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Two of a KinD (**K**idneys **in** **D**iabetes)

The burden of diabetic kidney disease and the cost effectiveness of screening people with type 2 diabetes for chronic kidney disease

Kidney Health Australia

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Glossary

ABS	Australian Bureau of Statistics
ACE	angiotensin-converting enzyme
ACR	albumin to creatinin ratio
AE-DEM	Deloitte Access Economics' Demographic Model
AER	albumin excretion rate
AIHW	Australian Institute of Health and Welfare
ARB	angiotensin receptor blocker
ANZDATA	Australian and New Zealand Dialysis and Transplant Registry
AusDiab	Australian Diabetes, Obesity and Lifestyle study
BMI	bodymass index
CARI	Caring for Australians with Renal Impairment
CKD	chronic kidney disease
CKD-EPI	Chronic Kidney Disease Epidemiology Collaboration
CVD	cardiovascular disease
DALY	disability adjusted life year
DBP	diastolic blood pressure
DoFD	Department of Finance and Deregulation
DoHA	Department of Health and Ageing
DSP	Disability Support Pension
DWL	deadweight loss
eGFR	estimated glomerular filtration rate
ESKD	end-stage kidney disease
GFR	glomerular filtration rate
GP	general practitioner
ICD-10	International Classification of Diseases, Tenth Revision
ICER	incremental cost effectiveness ratio
KEY	Kidney Evaluation for You
MDRD	modification of diet in renal disease
NDOQI	National Kidney Foundation's Kidney Disease Outcomes Quality Initiative
NEFRON	National Evaluation of the Frequency of Renal Impairment cO-existing with Non-insulin dependent diabetes mellitus
NHFA	National Heart Foundation of Australia

NHMRC	National Health and Medical Research Council
NHS	National Health Survey
NSA	Newstart Allowance
PATS	Patient Assisted Travel Scheme
QALY	quality adjusted life year
RRT	renal replacement therapy
SDAC	Survey of Disability, Ageing and Carers
SBP	systolic blood pressure
USRDS	United States Renal Data System
VSL	value of a statistical life
VSLY	value of a statistical life year
WHO	World Health Organization
WTP	willingness to pay
YLD	years of healthy life lost due to disability
YLL	years of healthy life lost due to premature death
YLS	years of life saved

Executive Summary

Type 2 diabetes is now the leading cause of life threatening kidney disease in Australia, with the two conditions forming an interrelated and sinister relationship called 'diabetic kidney disease'.

In 2010, there were approximately 1.7 million people in Australia with chronic kidney disease (CKD). Of these, 282,146 Australians had diabetic kidney disease, a condition that is likely to escalate as both the population ages and the prevalence of diabetes increases.

In patients with type 2 diabetes, kidney disease increases the complications of diabetes including nerve and eye damage, and cardiovascular disease, while poor glycaemic control can accelerate the progression of kidney disease.

The greatest cost burden associated with diabetic kidney disease is incurred when patients progress to end-stage kidney disease (ESKD) and require Renal Replacement Therapy (RRT). The annual per person health care cost for RRT was estimated to be $73,527 - a cost almost three times higher than the annual per person cost of a heart attack.

Although some patients with type 2 diabetes are routinely screened to assess their level of kidney function there is no systematic CKD screening program in Australia. This has large cost consequences through low rates of early diagnosis and the associated loss of quality of life and increased health care expenditure that accompanies later stages of the condition.

The implementation of an annual kidney function screening program for patients with type 2 diabetes would help delay or prevent the progression of diabetic kidney disease in these patients and reduce the associated burden. Deloitte Access Economics recommends the implementation of a CKD screening program for people with type 2 diabetes aged 50-69 years.

Deloitte Access Economics was commissioned by Kidney Health Australia to estimate the economic cost of CKD in people with type 2 diabetes, and to evaluate the cost effectiveness of an Australia wide CKD screening program for all people with type 2 diabetes.

This major study has estimated the prevalence of CKD in Australia and the prevalence of CKD in people with type 2 diabetes. The total economic cost includes direct health care system costs, the additional economic costs experienced outside the health care system, and the loss in healthy life. A breakdown of estimated CKD prevalence is shown in Table i.

The economic cost and health burden due to CKD in people with type 2 diabetes is mostly associated with ESKD. In 2010, there were an estimated 23,041 people with ESKD, while 7,098 also had type 2 diabetes. Approximately 82.6% received renal replacement therapy (RRT), which consisted primarily of dialysis due to a shortage in the supply of kidney transplant donors. The remaining 17.4% received conservative care, using diet and medication to manage complications from kidney failure.

Table i: Estimated prevalence of CKD, 2010[(a)]

CKD stage	All	People with type 2 diabetes
	000s	*000s*
CKD stages one to four	**1,725.0**	**275.0**
One	342.9	71.3
Two	513.6	93.9
Three	828.1	99.7
Four	40.4	10.1
Total ESKD patients	**23.0**	**7.1**
ESKD patients on RRT	19.0	5.9
ESKD patients treated conservatively	4.0	1.2
Total CKD	**1,748.0**	**282.1**

Note: (a) Prevalence relates to people aged 25 years and over for CKD stages one to four.
Source: Deloitte Access Economics calculations using White et al (2010), AusDiab data (1999-00) using Baker IDI Heart and Diabetes Institute special data request and ANZDATA (2006; 2007; 2008; 2009; 2010).

There were an estimated 7,030 hospital separations (excluding dialysis) for diabetic kidney disease in 2009-10. However, most hospital separations for CKD are related to dialysis, with people receiving out-of-home dialysis attending a hospital or satellite clinic three times a week. Consequently, there were approximately 1.1 million dialysis separations in 2009-10, with 336,000 for people with type 2 diabetes.

CKD is also a significant contributor to mortality in Australia. The estimated number of deaths associated with CKD in 2010 was 2,920 as the underlying cause and 11,100 deaths as an associated cause. Diabetic kidney disease was responsible for 141 deaths, accounting for around 4.8% of all CKD deaths, and was an associated cause in another 77 deaths. However, this may underestimate the true number of diabetic CKD deaths. Rao et al (2011) found that multiple cause death rates from diabetic CKD are actually four to nine times higher than recorded underlying cause rates for 'diabetes with renal complications'.

Total economic cost of CKD in people with type 2 diabetes was estimated to be $674.8 million in 2009-10. Table ii presents the estimated cost of CKD in people with type 2 diabetes by cost item.

Table ii: Total cost of CKD in people with type 2 diabetes, 2009-10

	Cost
	$ (million)
Health care costs	**466.8**
Indirect economic loss	**208.0**
Productivity loss	65.8
Informal carer costs	38.9
Transport costs	3.5
Deadweight loss	99.8
Total - Health care costs and indirect economic loss	**674.8**

Source: Deloitte Access Economics calculations.

Approximately $466.8 million was spent on health care costs, such as hospital services, out of hospital medical services (general practitioners (GP), imaging and pathology, and specialists), pharmaceuticals (over-the-counter drugs, pharmaceuticals requiring prescriptions and highly specialised drugs for kidney patients) and other health professionals.

These costs were projected to increase to $682.7 million by 2015-16, and $914.3 million by 2020-21. The cost growth was based on the expected increase in the number of people with ESKD and the real increase in the cost of delivering health care.

The total health care cost associated with CKD in people with type 2 diabetes is significant when compared to health care costs associated with type 2 diabetes. For example, allocated direct health care expenditure for all of type 2 diabetes was estimated to be $969.3 million in 2009-10.

Despite this, health care costs presented in Table ii are significantly underestimated. Data from the Australian Institute of Health and Welfare (AIHW, 2009) used to estimate costs do not account for expenditure on health care due to the complications of CKD on comorbidities, such as cardiovascular disease. AIHW (2009) noted that complications may increase expenditure substantially, particularly for earlier stages of CKD. For example, Smith et al (2004) found among people in CKD stages two to four:

- people with CKD related comorbidities had costs double that of people with CKD but without comorbidities;
- there is an interaction between CKD and some comorbidities that incurs costs greater than the sum of the two parts; and
- estimated cost of CKD related comorbidities was greater than the estimated cost of CKD.

Furthermore, while estimated expenditures overlap with health care costs for other co-morbid conditions where CKD was the primary condition for care, AIHW (2009) expenditure data excludes a portion of CKD expenditure where CKD was not the primary reason for care. This is also expected to lead to underestimated costs.

The annual per person health care cost is greatest for RRT patients with type 2 diabetes. This was estimated to be $73,527 in 2009-10, increasing to $80,917 by 2015-16 and $87,051 by 2020-21. In comparison to other cardiovascular disease conditions, treating CKD in patients with type 2 diabetes is extremely expensive. For example, the cost of a heart attack is estimated to be around $25,000 per patient (Access Economics, 2009). Consequently, the annual per patient cost of treating ESKD for patients with type 2 diabetes is around three times greater.

Some ESKD patients may choose not to receive RRT or they may be refused treatment if deemed inappropriate due to comorbidities. For example, access to a kidney transplant is partly determined by recipient suitability, which is dependent on age and co-morbidity profile (Cass et al, 2010). Conservative care for ESKD may be offered as a legitimate option for some older patients, or those with serious comorbidities who will have an increasingly reduced quality of life as a result of dialysis (Carson et al, 2009). The average per person health care cost for people with type 2 diabetes receiving conservative care was estimated to be $12,174 in 2009-10.

There are also economic costs associated with CKD that are incurred outside the health care system. These 'indirect costs' accounted for $208.0 million in 2009-10, and are incurred by people in ESKD. They include productivity loss through reduced employment and premature mortality ($65.8 million), informal carer costs due to reduced productivity and leisure time ($38.9 million), transport costs for people receiving out-of-home dialysis ($3.5 million), and a loss in economic efficiency (known as deadweight loss) through additional taxation to fund public health care expenditure and welfare payments ($99.8 million).

There is also a loss of healthy life in people with ESKD, including those with a functioning kidney transplant. Using the 'Burden of Disease' methodology developed by the World Health Organization (WHO) (Murray and Lopez, 1996), CKD in people with type 2 diabetes was responsible for 3,418 disability adjusted life years (DALYs). Converting this loss of healthy life into a monetary equivalent using the value of a statistical life year (VSLY), the value of the loss was estimated to be $569.5 million in 2009-10.

Cost effectiveness of CKD screening

Although some people are screened for CKD by their GP, there is currently no systematic screening program in Australia. The asymptomatic nature of CKD in the early stages means many people are not aware they have CKD until ESKD when it is too late to undertake preventative treatment. This has high cost consequences through loss in patient quality of life, health care resources and across the economy more broadly.

The most recent CKD screening pilot in Australia was undertaken by Mathew et al (2010). Of 402 study participants, approximately 20% were found to have CKD that was previously undiagnosed. Of these people, 48% were categorised as having stage three CKD and 1% stage four CKD. Only 14% of participants were aware that 90% of kidney function could be lost before symptoms occur.

The benefit of a screening program stems from the avoidance of ESKD through early treatment. Early treatment using an angiotensin receptor blocker (ARB) or angiotensin converting enzyme (ACE) inhibitor can reduce the progression of CKD to ESKD, thereby avoiding significant health care costs, indirect costs, and poor health outcomes. This is especially the case for people with type 2 diabetes, as the likelihood of progression to ESKD is much greater (Chadban et al, 2003).

For example, Brenner et al (2001) found that people with type 2 diabetes who received ARB treatment had a 28% reduction in the risk of developing ESKD after four years compared to the placebo group. Furthermore, the median change in the baseline level of proteinuria was around 35% for the group that received ARB treatment, and over 40% at the end point, whereas the placebo group experienced an increase in the level of proteinuria. Overall, ARB treatment reduced the rate of decline in kidney function by around 18%.

There have been several detailed studies on the potential cost effectiveness of CKD screening in Australia (Craig et al 2002; Higashi 2010; Howard et al 2006; 2010). All have found CKD screening to be extremely cost effective.

Higashi (2010) found that CKD screening for people aged 25 years and older with diabetes has a 100% probability of being cost effective. Targeting the general population with

diabetes who are aged between 50-79 years accrued more health benefits at a lower cost than standard treatment. Targeting the general population with diabetes who are aged between 40-49 years and 25-39 years was estimated to cost $4,000 per DALY and $8,000 per DALY respectively. The author recommended that CKD screening to be implemented for people with diabetes at all age groups, and for indigenous people without diabetes at all age groups. It was also recommended that CKD screening be implemented for people without diabetes who are aged 50 years and over.

