foot complications

Diabetes is associated with nerve damage (peripheral neuropathy) and poor circulation (peripheral vascular disease) in the lower limbs. These factors increase the risk of developing foot ulcers and infections. Progression of these conditions in people with diabetes often leads to lower extremity amputations. Amputations are associated with increased morbidity and mortality and high treatment costs. Diabetes is estimated to account for approximately half of all non-traumatic amputations (ADA 2007a).

Foot ulcer

Over time, diabetes can damage the nerves in the feet, resulting in a loss of sensation. Reduced sensation of pain and discomfort from foreign bodies, injury or even tightly fitting shoes can predispose people to foot trauma and ulceration (ADA 2007a). Damage to nerves also causes wasting of the foot muscles, reduced joint mobility and foot deformities such as claw or hammer toes that are vulnerable to ulceration.

High blood sugar can also damage blood vessels in the lower limbs. Without a healthy supply of oxygen and nutrients, feet are predisposed to ulceration and infection.

Foot ulceration is a common reason for hospital admission for people with diabetes and is estimated to precede more than half of all diabetes-related amputations.

Lower extremity amputation

The combination of diabetic neuropathy, peripheral vascular disease (PVD) and foot deformity increases the risk of lower limb ulcers. Non-healing ulcers can result in gangrene (chronic infection resulting in tissue death). Amputation of the affected area may be necessary as a limb-saving procedure if medical treatment is unsuccessful.

Amputation is estimated to be 15 times more common in people with diabetes compared with other people. Nearly half of the amputations in people with diabetes are minor (involving toes, feet and ankles); the other half are major (below

knee or above knee) (Campbell et al. 2000). Major amputations are associated with greater loss of limb function and greater rehabilitation following amputation (Oyibo et al. 2002).

Many diabetic patients who undergo amputation will have a subsequent amputation on the other side within a few years. The remaining limb becomes more vulnerable to ulceration and infection because it has to bear extra pressure.

Risk factors

The risk of lower limb ulcers and amputations is higher in people who have had diabetes for 10 years or more, are male, have poor blood sugar control, have cardiovascular, visual, or kidney complications or smoke. Certain foot-related conditions are associated with an increased risk of foot ulcer and amputation: peripheral neuropathy (particularly loss of protective sensation), peripheral vascular disease (PVD), foot deformity, and prior history of foot ulcers or amputation (Lavery et al. 2006).

How many Australians with diabetes also have foot complications?

Foot ulcer

The 1999–2000 AusDiab study found that, among people with diabetes, 2.1% had had aprevious foot ulceration and 19.6% were found to be at risk of foot ulcer (defined by the presence of any one of neuropathy, PVD or history of foot ulceration). The greatest risk was evident in those with a diabetes duration of 20 years or more where more than half (53%) were at risk (Tapp et al. 2003a).

Based on the ANDIAB data for 2004, the prevalence of current foot ulcers among adult patients attending diabetes clinics was 1.9%. In addition, 5.3% of patients had a past history of foot ulcers. The vast majority (77.2%) of patients with a current foot ulcer had a past history of foot ulceration (NADC 2005). Also indicative of potential foot problems, peripheral neuropathy, PVD and foot deformity were recorded for a total of 25.5%, 12.7% and 4.4% of adult patients, respectively.

Among patients registered in the NDDP Data Collation Project during 2002, 20.8% were identified with foot risk (indicated by a history of foot problems, and/or presence of peripheral neuropathy, PVD or foot deformity on examination).

Lower limb amputation

In 2004, the incidence of lower limb amputation among adult ANDIAB patients was estimated to be 0.6%. Further analysis revealed that 76.5% of patients undergoing a lower limb amputation in the previous 12 months had a past history of foot ulceration (NADC 2005).

Hospitalisations

The majority of foot ulcers are treated in outpatient settings, which limits effective surveillance of the problem due to lack of available data relating to these visits (DHAC & AIHW 1999). However, some information on the extent of lower limb ulcer and amputation is available from hospital data that cover admitted patient episodes.

Lower limb ulcer

In 2004–05 there were approximately 9,900 diabetes hospitalisations in which patients were treated for lower limb ulcers and this represented 2% of all diabetes hospitalisations in that year. Over 56% of these hospitalisations were for males. Diabetes hospitalisations with lower limb ulcers increased with age, with over two-thirds of such cases being among people aged 65 and over in 2004–05.

People hospitalised with lower limb ulcer and diabetes required long hospitalisations: the average length of stay was 12 days for males and 13 days for females.

Lower limb amputation

In 2004–05, there were close to 3,400 lower limb amputations, which accounted for 0.6% of all diabetes hospitalisations. Overall, hospitalisations for lower limb amputations among people with diabetes were more common among males than females (70% of the amputations were for males); this pattern

occurred across all age groups. The number of diabetes-related amputations in hospital increased with age, with people aged 65 years and over accounting for 61% of all such hospitalisations (Figure 4.4).