Howard et al (2010) estimated the cost effectiveness of early detection and intervention to prevent the progression of CKD in Australia. Using a Markov model, the authors calculated the incremental cost effectiveness ratio (ICER) as $4,781 per QALY for people with diabetes aged 50-69 years. They also found that for every 1,000 patients with diabetes screened for proteinuria and treated with an ACE inhibitor, and treating all people with diabetes with an ACE inhibitor, there would be:

- three less deaths from cardiovascular disease;
- one less death from other causes (i.e., not cardiovascular disease); and
- three patients that would avoid RRT.

Using cost effectiveness results presented by Howard et al (2010), and the prevalence of people aged 50-69 years with diagnosed type 2 diabetes in 2010, this study estimated the expected benefits and costs from a screening program if undertaken in Australia. Results from Howard et al (2010) updated to 2010 dollars are presented in Table iii.

Table iii: Markov model results of screening for CKD in people with type 2 diabetes, 2010

	Mean cost	QALY	ICER
	$	*No.*	*$ per QALY*
Intervention	18,078	12.763	5,092
Comparator	17,915	12.731	n/a
Difference	163	0.032	n/a

Note: Relates to screening people aged 50 to 69 years for proteinuria and an addition of an ACE inhibitor in all known people with diabetes and screen detected patients with proteinuria.
Source: Deloitte Access Economics calculations using Howard et al (2010).

An opportunistic proteinuria screening program and subsequent ARB or ACE inhibitor treatment for all know people with diabetes and people who tested positive to proteinuria was estimated to save 14,485 years of healthy life (represented by QALYs). In addition, there would be:

- 1,811 fewer deaths, consisting:
  - 1,358 fewer deaths from CVD causes; and
  - 453 fewer deaths from non CVD causes.
- 1,358 fewer people requiring RRT.

The improved health associated with avoiding ESKD would come at an additional health care system cost of $73.8 million. However, this represents a long term cost over the lifetime of people screened. The annual screening cost would be relatively small as a large proportion of the cost is associated with treatment and not the screening program itself. For example, Howard et al (2010) note the cost of a dipstick is $1, while the total cost of a

GP consultation would be $34.90.[1] For those who return a positive screening result, there would be an additional consultation cost and a protein to creatine ratio test that cost $11.75.[2]

The only additional cost from a screening and treatment program would occur from screening new cases of people with diabetes. Using incidence rates for people aged 50-69 years derived from the updated AusDiab study (Barr et al, 2006) there were approximately 47,378 new cases of type 2 diabetes in people aged 50-69 years in 2010.[3] Thus, for an incremental cost of screening and subsequent treatment with ARBs or ACE inhibitors of $7.7 million, 190 lives could be saved and 1,516 years of healthy life could be gained. These costs and benefits are not annual as they would occur over the lifetime of people newly diagnosed with type 2 diabetes and CKD.

Given these results and those from Higashi (2010) and Howard et al (2010), Deloitte Access Economics recommends the implementation of a CKD screening program for people with type 2 diabetes aged 50-69 years with subsequent treatment for those with CKD using ARBs or ACE inhibitors.

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[1] Consultation cost is based on Medicare Benefit Schedule (MBS) Item 23 as at 14 February 2011.

[2] Protein to creatine ratio test is based on MBS Item 66500 as at 14 February 2011.

[3] Barr et al (2005) does not differentiate between type 1 and type 2 diabetes. However, a large majority of new diabetes cases are expected to be type 2.

1 Epidemiology of diabetic kidney disease

An insidious relationship exists between type 2 diabetes and chronic kidney disease with the complications associated with each of these conditions accelerating the progression of the other. Treatment strategies for these disease states need to recognise and reflect that the conditions often co-exist and that these conditions can quickly progress, often without overt symptoms.

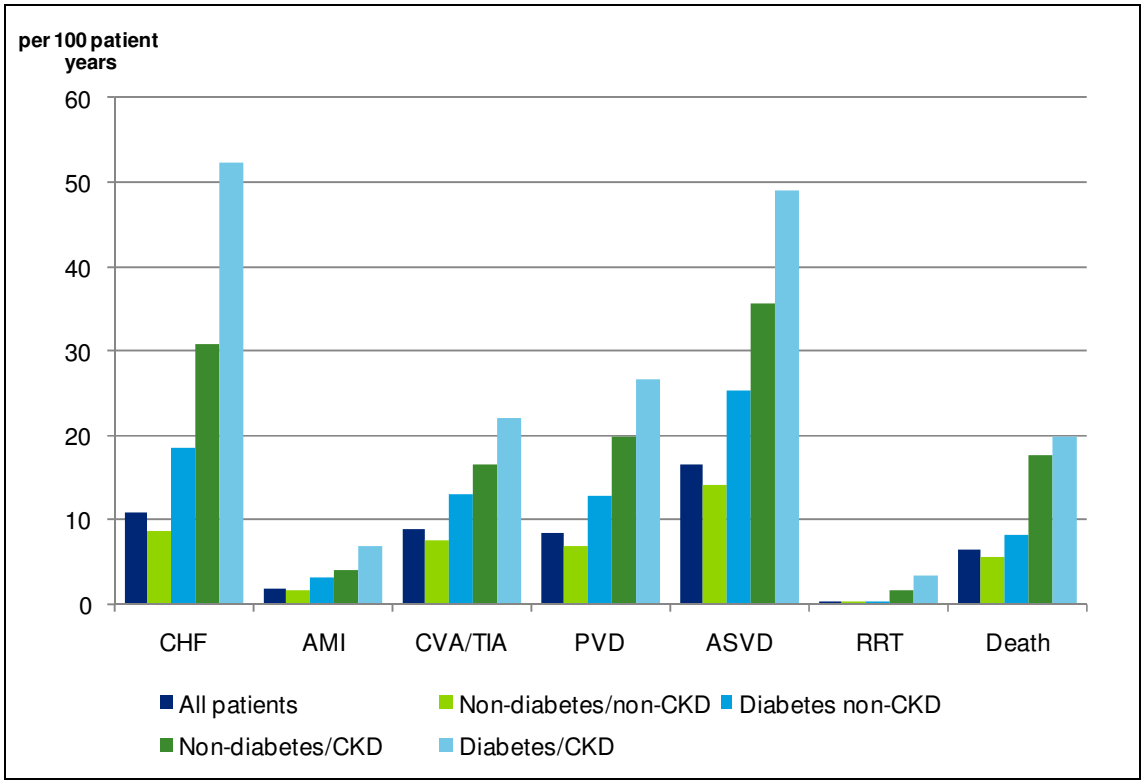
This chapter defines chronic kidney disease (CKD) and reviews its causes, stages and risk factors. It also presents trends in prevalence rates, hospitalisation rates, the number of hospitalisations, and deaths associated with CKD in all people, and specifically in people with diabetic kidney disease.

Diabetes is both a major cause of CKD and a complication of CKD. Diabetes occurs in approximately 12% of people entering dialysis programs in addition to 32% of new dialysis patients who have diabetes as the cause of kidney failure. In Indigenous people, over 80% of new dialysis patients are diabetic (ANZDATA, 2010). Diabetes is especially common as a complication after kidney transplantation.

Diabetic kidney disease is a specific entity that affects about half of all people with diabetes attending their general practitioner in Australia (Thomas et al, 2006a). The presence of diabetes is a significant risk factor for accelerated progression of CKD towards kidney failure and renal replacement therapy (Levin et al 2008; Johnson et al 2008). The overlap between diabetes and the kidney is a major contributor to the prevalence and cost of chronic vascular disease (AIHW, 2007).

The presence of diabetes in people with CKD worsens the outcome of cardiovascular events and worsens the survival both of people on dialysis and after transplantation (Foley et al 2005; ANZDATA 2010). The relationship between diabetes and the kidney is truly a sinister one. Chart 1.1 shows that among patients with diabetic kidney disease, the rate of cardiovascular events is more than twice the rate among patients with diabetes alone. Relative to healthy people, patients with diabetic kidney disease have a 79% increased risk of congestive heart failure, a 41% increased risk of atherosclerotic vascular disease, and a 56% increased risk of death (Foley et al, 2005).

Chart 1.1: Incident event rates, by event type and comorbidity



Note: AMI = Acute Myocardial Infarction, ASVD = Atherosclerotic vascular disease, CHF = Chronic Heart Failure, CVA = Cerebrovascular accident, PVD = Peripheral vascular disease, RRT = Renal replacement therapy, TIA = Transient ischemic attack,
Source: Foley et al (2005).

1.1 Definition of CKD

Chronic kidney disease (CKD) occurs when there is kidney damage and/or reduced kidney function lasting for more than three months (AIHW, 2010c). There is an increased risk of end-stage kidney disease (ESKD) requiring dialysis or kidney transplant among people with CKD, and increased risk of premature cardiovascular disease (CVD) and death (Barr et al, 2005).

The rate of kidney function is measured using the glomerular filtration rate (GFR), which is the amount of blood the kidneys clear of waste products in one minute. The current recommendation is to estimate GFR (eGFR) using a formula that takes into account age, gender and creatinine levels in the blood (Mathew et al, 2007).

The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NDOQI) defines CKD as:

- GFR <60mL/min/1.73m^2 that is present for three months or more; or
- evidence of kidney damage for three months or more with or without decreased GFR as evidenced by:
  - microalbuminuria – the kidney leaks small amounts of albumin into the urine;
  - macroalbuminuria/proteinuria – excess of serum proteins in the urine;
  - glomerular hematuria – presence of red blood cells in the urine;

- pathological abnormalities; and
- anatomical abnormalities (National Kidney Foundation, 2002).

This definition of CKD is adopted by the Australian Institute of Health and Welfare (AIHW), Diabetes Australia and the National Health and Medical Research Council (NHMRC).

1.1.1 Causes of ESKD

The most common causes of ESKD in Australia are:

- diabetes – kidney disease caused by diabetes (33%) (also known as diabetic nephropathy and commonly referred to as diabetic kidney disease);
- glomerulonephritis – inflammation of the filtering units in the kidney (24%); and
- hypertension – high blood pressure (14%) (KHA, 2010).

Other causes may include polycystic kidney disease and reflux nephropathy caused by the backward flow of urine into the kidneys.

Type 2 diabetes is the most common cause of ESKD in Australia. Consistently high blood sugar levels can damage the blood-filtering capillaries in the kidneys, leading to diabetic kidney disease. Diabetic kidney disease represents around 31% of all new cases starting renal replacement therapy (RRT) (either dialysis or kidney transplant), with 90% of these cases being type 2 diabetes (McDonald et al, 2009).

1.1.2 Stages of CKD

The five stages of kidney disease are summarised in Table 1.1. People with kidney disease generally do not present with symptoms until they have reached stage four or stage five CKD. By ESKD, RRT is necessary to avoid death.

Kidney damage may manifest as albuminuria or proteinuria, glomerular haematuria or anatomical or pathological abnormalities. In practice, albuminuria and proteinuria are by far the most common means of detecting kidney damage and for the purposes of this report CKD stages one and two are defined by the presence of albuminuria or proteinuria.

Kidney disease remains asymptomatic until about 75% of kidney function has been lost (Bakris, et al 2000). Proteinuria occurs when there is an excess of serum proteins in the urine, usually because the filters of the kidney (glomeruli) are damaged and proteins leak from the blood into the urine. The progression of CKD to ESKD once proteinuria is present varies from 4 to 18 years (Chadban, 2009), but is generally within 10 years for patients with diabetes (Adler et al, 2003). However, the progression of CKD can be delayed by pharmacotherapy and management of risk factors.

Table 1.1: Five stages of kidney disease

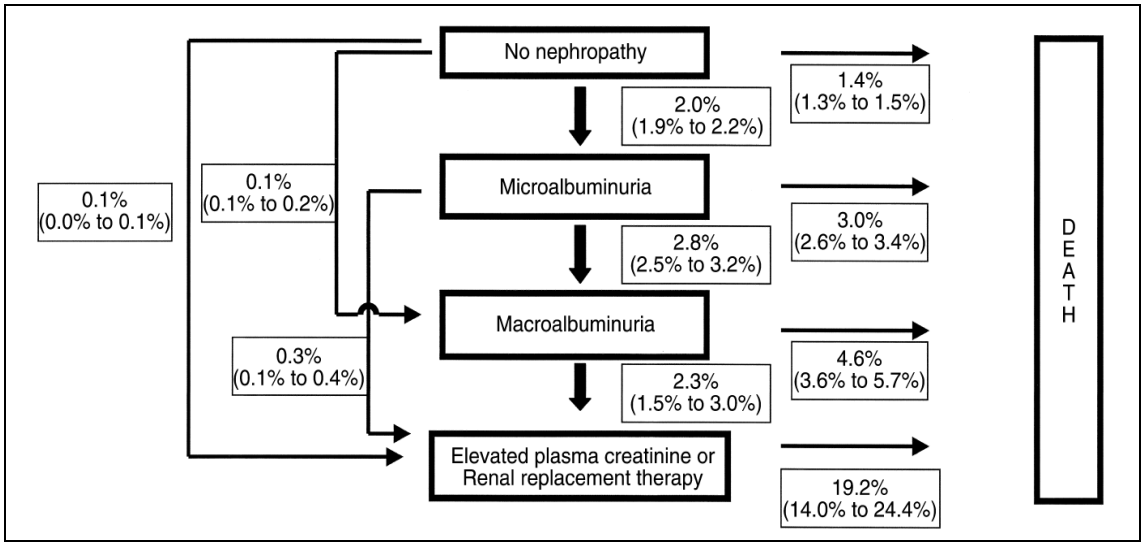
Stage	GFR	Description	Symptoms
1	≥ 90mL/min/1.73m^2	Evidence of kidney damage (albuminuria/proteinuria) but without decreased GFR.	Usually no symptoms.
2	60 -89mL/min/1.73m^2	Evidence of kidney damage (albuminuria/proteinuria) with some reduction in GFR.	Most patients have no symptoms.
3	30-59 mL/min/1.73m^2	GFR significantly reduced. May show signs of kidney damage and often indications of dysfunction in other organs.	Often asymptomatic despite reduction in kidney function of up to 70%.
4	15-29 mL/min/1.73m^2	Kidney function significantly reduced. Blood levels of urea and creatinine increase and greater evidence of dysfunction in other organs.	Usually only mild symptoms.
5	≤ 15 mL/min/1.73m^2	End-stage Kidney Disease (ESKD). Kidney replacement therapy (dialysis or transplant) is required when kidney function is no longer sufficient to sustain life (GFR around 7-8 mL/min/1.73m^2).	Range of symptoms and laboratory abnormalities in several organ systems (uraemia).

Source: AIHW (2009c).

For people with type 2 diabetes, CKD generally begins by changes in the albumin excretion rate (AER) including normoalbuminuria (AER <20µg/min), microalbuminuria (AER 20-200µg/min) and proteinuria (or macroalbuminuria with AER >200µg/min). Approximately 25% of people with type 2 diabetes will develop microalbuminuria or worse nephropathy after 10 years from diagnosis (Adler et al, 2003). Although there are relatively fewer patients with type 2 diabetes who develop macroalbuminuria, those who do will have a greater probability of death than advancing to the next stage of nephropathy (Adler et al, 2003).

Figure 1.1 shows the annual transition rates through the different stages of nephropathy to any cause mortality for patients with type 2 diabetes. From any stage of nephropathy at time of diagnosis, the rate of deterioration to the next stage is approximately 2-3% per annum. Patients without microalbuminuria at diagnosis of diabetes may not develop nephropathy for a median of 19 years (Adler et al, 2003). Among those who develop microalbuminuria, the median time to macroalbuminuria or worse nephropathy is 11 years, which means those diagnosed with diabetes at a later stage in life have a lower chance of ESKD (Adler et al, 2003).

Figure 1.1: Annual transition rates from no nephropathy to death



Source: Adler et al (2003).

1.2 Major CKD risk factors

Major CKD risk factors can be categorised into fixed, behavioural and biomedical (AIHW, 2009c). Fixed factors are those influenced by genetic composition and are therefore not modifiable. These include family history, increasing age, previous kidney disease or injury, low birth weight and male sex.

Behavioural risk factors are associated with lifestyle choices. As such, they are considered to be modifiable. CKD behavioural risk factors include tobacco smoking, physical inactivity and poor nutrition. Biomedical risk factors are influenced by a combination of genetic composition and lifestyle choices. The major biomedical risk factors that contribute to CKD include high blood pressure, overweight and obesity, cardiovascular disease, systemic kidney inflammation and diabetes.

Several studies have estimated the impact of various risk factors on the development of CKD and ESKD. The standard approach for estimating the contribution of risk factors on the burden of disease is to compare the burden of disease due to the observed exposure distribution in a population to a hypothetical distribution constructed using the theoretical minimum risk exposure. Knowledge of the relative risk is used to construct a population attributable fraction (PAF), which measures the proportion of disease that would be avoided if the risk factor were removed. A selection of studies on the impact of various behavioural and biomedical risk factors on CKD is presented in Table 1.2.

Due to the complex relationship between risk factors, it is not possible to add attributable fractions for a number of risk factors (WHO, 2001). However, the size of the PAFs for each risk factor can be compared to gain a more general sense of which risk factor contributes most to CKD.

Table 1.2: The impact of select behavioural and biomedical risk factors on CKD

Risk Factor	Study	Population	PAF (%)
Physical inactivity	Stengel et al (2003)	US adults aged 30-74	11[(a)]
Smoking	Stengel et al (2003)	US adults aged 30-74	21[(a)]
	Shankar et al (2006)	US adults in Beaver Dam aged 43-84	10
	Haroun et al (2003)	US adults in Washington County Maryland	31
High blood pressure	Haroun et al (2003)	US adults in Washington County Maryland	23
	Sabayagam et al (2010)	Singaporean adults aged 24-95	17-23[(b)]
Obesity	Wang et al (2008)[(c)]	US adults	33
		Adults in Industrialised Countries	24
Diabetes	Perneger (1994)	US adults in DC, Virginia and Maryland aged 20-64 years	42
	Sabayagam et al (2010)	Singaporean adults aged 24-95	22-45[(b)]

Note: (a) Deloitte Access Economics calculation of PAF based on reported relative risk ratios (b) The Sabayagam et al (2010) study calculated separate PAR figures for Singaporeans of Indian, Chinese and Malaysian descent hence their results are presented as a range across the three ethnic groups (c) Wang et al (2008) undertook a statistical review of the results of previous studies of the relationship between obesity and CKD.
Source: Deloitte Access Economics.

High blood pressure and obesity have high PAFs in relation to CKD, whereas physical inactivity is smaller. The impact of smoking on CKD varied considerably across studies, ranging from 10-31%.

The greatest contributing factor to CKD is diabetes. Table 1.2 indicates that if diabetes was not present, between 22-45% of the CKD burden would not have occurred. Alternatively, this could be interpreted as the potential to avoid 22-45% of the future CKD burden by removing diabetes as a risk factor. This finding is important for policy purposes because it suggests a good place to start reducing the incidence of CKD (and therefore future health burden and economic costs) is to reduce the incidence of diabetes.

The impact of fixed risk factors on CKD has also been investigated. Drey et al (2003) found that 74% of those diagnosed with CKD were aged over 70 and that the relative risk of CKD for men was 1.6 times higher than that for women. Low birth weights have also been shown to be associated with CKD. Vikse et al (2008) show that those born with low birth weights had a relative risk of ESKD of 1.7 compared to those with normal birth weights.

Other studies have highlighted the proportionately higher rates of CKD among ethnic groups. Tarver-Carr et al (2003) found that after adjusting for lifestyle and socio demographic factors, the relative risk of CKD for African Americans was two times higher than for whites. A disproportionately high risk of developing ESKD has also been observed among Australian

Aboriginal communities (Spencer et al, 1998), while other studies have noted that the relative risk of CKD is magnified if either a first or second degree relative also has CKD (Spray et al, 1995).

Given the contribution of behavioural and biomedical risk factors on the prevalence of CKD, the following presents the prevalence of each risk factor and comments on the trends in risk factors to provide an indication of the future direction of CKD prevalence in Australia.

1.2.1 Behavioural risk factors

Behavioural risk factors for CKD include physical inactivity, poor nutrition and tobacco smoking (AIHW, 2009). These are further discussed below.

Physical inactivity

The national physical activity guidelines recommend individuals undertake moderate physical activity for 30 minutes on most, preferably all, days of the week (DoHA, 2005). This has been interpreted as requiring individuals to undertake 30 minutes of exercise on at least five days of the week.

In the literature, physical inactivity has been found to significantly increase the risk of CKD. Stengel et al (2003) found that the risk of CKD more than doubles for those who are inactive compared to those who are active. Furthermore, physical inactivity increases the risk of individuals developing other risk factors associated with CKD including type 2 diabetes, high blood pressure and obesity (AIHW, 2005).

Although there are several studies on physical activity in Australia, this report uses the 2007-08 National Health Survey (ABS, 2009) to estimate the prevalence of physical inactivity in 2010.[4,5]

Estimated physical activity levels across age groups in 2010 are shown in Table 1.3. The table indicates that physical activity levels decline significantly with age. Of those in the 25-34 age group, only 32.9% were sedentary compared to 59.3% of those aged 75 and over. In total, more than 70% of the population across all age groups were either sedentary or had low levels of physical activity.

[4] The prevalence of physical activity by age was estimated by applying the average annual growth determined from the 2004-05 NHS (ABS, 2006) and 2007-08 NHS (ABS, 2009) to the prevalence reported in the 2007-08 NHS.

[5] In the NHS an individual's exercise level is defined as the product of the number of times they had exercised in the last two weeks, the average duration of each exercise routine in minutes and the intensity of exercise. Walking is deemed to have an intensity level of 3.5, moderate exercise is deemed to have an intensity level of 5 and vigorous exercise is deemed to have an intensity level of 7. An individual who just met the national guidelines for physical activity would have an exercise level of 1,500 (10x30x5). Based on exercise levels the NHS classifies individuals into four different physical activity categories.

- Sedentary- exercise level less than 100.
- Low Activity- exercise level between 100 and 1,600.
- Medium Activity- exercise level between 1,600 to 3,200 but less than two hours of vigorous exercise.
- High Activity- exercise level greater than 3,200 including more than two hours of vigorous exercise.

Table 1.3: Estimated prevalence rate of physical inactivity, 2010

	Per cent of population			
Age Group	Sedentary	Low	Moderate	High
25–34	32.9	41.0	19.5	7.8
35–44	36.2	40.1	18.8	5.7
45–54	37.2	37.2	20.1	5.6
55–64	38.2	35.0	23.1	3.9
65–74	40.7	32.0	25.1	2.3
75 and over	59.3	25.8	15.5	0.4

Source: Deloitte Access Economics calculations using ABS (2006; 2009).

Poor nutrition

Good nutrition requires a balanced diet of cereals, fruits, vegetables, legumes and nuts. National guidelines require adults to consume at least five serves of vegetables and two serves of fruit per day for an adequate diet (NHMRC, 2003).

Poor nutrition is considered a risk factor for CKD because it is closely related to various other risk factors including:

- type 2 diabetes;
- increased blood pressure; and
- obesity.

The most recent data on the prevalence of poor nutrition in the Australian community is contained in the 2007-08 NHS (ABS, 2009). Table 1.4 shows the prevalence of poor nutrition in terms of the proportion of males and females in the population consuming inadequate amounts of fruit and vegetables. Prevalence rates have not been projected to 2010 because the trend in poor nutrition has been relatively flat in the last decade.

The proportion of the population consuming inadequate amounts of fruit and vegetables increases with age. While 61.8% of males and 50% of females aged 25-34 consumed less than two serves of fruit a day, this proportion fell to 36.4% for males and 33.2% for females in the over 75 age group.

Women were more likely than men to consume adequate amounts of fruit across all age groups and were also more likely to consume adequate amounts of vegetables across most age groups except for those aged 65-74 years.