People with diabetes hospitalised for lower limb amputation tended to stay considerably longer than those hospitalised for other diabetes-related conditions. The average length of stay in hospital for lower limb amputation among people with diabetes was 26 days.

Deaths

In 2005, there were 1,001 diabetes deaths where lower limb ulcers were recorded as a cause of death, which accounted for 8% of all diabetes deaths. Males had a death rate of 6 per 100,000 people and females half that at 3 per 100,000 people. Between 1997 and 2005, diabetes death rates where lower limb ulcers were also implicated decreased by 12%, from 5.2 to 4.6 deaths per 100,000 people.

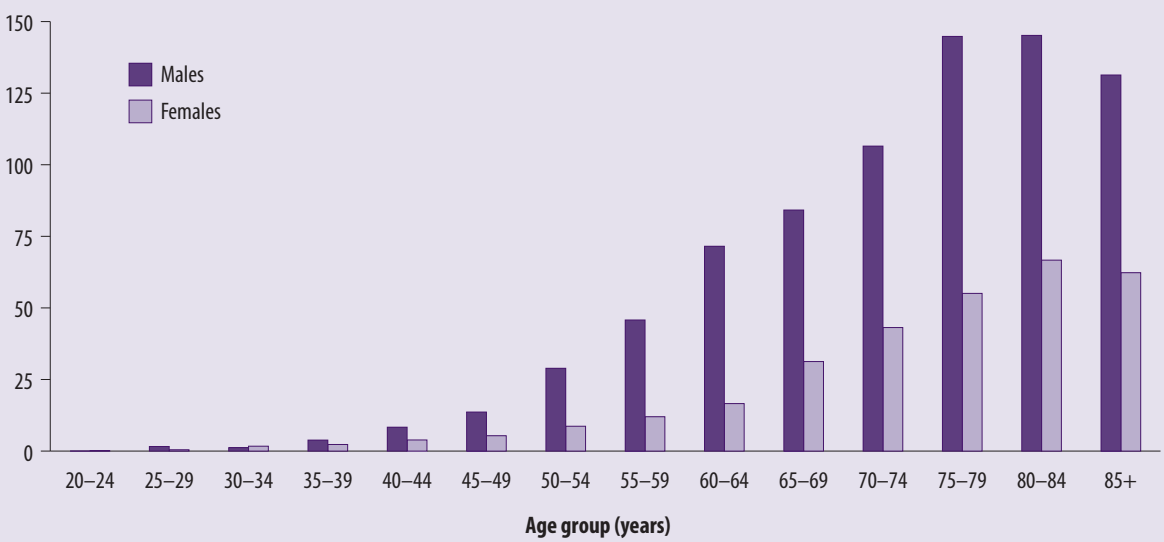
Oral complications

Diabetes can lead to oral complications. Diabetes may manifest initially with oral symptoms other than thirst. For instance, burning tongue, gum bleeding and excessive salivation have been found in people with undiagnosed diabetes and resolved on treatment to improve glycaemic control. This is very uncommon in Westernised societies but is more common in underdeveloped countries or in lower socioeconomic groups, especially where there is poor hygiene and delayed diagnosis of diabetes.

Periodontal disease

There is growing acceptance that diabetes is associated with increased occurrence, extent and severity of periodontitis (inflammation of the tissues supporting the teeth). The risk is independent of whether the diabetes is Type 1 or Type 2 (Lalla et al. 2006; Southerland et al. 2005). Some researchers point to a two-way connection between diabetes and periodontal disease, proposing that not only are diabetic patients more prone to periodontal disease, but the presence of periodontal disease affects control of blood sugar.

International studies have shown that people with Type 2 diabetes are at increased risk of more severe periodontal disease compared with those without diabetes (Campus et al. 2005). Diabetes can affect the tissues supporting the teeth (periodontium) and the treatment of periodontal diseases. Patients with long-term poor control



Note: Diabetes and related complications are classified according to ICD-10-AM codes. See appendix 1.
Source: AIHW National Hospital Morbidity Database.

Figure 4.4: Number of diabetes hospitalisations where a lower limb amputation was performed, 2004–05

of diabetes have increased extent and severity of periodontal disease, whereas those who maintain good metabolic control have minimal periodontal problems. Integrated medical and dental management of these conditions is essential for the general health and quality of life of patients. Treatment of periodontal infections with systemic antibiotics can contribute to the control of diabetes.

Other oral problems

Caries (tooth decay) in the crowns of teeth appear to be more frequent in adults with poor control of insulin-dependent diabetes. Oral infections other than dental caries and periodontal disease are often more severe in people with diabetes. Examples of these are life-threatening deep neck infections and fatal ulcers of the palate.

Risk factors

Risk factors for oral complications in people with diabetes include poor oral hygiene, poor control of blood sugar levels, smoking and inadequate nutrition.

How many Australians with diabetes also have oral complications?

Currently there are no national data on the dental visits of people with diabetes or the prevalence of oral complications among people with diabetes. Hospitalisations data are presented in this report as they give some indication of the number of people using the hospital system to deal with such problems.