Table 1.4: Estimated prevalence rate of poor nutrition by age and gender 2007-08

	Per cent of population			
	Males		Females	
Age Group	Inadequate fruit	Inadequate veg	Inadequate fruit	Inadequate veg
25–34	61.8	95.1	50.0	93.7
35–44	60.0	94.0	49.1	91.4
45–54	56.7	94.3	41.2	87.3
55–64	46.6	(np)	35.2	(np)
65–74	37.4	86.0	32.5	86.6
75 and over	36.4	(np)	33.2	(np)

Note: A person is defined as having inadequate fruit in their diet if they consume less than 2 serves per day on average and a person is defined as having inadequate vegetables (veg) in their diet if they consume less than 5 serves per day on average (np) indicates that the ABS has chosen not to make these results available for publication.
Source: ABS (2009).

Tobacco smoking

Tobacco smoking includes the smoking of tobacco products such as packet cigarettes, roll-your-own cigarettes, pipes and cigars. Smoking can cause kidney disease or reduced kidney function by:

- narrowing the blood vessels and reducing blood flow in the kidneys;
- increasing production of angiotensin II (a hormone produced in the kidneys);
- forming arteriosclerosis (thickening and hardening) of the renal arteries; and
- accelerating the loss of kidney function.

Several surveys investigating active smoking in Australia have been undertaken in recent years. The 2007-08 National Health Survey (ABS, 2009) data have been used to estimate the prevalence of tobacco smoking in 2010.[6]

Estimated prevalence of active adult smokers in 2010 is shown in Table 1.5. The total proportion of smokers decreases with age, ranging from 26.4% for people aged 25-34 years, to 4.7% for people aged 75 years and over.

The full impact of smoking is underestimated in Table 1.5 as the NHS data do not include passive smoking. The NHMRC estimated that 77 coronary deaths occur each year due to tobacco in people who have never smoked (NHMRC, 1997).

[6] Prevalence of tobacco smoking by age and smoking status for 2010 was estimated by applying the average annual growth determined from the 2001 NHS (ABS, 2003), 2004-05 NHS (ABS, 2006) and 2007-08 NHS (ABS, 2009) to the prevalence reported in the 2007-08 NHS.

Table 1.5: Estimated prevalence rate of tobacco smoking, 2010

Age group	Per cent of population		
	Never smoked[(a)]	Ex-smoker[(b)]	Smoker[(c)]
25–34	47.1	27.5	26.4
35–44	49.5	26.7	24.1
45–54	44.6	32.4	23.1
55–64	43.4	40.7	16.2
65–74	47.8	42.8	9.5
75 and over	52.0	43.3	4.7

Note: (a) Never smoked more than 100 cigarettes or the equivalent tobacco in their life (b) Smoked at least 100 cigarettes or the equivalent tobacco in their life and no longer smoke (c) At the time of survey smoked daily, weekly or less than weekly.
Source: Deloitte Access Economics calculations using ABS (2003; 2006; 2009).

1.2.2 Biomedical risk factors

Biomedical risk factors for CKD include high blood pressure, overweight and obesity, cardiovascular disease, systemic kidney inflammation and diabetes (AIHW, 2009). These are further discussed below.

High blood pressure

The National Heart Foundation of Australia (NHFA) guidelines define high blood pressure as systolic pressure (SBP) at or above 140mmHg or diastolic pressure (DBP) at or above 90mmHg (NHFA, 2008).

High blood pressure is one of the major risk factors for CKD as it can lead to damaged blood vessels in the kidneys. In particular, elevated blood pressure is strongly associated with the development of albuminuria in people with type 2 diabetes (NHFA, 2008). This causes the walls of the blood vessels to become thick and narrowed, leading to reduced blood supply and deteriorating kidney function. For people with both CKD and high blood pressure, the rate of decline of kidney function is much faster (AIHW, 2007).

Major contributors to high blood pressure include poor diet (especially high salt intake), overweight, excessive alcohol consumption and insufficient physical activity. Because people with high blood pressure are usually asymptomatic, high blood pressure is generally under-diagnosed. Diagnosis relies on routine blood pressure screening to monitor and detect affected individuals.

The most recent measured national data that reports the prevalence of high blood pressure is the Australian Diabetes, Obesity and Lifestyle (AusDiab) study conducted in 1999-00 (Dunstan et al, 2001). Given that the dataset does not suffer from the potential downward bias due to self-reported data (as is the National Health Survey), this was used to estimate prevalence rates of high blood pressure in 2010. These are presented in Table 1.6.[7]

[7] To estimate the prevalence of high blood pressure in 2010, an exponential trend in blood pressure between 1980 and 1999 for males and a logarithmic trend in blood pressure between 1980 and 1999 for females was fitted to data presented in Mathur (2002) and applied to AusDiab data.

The prevalence rate of high blood pressure is estimated to increase with age, both on average and within gender. A significant increase in prevalence rates occur across all age groups, although the greatest proportional increases are between 35-44 years and 45-54 years, with prevalence rates more than doubling for males and more than tripling for females. The greatest absolute increase in prevalence rates for all people occurs between 55-64 year and 65-74 year age brackets.

Table 1.6: Estimated prevalence rate of high blood pressure, 2010

	Per cent of population		
Age group	Males	Females	Persons
25-34	5.0	2.9	4.1
35-44	10.0	6.6	8.5
45-54	21.8	20.6	21.5
55-64	35.1	38.9	37.2
65-74	49.6	58.8	54.2
75 years and over	56.9	66.2	61.4

Note: High blood pressure is defined as systolic blood pressure of 140 mmHg or more or diastolic blood pressure of 90 mmHg or more or receiving medication for high blood pressure.
Source: Deloitte Access Economics calculations using AIHW (2009b) and Mathur (2002).

Overweight and obesity

Being overweight is a condition of excess body fat (adipose tissue) that results from a sustained energy imbalance. This occurs when dietary energy intake exceeds energy expenditure over a period of time. There are a number of methods used for measuring overweight and obesity (such as waist measurements and waist to hip ratios) although body mass index (BMI) is the most common measure.[8] A BMI score greater than or equal to 25 but less than 30 indicates overweight, and a BMI score of 30 or more indicates obesity (WHO, 2000).

Being overweight or obese increases the risk of developing CKD through a range of other health problems, such as type 2 diabetes and high blood pressure (WHO, 2000).

The most recent data available to estimate the prevalence of being overweight and obese are from the 2007-08 NHS. Estimated prevalence of overweight and obesity for 2010 is presented in Table 1.7.[9]

[8] BMI is calculated as the weight in kilograms divided by the square of the person's height in metres. Excessive body-weight gain results in abnormalities in blood lipids, leading to an increased risk of developing CHD. However, BMI is a crude measure of obesity and does not take into account the distribution of body fat. Furthermore, BMI does not allow for differences across individuals and populations with different body builds, such as those of different racial backgrounds. Welborn et al (2003) proposed that the waist-hip ratio (a measure of abdominal obesity) is an important determinant of the risk of coronary disease and death and is a better predictor than BMI.

[9] To estimate the prevalence of overweight and obesity for 2010, linear trends were established for overweight and obesity by age and gender using the 2001 NHS (ABS, 2003), 2004-05 NHS (ABS, 2006) and 2007-08 NHS (ABS, 2009) and applied to measured BMI data contained within the 2007-08 NHS.

Table 1.7: Estimated prevalence rate of overweight and obesity[(a)], 2010

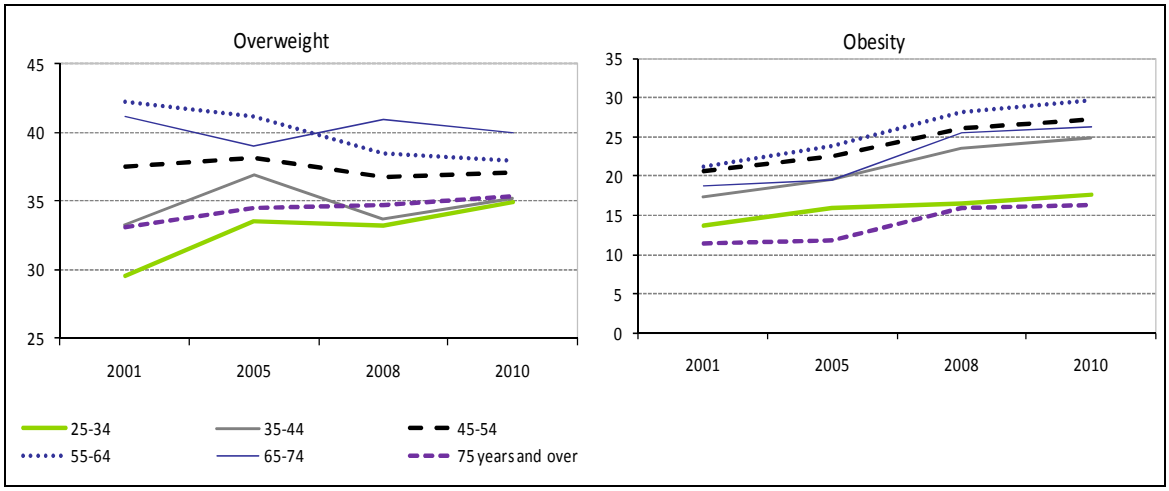
	Per cent of population			
	Males		Females	
Age group	Overweight	Obese	Overweight	Obese
25-34	42.4	19.5	26.5	18.0
35-44	44.2	26.6	32.5	22.8
45-54	47.0	29.8	32.5	26.4
55-64	40.0	34.9	34.7	33.2
65-74	45.1	33.8	41.9	29.3
75 years and over	52.8	21.5	32.5	24.2

Note: (a) Overweight = 25≥BMI<30, Obese = BMI≥30. Based on measured data and age standardised to the 2001 Australian population.
Source: Deloitte Access Economics calculations using AIHW (2009b).

Across all ages, overweight and obese prevalence rates are higher for males. For both males and females, the prevalence rate of obesity peaks between 55-64 years, and then declines as age increases. For overweight males, the greatest prevalence rate is for those aged 75 years and over, while for females the prevalence rate peaks between 65-74 years. For obese males and females, the greatest prevalence rate is for those aged 55-64 years.

Chart 1.2 shows the trend in the prevalence rate of overweight people has increased for some age brackets (e.g., 25-34 years), remained relatively stable for others (e.g., 45-54 years), and decreased for others (e.g., 55-64 years). However, the trend in the prevalence rate of obese people has increased for all age brackets, especially the older age brackets, suggesting there will be a significant increase in the proportion of people with diabetes and CKD in the future.

Chart 1.2: Trends in overweight and obesity prevalence rates



Source: Deloitte Access Economics calculations using ABS (2003; 2006; 2009).

Systemic kidney inflammation

Glomerulonephritis encompasses a series of kidney diseases that inflame the glomeruli, a group of blood vessels in the kidney which filter the blood and remove waste products (AIHW, 2005). Milder forms are relatively common and can be addressed through treatment, especially in children (AIHW, 2005). More aggressive forms may lead to the development of

ESKD, in some cases over a period of a few weeks, although more typically over a period of 10-20 years (Braunwald et al, 2001).

Some of the key causes of glomerulonephritis are autoimmunity (a reaction of a person's immune system to their own body), cancer, structural abnormalities within the kidney and infections (Chadban and Atkins, 2005). The rate of incidence and prevalence among the Australian community remains unknown although a Victorian study of renal biopsies found that the incidence of biopsy proven glomerulonephritis was 12.3 per 100,000 people (Briganti et al, 2000).

A related biomedical risk factor is tubulo-interstitial kidney disease, which affects the kidney tubules or interstitial tissue attached to the glomeruli (AIHW, 2005). One of the major causes of tubulo-interstitial kidney disease is adverse reactions to medications, which according to one study accounts for 92 per cent of acute cases (Clarkson et al, 2004). Other causes include urinary reflux and toxins from heavy metals (AIHW, 2005).

Diabetes

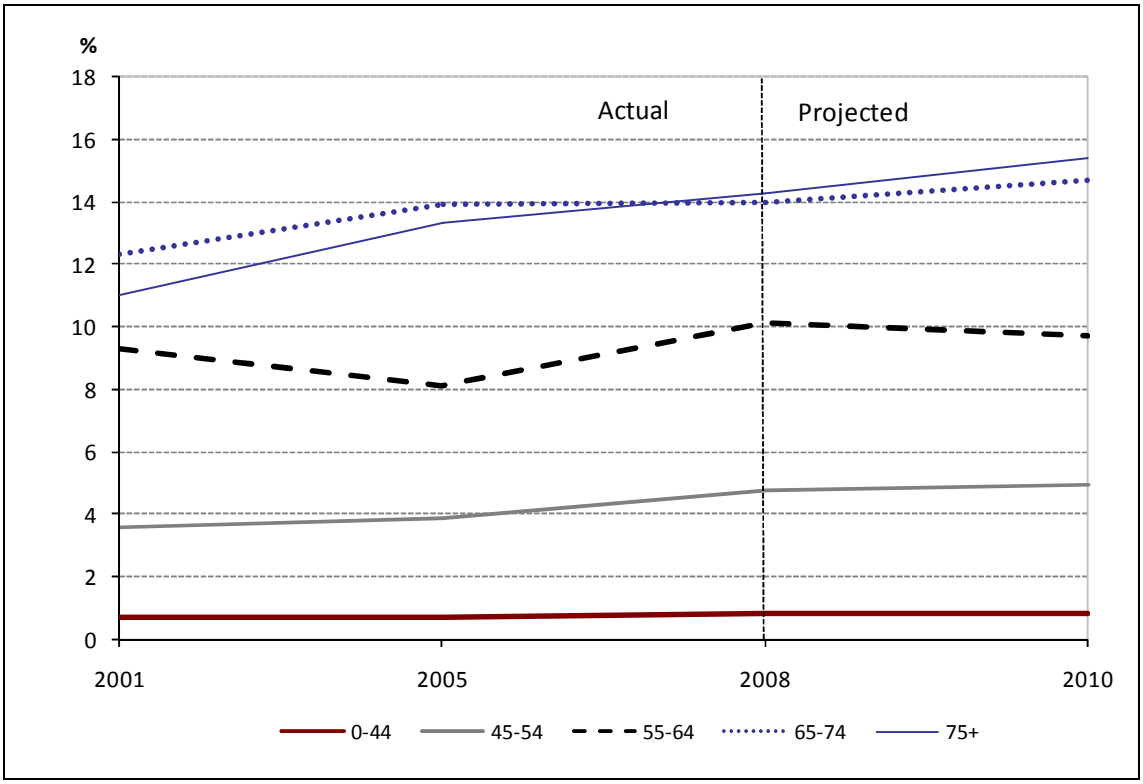
Diabetes is characterised by high blood glucose levels resulting from defects in secretion or action of insulin. Chronic high blood glucose levels (hyperglycaemia) are associated with long term damage, dysfunction and failure of various organs, especially eyes, kidneys, nerves, heart and blood vessels. Diabetes is the seventh leading cause of death in Australia, and contributes significantly to total morbidity (ABS, 2007).

Diabetes shares risk factors with, and is one of the major causes of CKD. Approximately 5-30% of people with type 2 diabetes are affected by CKD (Chadban et al, 2009). People with diabetes are more likely to have a clustering of risk factors such as being overweight, high blood pressure and certain lipid abnormalities such as low HDL cholesterol. Diabetes can lead to kidney damage, which results from high blood glucose levels damaging the blood-filtering capillaries in the kidneys (AIHW, 2007).

Several data sources have estimated the prevalence of diabetes in Australia (AIHW, 2009b), each with their own advantages and disadvantages. The most recent data on diagnosed diabetes prevalence rates are from the 2007-08 NHS (ABS, 2009). The actual and projected trend in NHS diagnosed diabetes prevalence rates are shown in Chart 1.3.

The prevalence rate of diagnosed diabetes has increased for all age groups between 2001 and 2010, particularly in the older age cohorts. For example, the prevalence rate has increased from 11.0% in 2001 to 15.4% in 2010 for people aged 75 years and over. This equates to an increase of around 40%.

Chart 1.3: Trends in the estimated prevalence rates of diagnosed diabetes



Source: Deloitte Access Economics calculations using AIHW (2009b) and ABS (2009).

However, NHS estimates are based off self reported data and therefore represent diagnosed diabetes only. There is evidence to suggest self reported data underestimate total diabetes prevalence, especially for new cases due to the asymptomatic nature of the condition at early stages. For example, Dunstan et al (2001) found that around half of people with diabetes in the AusDiab study were unaware of their condition. Underreporting in the NHS may also be exacerbated by the fact that only people who reported diabetes as a long term condition were recorded as having diabetes (AIHW, 2009b).

As the NHS excludes people in institutional care (e.g., hospitals and residential care facilities) there is also the potential for sample bias. Due to the relatively poor health condition of people in institutional care, this bias is expected to reduce estimated diagnosed diabetes prevalence rates.

Although NHS diabetes prevalence rates are the preferred source of data for the AIHW (2009b), due to the limitations associated with the NHS outlined above, in this study AusDiab prevalence rates were applied to 2010 population estimates to estimate the number of people with diabetes (diagnosed and undiagnosed). These prevalence rates are shown in Table 1.8.

The diabetes prevalence rate increases significantly with age. For example, the prevalence rate in males and females aged 25-34 years is estimated to be 0.1% and 0.4% respectively, while the prevalence rate in males and females aged 75 years and over is estimated to be 22.4% and 24.5% respectively.

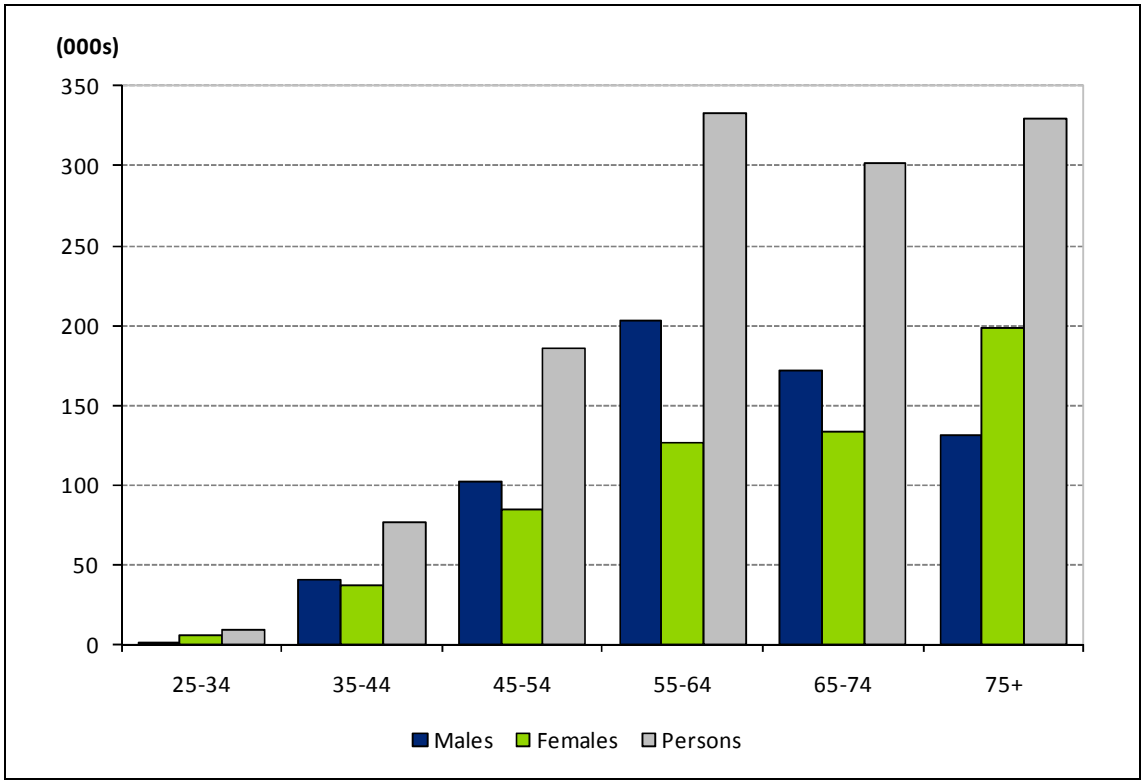
Table 1.8: Diabetes prevalence rates by age and gender, 1999-00

	Per cent of population		
Age group	Males	Females	Persons
25-34	0.1	0.4	0.3
35-44	2.6	2.3	2.4
45-54	6.8	5.5	6.1
55-64	16.1	9.9	13.1
65-74	21.6	16.1	18.6
75 years and over	22.4	24.5	23.7

Note: Includes all diabetes (type 1 and 2), diagnosed and undiagnosed based on AusDiab (1999-00) data.
Source: Dunstan et al (2001).

Estimated diabetes prevalence is shown in Chart 1.4. Around 1.2 million people aged 25 years and older are estimated to have diabetes in 2010, with 52.6% of these being male. Around 633,300 people are aged 55 years or over, which is the age bracket most at risk of CKD.

Chart 1.4: Estimated diabetes prevalence by age and gender, 2010



Note: Includes diagnosed and undiagnosed diabetes based on AusDiab (1999-00) data.
Source: Deloitte Access Economics calculations using Dunstan et al (2001).

However, estimated diabetes prevalence based on AusDiab data may underestimate the true prevalence of diabetes in Australia. Diabetes prevalence rates are expected to have grown since 1999-00 when the AusDiab sample was collected. This is primarily due to improved life expectancy, decreasing age of onset, reduced physical inactivity, increased prevalence of people who are overweight or obese, longer survival with the condition and better detection of diabetes (Colagiuri et al, 2005; AIHW, 2009b).

1.3 Prevalence of CKD

CKD prevalence consists of ESKD prevalence and prevalence of CKD stages one to four. The main source of data on the prevalence of ESKD was derived from the Australia and New Zealand Dialysis and Transplant Registry (ANZDATA).

The main source of data on the prevalence rate of CKD stages one to four, and the prevalence rate of CKD in people with diabetes were derived from a special data request for AusDiab data to Baker IDI Heart and Diabetes Institute.[10] The AusDiab survey recruited 11,247 adults from 42 randomly selected population clusters across Australia between 1999-00. Data was collected to indicate kidney damage, including proteinuria and hematuria. Survey participants were tested for their eGFR using the MDRD 175 formula to determine their kidney status, and diabetes was diagnosed based on glucose levels.[11]

1.3.1 Prevalence of ESKD

There were 18,267 RRT patients in 2009 of whom 30% had type 2 diabetes (ANZDATA, 2010). Applying the trend in annual growth of RRT patients from 1998 to 2009, it was estimated there were approximately 19,042 people on RRT in 2010. [12]

Table 1.9 shows the proportion of RRT patients with type 2 diabetes has been increasing over time, rising from 17.7% to 30.1% between 2001 and 2009 respectively. This is an overall increase in the proportion of 70.4%.

Table 1.9: Proportion of RRT patients by type 2 diabetes status

	2001	2002	2003	2004	2005	2006	2007	2008	2009
	%	%	%	%	%	%	%	%	%
Patients with type 2 diabetes	17.7	20.3	21.7	24.8	25.7	27.5	28.1	29.4	30.1
Patients without type 2 diabetes	82.3	79.7	78.3	75.2	74.3	72.5	71.9	70.6	69.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: ANZDATA (2006; 2007; 2008; 2009; 2010).

Assuming the trend continues, the proportion of RRT patients with type 2 diabetes was estimated to be 30.8% in 2010, equating to 5,866 people. The age distribution of people with type 2 diabetes caused ESKD was applied to total RRT patients with type 2 diabetes to estimate patients by age (see Table 1.10).

[10] For more information on Baker IDI Heart and Diabetes Institute see http://www.bakeridi.edu.au/, accessed 01 February 2011.

[11] More information on AusDiab can be found at http://www.bakeridi.edu.au/ausdiab/, accessed 01 February 2011.

[12] A projected average annual growth rate of approximately 4.2% was used to estimate the increase in dialysis and transplant patients with type 2 diabetes in 2010 (see Appendix A for estimated and projected annual growth rates of people on RRT).