In 2004–05, there were 98 hospitalisations for periodontal complications where diabetes was the principal diagnosis and 202 hospitalisations for periodontal complications where diabetes was the principal or additional diagnosis (Table 4.3).

The average length of stay for diabetes with periodontal complications was 3 days when diabetes was a principal diagnosis and 7 days as any diagnosis.

Table 4.3: Number of diabetes hospitalisations with periodontal complications, 2004–05

	Diabetes as	
	Principal diagnosis	Any diagnosis[(a)]
Males	50	106
Females	48	96
Persons	98	202

(a) Includes principal and additional diagnosis.
Note: Diabetes and related complications are classified according to ICD-10-AM codes. See Appendix 1.
Source: AIHW National Hospital Morbidity Database.

Complications in pregnancy

Pregnancy complicated by diabetes can be divided into 2 main groups: pre-gestational diabetes and gestational diabetes. Pre-gestational diabetes is defined as pre-existing diabetes in pregnancy among women who had Type 1 or Type 2 diabetes before conception. Pre-gestational diabetes represents about 10% of cases of pregnancy complicated by diabetes. Gestational diabetes is the more common type of diabetes complicating pregnancy. Gestational diabetes is defined as diabetes first diagnosed during pregnancy, and is a transient condition that usually develops late in the second trimester and resolves shortly after the birth (Barbour & Friedman 2003).

What is diabetes in pregnancy?

In all pregnant women, pregnancy hormones induce insulin resistance, which means there is a higher insulin requirement in order to keep the blood sugar levels in the 'normal range'. In women without diabetes there is on average a 3-fold increase in insulin production by late pregnancy. Gestational diabetes occurs when the pancreas is not able to adequately increase insulin production to overcome the effects of insulin resistance. Pre-gestational Type 1 diabetes leads to an average 50% increase in insulin requirements by late pregnancy. Women with pre-gestational Type 2 diabetes are likely to require insulin therapy during pregnancy (Barbour & Friedman 2003).

Effect of diabetes in pregnancy

Diabetes in pregnancy has potential effects on the mother's health as well as on the foetus and newborn baby. Women with well-controlled diabetes lower the risk of complications for themselves and their babies.

Maternal risks

Some diabetes complications may be exacerbated by pregnancy. Retinopathy may worsen during pregnancy and the risk is particularly increased with longer duration of diabetes and with the degree of blood sugar control. Laser therapy may be needed during pregnancy (Van Impe 2005). Pregnancy can lead to a reduction in kidney function in about one-third of women with pre-existing kidney disease (Willams 2007).

Common pregnancy complications are more common in women with diabetes. Pregnancy-induced hypertension is more common in women with pre-existing diabetes than in women without diabetes (Leguizamon et al. 2006) and caesarean delivery is more frequent in pregnancies complicated by diabetes (Gonzalez-Quintero et al. 2007).

Women with gestational diabetes are at significantly increased risk of developing Type 2 diabetes and at an increased risk of developing cardiovascular disease later in life (Lee et al. 2007).

Foetal risks

Babies of women with gestational diabetes may have a greater risk of perinatal death, and newborn problems including: hypoglycaemia in the newborn, low birthweight, jaundice, respiratory distress and birth trauma due to very high birthweight (Gonzalez-Quintero et al. 2007). Pre-gestational diabetes is also associated with an increased rate of major congenital malformations in the foetus and a higher rate of spontaneous abortions (Barbour & Friedman 2003).

How many Australian women are affected by maternal diabetes?

Nearly 11,000 Australian women giving birth in hospital in 2004–05 had gestational diabetes, which is 4.2% of all deliveries. For more details refer to Chapter 2 of this report. Another 1,200 women giving birth in hospital in that year had pre-existing diabetes and a further 800 women had diabetes at the time of delivery, though it was not specified whether it was pre-existing or gestational diabetes.

Table 4.4: Pre-existing and gestational diabetes, 2004–05

	Number	Per cent[(d)]
Pre-existing diabetes in pregnancy[(a)]	1,257	0.5
Gestational diabetes[(b)]	10,861	4.2
Diabetes of unknown onset in pregnancy[(c)]	826	0.3

(a) Pre-existing diabetes in pregnancy defined by ICD-10-AM codes 0240–0243.
(b) Gestational diabetes defined by ICD-10-AM code 0244.
(c) Diabetes of unknown onset in pregnancy defined by ICD-10-AM code 0249.
(d) Percentage of all births in hospital, defined by ICD-10-AM code Z37.
Source: AIHW National Hospital Morbidity Database.

Information is also available from state and territory midwives data collections. These data are not yet available as national estimates; however, the development of a nationally consistent scope, collection methods and classifications of gestational diabetes and pre-existing diabetes in pregnancy is progressing (NPSU 2006). The available state and territory data (excluding Tasmania) show that in most jurisdictions pre-existing diabetes was present in less than 1% of women giving birth in 2004. Gestational diabetes was reported in 4.0 to 6.3% of women across these states and territories.