Table 1.10: Estimated number of RRT patients with type 2 diabetes, 2010

Age group	Total RRT patients	Dialysis patients with type 2 diabetes	Transplant patients with type 2 diabetes	RRT patients with type 2 diabetes
0-4	24	0	0	0
05-14	157	0	0	0
15-24	416	0	0	0
25-34	1,110	33	12	45
35-44	2,378	161	60	221
45-54	3,795	680	264	944
55-64	4,462	1,301	512	1,813
65-74	3,828	1,323	422	1,745
75-84	2,491	799	198	997
85-94	382	80	20	100
Total	19,042	4,378	1,488	5,866

Source: Deloitte Access Economics calculations using ANZDATA (2010).

Table 1.11 shows the projected number of RRT patients with type 2 diabetes from 2010 to 2020. The number of RRT patients who have type 2 diabetes is expected to reach 9,766 people in 2020, which equates to 36.7% of the total projected number of RRT patients.

Table 1.11: Projected number of RRT patients with type 2 diabetes

Year	RRT patients	Proportion with type 2 diabetes	People with type 2 diabetes
	No.	*%*	*No.*
2010	19,042	30.8	5,866
2011	19,817	31.6	6,253
2012	20,602	32.3	6,645
2013	21,379	32.9	7,036
2014	22,154	33.5	7,429
2015	22,926	34.1	7,823
2016	23,691	34.7	8,216
2017	24,413	35.2	8,597
2018	25,139	35.7	8,981
2019	25,884	36.2	9,374
2020	26,620	36.7	9,766

Source: Deloitte Access Economics calculations using ANZDATA (2006; 2007; 2008; 2009; 2010).

However, some ESKD patients may choose not to receive RRT or they may be refused treatment if deemed inappropriate due to comorbidities. For example, access to kidney transplants is partly determined by recipient suitability, which is dependent on age and co-morbidity profile (Cass et al, 2010). Additionally, depression in ESKD patients can affect treatment compliance, and poor quality of life may prompt elective withdrawal from dialysis causing death (Tossani et al, 2005). Conservative care for ESKD may be offered as a legitimate

option for some older patients, or those with serious comorbidities who will have an increasingly reduced quality of life as a result of dialysis (Carson et al, 2009).

Conservative care can involve active management of symptoms such as pruritis and other uremic symptoms, prevention of anaemia and palliative care and support (Burns and Davenport, 2010). Health care costs from conservative care can result from:

- medicines to protect remaining kidney function for as long as possible;
- advice on diet and preventing further kidney damage;
- medicines to treat symptoms of kidney failure such as shortness of breath, anaemia, poor appetite and itchiness;
- community support such as home help and district nursing; and
- palliative care (Kidney Health New Zealand, 2010).

Comparing the incidence rate of treated and untreated ESKD (COAG 2010; SCRGSP 2009) to the incidence rate of treated ESKD (ANZDATA, 2007) between 2003 and 2006, approximately 46% of new ESKD patients are untreated (i.e., receive conservative care).

Chandna et al (2010) found that the median survival for patients aged 75 years and over with ESKD who are treated conservatively in the UK was 29.4 months for people with low comorbidity, and 20.4 months for people with severe comorbidity.

Using a simple average between the two median survival points (24.9 months), and the projected incidence of RRT in 2010 derived from ANZDATA (2010), the prevalence of conservative care patients in 2010 was estimated to be 3,999 people. Around 1,232 people also had type 2 diabetes (see Table 1.12).[13] The total prevalence of ESKD was therefore 23,041 people, with 7,098 people also having type 2 diabetes. This is projected to increase to 9,385 people by 2015 and 11,671 people by 2020.

Table 1.12: Estimated and projected prevalence of ESKD by treatment type

Treatment type	All people	People with type 2 diabetes		
	2010	2010	2015	2020
	No.	*No.*	*No.*	*No.*
ESKD patients on RRT	19,042	5,866	7,823	9,766
ESKD patients treated conservatively	3,999	1,232	1,562	1,904
Total ESKD patients	**23,041**	**7,098**	**9,385**	**11,671**

Source: Deloitte Access Economics calculations.

1.3.2 Prevalence of CKD stages one to four

The prevalence rates of CKD stages one to four were estimated based on AusDiab survey results and the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation (as presented in White et al (2010)). Prevalence of CKD in people with type 2 diabetes was estimated using data on the proportion of CKD patients with type 2 diabetes estimated from AusDiab data using a special data request to Baker IDI Heart and Diabetes Institute.

[13] Assuming a steady state, the prevalence of conservative care patients was approximated by multiplying the incidence of conservative care patients by the average duration (Freeman and Hutchison, 1980).

As AusDiab data relates to 1999-00, prevalence rates may be underestimated given their expected increase due to trends in diabetes and obesity (see Section 1.2.2). However, there are no data on more recent CKD prevalence rates, trends in CKD prevalence rates, or on trends in CKD prevalence rates in people with type 2 diabetes.

To determine the number of people within each CKD stage, prevalence rates were applied to population estimates derived from the Deloitte Access Economics' Demographic model (AE-DEM).[14] Prevalence rates, estimated prevalence for 2010, and projected prevalence for 2015 and 2020 in people aged 25 years and over are presented in Table 1.13.

Table 1.13: Estimated and projected prevalence of CKD stages one to four

CKD stage	Prevalence rate	Prevalence		
		2010	2015	2020
	%	*000s*	*000s*	*000s*
One	2.3	342.9	376.0	407.4
Two	3.4	513.6	563.2	610.2
Three	5.5	828.1	908.0	983.8
Four	0.8	40.4	44.3	48.0
Total	**n/a**	**1,725.0**	**1,891.4**	**2,049.5**

Note: In people aged 25 years and over. Assumes prevalence rates remain constant.
Source: Deloitte Access Economics calculations using White et al (2010).

The prevalence of stage one CKD was estimated at 2.3% of the population in people aged 25 years and over, increasing to 3.4% for stage two, and 5.5% for stage three. There is a large decrease in prevalence rates from stage three to stage four, with a prevalence rate of 0.8% for the latter (White et al, 2010). This decrease is most likely attributable to other cause mortality, especially considering the strong correlation between cardiovascular disease (CVD) and CKD.

In total, there were around 1.7 million people aged 25 years and over with CKD stages one to four in 2010. Of these, 1.68 million people were in stages one to three, while there were 40,429 people in stage four. The total number of people with CKD stages one to four is projected to increase to 1.9 million by 2015 and 2.0 million by 2020.

The proportion of people with CKD who also have type 2 diabetes was applied to CKD prevalence estimates and projections to calculate the prevalence of CKD stages one to four in people with type 2 diabetes. Results are summarised in Table 1.14.

In total, there were approximately 275,048 people aged 25 years and over with CKD stages one to four and type 2 diabetes in 2010. Of these people, 264,941 were in stages one to three, while 10,107 people were in stage four. The total number of people with CKD stages one to four and type 2 diabetes is projected to increase to 301,589 by 2015 and 326,788 by 2020.

[14] AE-Dem is an in-house population model created and maintained by Access Economics. Building up from the demographic 'first principles' of births, deaths, migration and household formation, the model projects population by age and gender for each State and Territory. Data is derived directly from publically available Australian Demographic Statistics, sourced from the Australian Bureau of Statistics (ABS).

Table 1.14: Estimated prevalence of CKD stages one to four in people with type 2 diabetes

CKD stage	Proportion of all CKD	Proportion of population	Prevalence		
			2010	2015	2020
	%	*%*	*000s*	*000s*	*000s*
One	20.8	0.5	71.3	78.2	84.7
Two	18.3	0.6	93.9	103.0	111.6
Three	12.0	0.7	99.7	109.4	118.5
Four	25.0	0.1	10.1	11.1	12.0
Total	**15.9**	**1.8**	**275.0**	**301.6**	**326.8**

Note: In people aged 25 years and over. Assumes prevalence rates remain constant.
Source: Deloitte Access Economics calculations using White et al (2010) and AusDiab data (1999-00) using Baker IDI Heart and Diabetes Institute special data request.

1.3.3 Total CKD prevalence

Prevalence of all CKD and prevalence of CKD in people with type 2 diabetes are shown in Table 1.15. In total, there was an estimated 1.7 million people with CKD in 2010. Of these, 282,146 also had type 2 diabetes, making up around 16.1% of all people with CKD, and 22.6% of all people with diabetes. ESKD contributed to around 1.3% of all CKD, and contributed to around 2.5% of all CKD and type 2 diabetes. The projected number of people with CKD and type 2 diabetes is projected to increase to 310,974 by 2015, and 338,459 by 2020.

Table 1.15: Estimated and projected prevalence of CKD

CKD stages	All people	People with type 2 diabetes		
	2010	2010	2015	2020
	000s	*000s*	*000s*	*000s*
Total ESKD patients	**23.0**	**7.1**	**9.4**	**11.7**
ESKD patients on RRT	19.0	5.9	7.8	9.8
ESKD patients treated conservatively	4.0	1.2	1.6	1.9
Total CKD stages one to four	**1,725.0**	**275.0**	**301.6**	**326.8**
Total CKD	**1,748.0**	**282.1**	**311.0**	**338.5**

Note: In people aged 25 years and over. Assumes prevalence rates remain constant.
Source: Deloitte Access Economics calculations using White et al (2010) and AusDiab data (1999-00) using Baker IDI Heart and Diabetes Institute special data request.

1.4 CKD treatment path

CKD is characterised by a decline in the ability of the kidney to remove waste from the blood. This generally happens over a long period of time, causing other problems such as anaemia, high blood pressure, acidosis, high cholesterol and bone disease.

Due to the irreversible nature of CKD, treatment focuses on slowing the progression towards ESKD. It is crucial to manage diabetes if present because uncontrolled glucose levels will increase progression to ESKD even if CKD is being treated using ACE inhibitors or ARBs. A summary of the recommended treatment path to manage CKD in order to slow its progression is summarised in Table 1.16.

Table 1.16: Recommended treatment path for CKD

Stage of CKD	Recommended treatment
Stage 1 – kidney damage with normal kidney function Stage 2 – kidney damage with mild reduction in kidney function	Additional diagnosis tests for those who are at increased risk of CKD (e.g. those with hypertension, diabetes, smokers, age >50 years, obesity, family history of kidney disease and Aboriginal and Torres Strait Islander people), including: - blood pressure; - assessment of proteinuria; and - urinalysis. Cardiovascular risk reduction via: - blood pressure, using ACE inhibitors and ARBs; - lipids, using statin therapy to reduce proteinuria; - blood glucose, especially for people with diabetes; and - lifestyle modification (smoking, weight, physical activity, nutrition and alcohol).
Stage 3 – moderate reduction in kidney function	As above, plus: - monitor eGFR three monthly; - avoid nephrotoxic drugs; - prescribe antiproteinuric drugs (ACE inhibitors and/or ARBs) if appropriate; - address common complications of CKD; and - ensure drug dosages are appropriate for level of kidney function for renally excreted medications. Consider indication for referral to a nephrologist.
Stage 4 – severe reduction in kidney function	As above plus referral to nephrologist for physical and psychosocial preparation for RRT (dialysis, pre-emptive transplantation or transplantation) or conservative medical management. As well, there needs to be early detection and management of complications associated with CKD.
Stage 5 – end-stage kidney disease	As above plus referral to a nephrologist for dialysis.

Source: Kidney Health Australia (2007).

Treatment of early CKD stages mainly focus on detecting signs of kidney damage using various urine and blood tests. Albuminuria can be tested using a timed urine collection (usually over 24 hours) to test the albumin excretion rate (AER) or using a spot urine sample and comparing it to creatinine ratio (albumin to creatinin ratio (ACR)). The glomerular filtration rate (GFR) can be estimated through a blood test for creatinine levels.

In CKD stages one to three it is important to manage any co-morbid conditions such as CVD and diabetes that lead to increased rate of progression towards ESKD. Prescription of angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARB) agents to control blood pressure, as well as managing blood glucose levels in people with diabetes are some of the main ways in which to reduce the progression of CKD. According to the National Evidence Based Guideline for Diagnosis, Prevention and Management of Chronic Kidney Disease in Type 2 Diabetes ('The National Guidelines'), the interval between early

stages of CKD and the onset of ESKD can be delayed by intensive antihypertensive intervention based on inhibitors of the rennin angiotensin system (Chadban, 2009).

The Caring for Australians with Renal Impairment (CARI) Guidelines recommend that patients should be referred to a nephrologist at least 12 months before they are expected to commence dialysis and/or kidney transplantation (CARI, 2009). However, each individual should be assessed on a case-by-case basis, and those with increased risk (such as those with diabetes or CVD, or younger patients) should be referred earlier where appropriate.

Once a patient reaches ESKD, they will require RRT. Dialysis involves artificially replacing lost kidney function in people with kidney failure, while kidney transplant involves replacing the failed kidney with one that is functioning from a living or deceased donor. There are two main types of dialysis treatments which are summarised in the box below.

Haemodialysis

In haemodialysis blood is diverted from the body to a dialysis machine, where it is filtered before being returned to the body. This type of dialysis can be done at home, in hospital, or in satellite clinics; however, the machine requires special plumbing and therefore the patient must limit their travel to places where dialysis facilities are available. In most cases, the patient requires assistance connecting to the machine, and a partner, relative or friend can be trained to do this for home dialysis patients. During haemodialysis the patient is usually connected to the machine for around 4-5 hours three times per week, during which time all their blood passes through the machine approximately six times. If performed at home patients may have the option of dialysing more frequently for a shorter period (5-7 times per week for around two hours) or nocturnally (six nights per week for around eight hours). During a haemodialysis session the patient cannot get up and move away from the machine, though they can perform activities which do not require much movement such as sleeping, reading, talking or using a computer.

Peritoneal dialysis

In peritoneal dialysis, the dialysis solution is pumped into the abdomen and the blood is filtered through the peritoneal membrane (the abdominal cavity which covers organs such as the stomach, liver and intestines). The dialysis solution contains a type of sugar (usually glucose or dextrose) which draws the waste products and extra fluid out of the blood, through the peritoneal membrane and into the solution. After a few hours, the used solution, now containing the wastes and extra fluid, is drained out of the body and replaced with fresh solution. This process is called an exchange, and takes about 30-45 minutes. In between exchanges, the patient is free to continue their usual activities. Peritoneal dialysis can either be performed by the patient during the day (continuous ambulatory peritoneal dialysis), usually three or four times, or automatically by a machine at night for around 8-10 hours while the patient sleeps (automated peritoneal dialysis). As the necessary equipment is portable, peritoneal dialysis can be performed almost anywhere. The patient does not need to be in a hospital or clinic, and can usually manage the procedure without assistance.

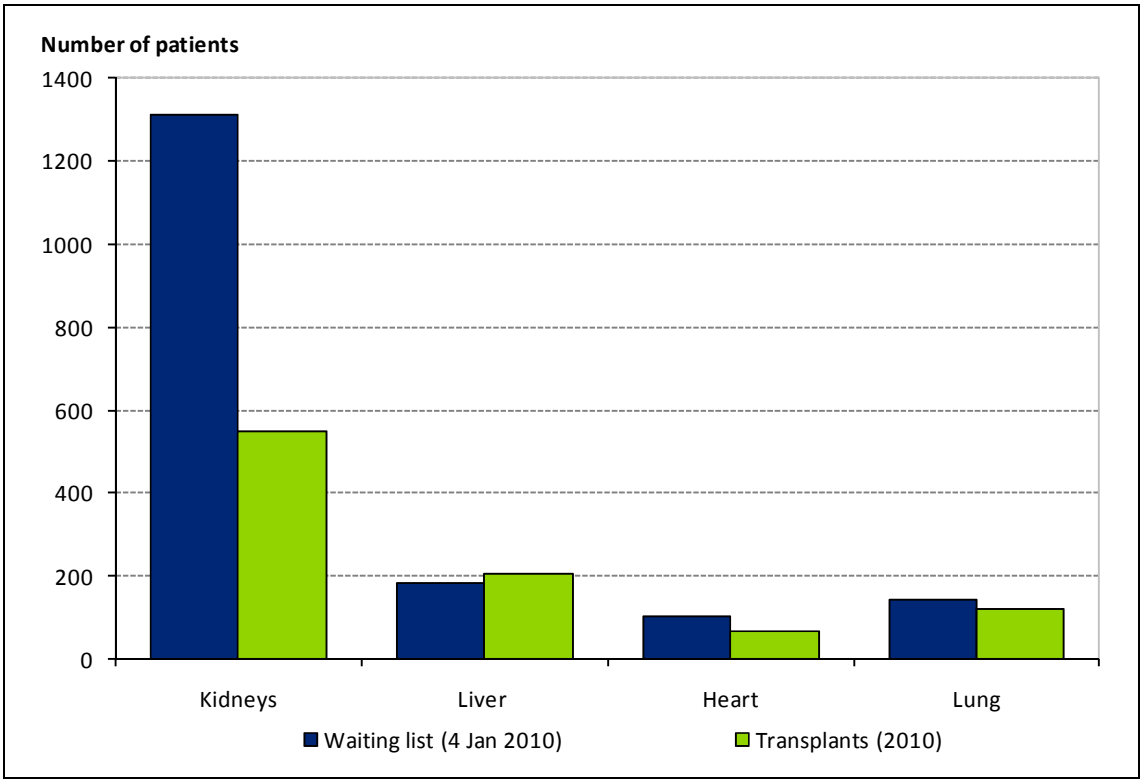
Source: AIHW (2009c).

At CKD stage four and early ESKD, it may be possible to have a pre-emptive kidney transplant to avoid dialysis. Kidney transplants are associated with reduced mortality and morbidity, and provide economic and psychosocial benefits associated with decreased need for regular

dialysis and ability to stay in work. Pre-emptive transplants can only be performed when kidney failure is inevitable but before a person requires dialysis.

Patients with ESKD may be placed on the kidney transplant waiting list if they are medically suitable and stable on dialysis. While kidney transplantation is mostly an effective method of preventing death for patients with ESKD, there is currently a shortage of kidneys available for transplant in Australia. Chart 1.5 shows that the demand for kidneys is much higher than that of other organs. At the start of 2010 there were 1,310 people on the kidney transplant waiting list and 548 kidney transplants from both deceased and living donors throughout the year (DonateLife, 2011). Mean waiting time for a kidney transplant is around 3.8 years from a deceased donor and 1.4 years from a living donor in 2006 (DoHA, 2008).

Chart 1.5: Number of patients on waiting lists and number of organ transplants



Source: DonateLife (2011).

1.4.1 Treatment for people with type 2 diabetes

In patients with type 2 diabetes CKD progresses more rapidly than in patients without the condition and is associated with an increased risk of other diabetic complications including nerve and eye damage, as well as cardiovascular disease. The risk of these micro and macrovascular complications escalates as the level of proteinuria increases in patients with type 2 diabetes (Loon, 2003).

Due to the array of comorbid diseases associated with diabetic kidney disease, including high blood pressure (hypertension) and abnormal lipid levels (dyslipidaemia), a multidisciplinary care approach is often initiated in order to provide optimal care for these complex patients (Cavanaugh, 2007).

Although some people are screened for CKD by their general practitioner, there is currently no systematic screening program in Australia. Screening for kidney disease in patients with type 2 diabetes would allow for strategies to be implemented which may delay or prevent the progression of diabetic kidney disease in these patients (Chadban, 2003).

For people with diabetes, it is recommended that microalbuminuria and GFR be screened on an annual basis from the time of diagnosis of type 2 diabetes. There is a correlation between poor glycaemic control and progression of albuminuria in microalbuminuric people with type 2 diabetes, which leads to nephropathy (Chadban et al, 2009).

The National Australian Guidelines for the diagnosis, prevention and management of CKD in patients with type 2 diabetes suggest that kidney status should be assessed by:

- annual screening for albuminuria by:
  - Albumin Excretion Rate (AER) – timed urine collection; or
  - Albumin to Creatinine Ratio (ACR) – spot urine sample;
  - If AER or ACR screening is positive for microalbuminuria, perform additional ACR or AER measurements 1-2 times within three months to confirm microalbuminuria (at least 2 of 3 tests are positive);
  - If AER or ACR screening is positive for macroalbuminuria, perform a 24 hour urine collection for quantification of protein excretion.
- annual estimation of the Glomerular Filtration Rate (eGFR) to identify signs of mild to moderate kidney dysfunction; and
- continue annual screening for albuminuria and eGFR in the event of negative screening tests (Chadban et al, 2009).

People with type 2 diabetes should also be given antihypertensive therapies, such as an ARB or ACE Inhibitor, to control blood pressure levels. This may decrease the rate of progression of albuminuria and subsequently reduce the risk of decline in kidney function (Chadban et al, 2010).

Abnormal blood lipid levels (or dyslipidaemia) have a strong association with the progression and severity of CVD in people with type 2 diabetes. While evidence on the relationship between dyslipidaemia and CKD is unclear, Chadban et al (2010) recommends that blood lipid levels should be managed through the use of statins regardless of the presence of CKD indicators.

Anti-diabetic medications that improve glycaemic control by regulating blood glucose levels form an essential role in treating patients with type 2 diabetes. Tight glycaemic control has been shown to be beneficial in slowing the progression of kidney disease in patients with type 2 diabetes. However, not all anti-diabetic treatments are appropriate for patients with or at risk of developing renal impairment (Dasgupta, 2004) and should either be avoided or used in reduced doses in these patients (Cavanaugh,2007).

The safety and efficacy concern relating to the use of certain agents rests with the decreased clearance of drugs by the kidneys and prolonged exposure to the drug or its metabolites, which may result in adverse side effects. Patients with moderate to severe CKD are at greatest risk of this occurring (Cavanaugh, 2007).

The need to re-evaluate the use of certain oral agents in patients with impaired renal function (i.e. GFR <60 ml/min/1.73m2 for greater than or equal to 3 months) adds an additional complication for the doctor and patient.

Reducing the dose of an anti-diabetic agent to avoid potential damage to the kidneys can lead to a reduction in glycaemic control and the requirement to add an additional therapy to manage the patient's diabetes.

Given that diet and lifestyle are important factors in a range of other health outcomes that indirectly impact CKD (including type 2 diabetes and CVD risk factors), diet modification should form a component of the overall management of type 2 diabetes.

1.5 CKD hospital separations

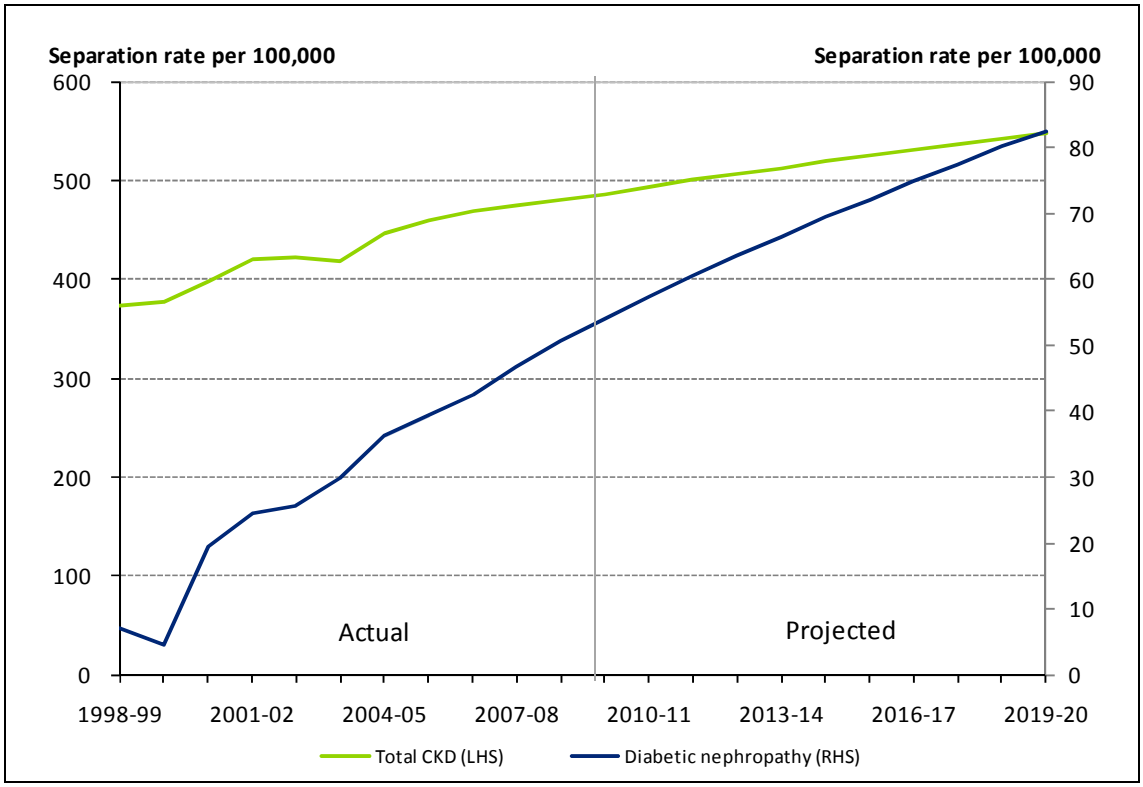
A separation is defined as 'an episode of care for an admitted patient, which can be a total hospital stay (from admission to discharge, transfer or death), or a portion of a hospital stay beginning or ending in a change of type of care' (AIHW, 2010a).

Actual and projected separation rates (excluding dialysis) for diabetic kidney disease and all cause CKD is shown in Chart 1.6. The separation rate for diabetic kidney disease is projected to increase at a much faster rate than separation rates for all cause CKD. The separation rate for all cause CKD was estimated to be 487 per 100,000 population in 2010, and is projected to increase to 548 per 100,000 population by 2020. This equates to 72,872 and 97,579 separations respectively. For diabetic kidney disease, the separation rate was estimated to be 47 per 100,000 population in 2010, and is projected to increase to 72 per 100,000 population by 2020. This equates to 7,030 and 12,777 separations respectively.

The largest number of CKD separations relate to dialysis. In 2007-08, there were 1.0 million separations for dialysis, with 99.2% related to haemodialysis (AIHW, 2010a). This had increased by 6.2% from the previous year.

Attributing dialysis separations between diabetic kidney disease and all cause CKD using the proportion of ESKD patients on RRT with type 2 diabetes, and growing the number of dialysis separations to 2010, it is estimated there were 1.1 million dialysis separations in 2010, with 335,709 separations attributable to people with type 2 diabetes.

Chart 1.6: Actual and projected separation rates for CKD



Note: Based on age 25 years and over.
Source: Deloitte Access Economics calculations using AIHW (2009a).

1.6 CKD mortality

CKD is a significant contributor to mortality in Australia. The rate of mortality with CKD as the underlying cause has remained relatively constant at around 14.2 per 100,000 for males and 10 per 100,000 for females (AIHW, 2009c). This is consistent with data on deaths in RRT patients between 1998 and 2008 (ANZDATA, 2009). Hence, mortality has been estimated by applying the mortality rate per 100,000 people in 2006 derived from AIHW (2009c) to the estimated population in 2010.

The estimated number of deaths associated with CKD in 2010 is presented in Table 1.17. There were 2,920 deaths with CKD as the underlying cause and 11,100 deaths with CKD as an associated cause. Diabetic kidney disease was responsible for 141 deaths, accounting for around 4.8% of all CKD deaths, and was an associated cause in another 77 deaths.

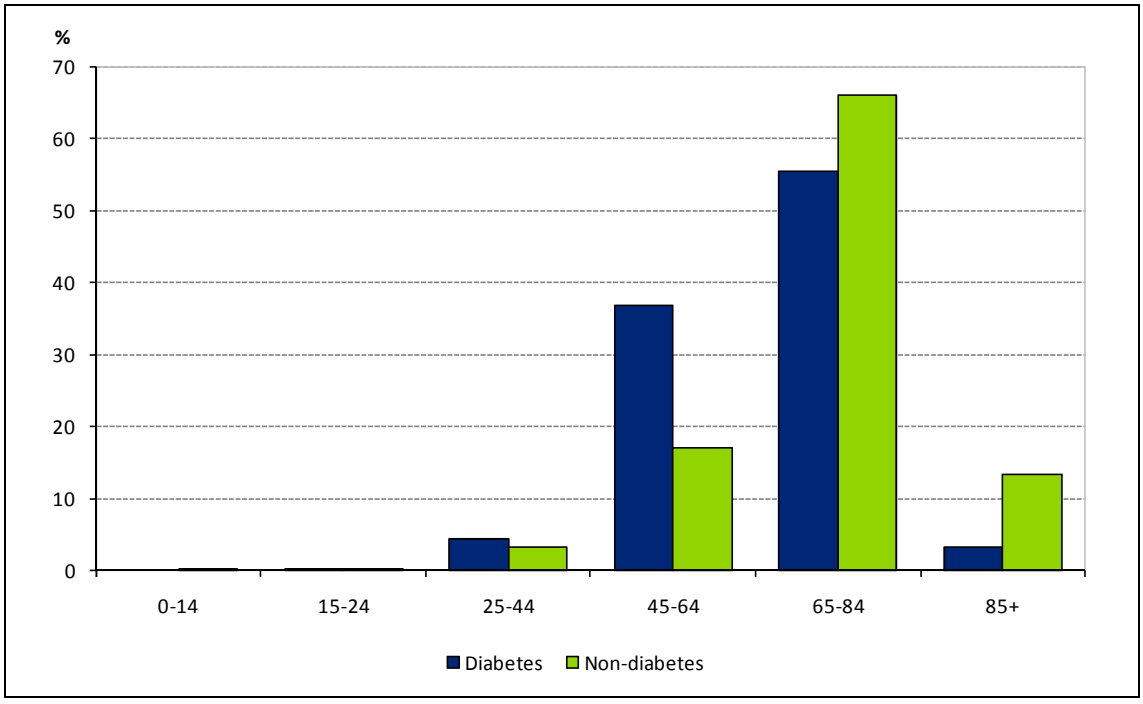
The age distribution of deaths for people with diabetes versus people without diabetes is not the same. People with diabetes and CKD tend to be younger at time of death. This is shown in Chart 1.7, whether the proportion of deaths on the ANZDATA registry have been split by diabetes status.

Table 1.17: Number of deaths by type of CKD, 2010

Type of CKD	Underlying cause of death	Associated cause of death
	No.	*No.*
Diabetic kidney disease	141	77
Hypertensive kidney disease	627	277
Glomerular diseases	79	119
Kidney tubulo-intersitial diseases	62	123
Chronic kidney failure	1,264	5,909
Unspecified kidney failure	644	4,507
Other disorders of the kidney and ureter	47	218
Congenital malformation of the kidney and ureter	55	55
Total deaths	2,920	11,100

Source: Deloitte Access Economics calculations using AIHW (2009c).

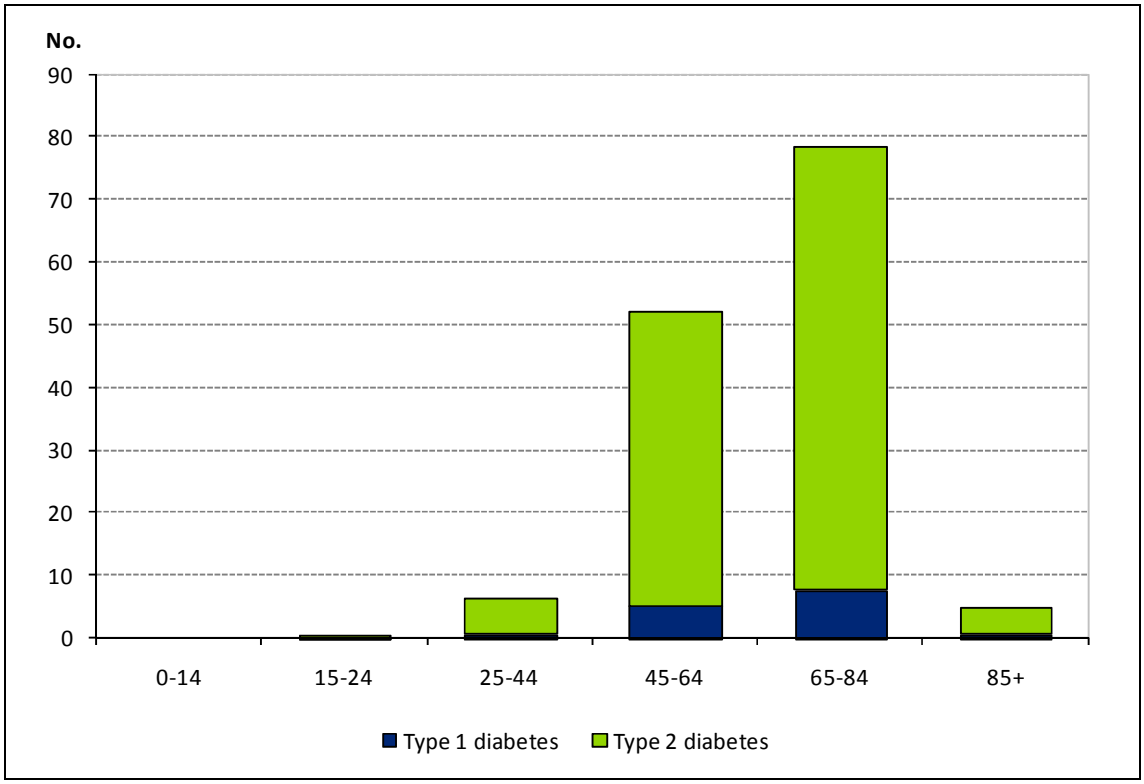
Chart 1.7: Proportion of deaths for people with and without diabetes on RRT, 2008



Source: ANZDATA (2009).

To break down estimated diabetic kidney disease deaths by age and gender for people with type 2 diabetes, the proportion of deaths for people with diabetes found in ANZDATA (2009a) was applied to the estimated number of underlying causes of death attributable to diabetic kidney disease in Table 1.17. Chart 1.8 shows estimated mortality associated with diabetic kidney disease in 2010 by type of diabetes and age. It was assumed the age distribution of diabetic kidney disease death was the same for type 1 and type 2 diabetes.

Chart 1.8: Diabetic kidney disease deaths by type of diabetes and age, 2010



Source: Deloitte Access Economics calculations using AIHW (2009c) and ANZDATA (2010).

It seems AIHW (2009a) data underestimate the number of deaths associated with diabetic kidney disease when compared to the number of deaths of people with diabetes recorded in ANZDATA. For example, there were 509 CKD deaths in 2008 in people with diabetes (ANZDATA, 2009). However, ANZDATA records whether the person had diabetes at the time of death, and not whether the death was related to diabetic kidney disease. In some cases, a person may die due to comorbidities, such as CVD or malignancy. Furthermore, a person may have diabetes and ESKD due to other causes, for example, if diabetes was developed later in life. Although diabetes is expected to have contributed to that death through complications, the initial development of ESKD was not related to diabetes. Consequently the CKD death cannot be attributed to diabetes.

There is also the possibility that standard mortality indicators used in Australia underestimate the number of deaths associated with CKD. Rao et al (2011) analysed multiple causes of death from death registration in Australia based on automatic coding programs. They found that recorded death in people with diabetes is biased towards deaths classified as 'diabetes without complications'. Rao et al (2011) estimate that multiple cause death rates from diabetic kidney disease are actually four to nine times higher than recorded underlying cause rates for 'diabetes with renal complications'. The authors concluded that mortality associated with diabetic kidney disease is substantially underestimated in Australia.

2 Direct health care system costs of diabetic kidney disease

Direct healthcare system costs associated with type 2 diabetes are extensive and well-known. However, additional costs relating to CKD in these patients are difficult to quantify as a result of low rates of diagnosis in the early stages of kidney function decline.

The greatest cost burden associated with diabetic kidney disease is incurred at the later stages of the disease when patients require Renal Replacement Therapy (RRT). For a person requiring RRT the annual per person health care cost is more than $73,500.

This chapter estimates the direct health care costs of chronic kidney disease (CKD) in all Australians and with people who also have type 2 diabetes. Costs include recurrent and capital expenditures on hospitals, medical services, patient transport, other health practitioner, community and public health services, medications, aids and appliances, health research and administration systems.

2.1 Health care expenditure on CKD

The Australian Institute of Health and Welfare (AIHW) published estimates of health care expenditure on CKD in 2004-05 (AIHW, 2009). These are the most recent estimates available for CKD in Australia and represent the cost of care for people with CKD as the primary cause for the episode of care. To estimate health care expenditure in 2009-10, cost estimates derived from AIHW (2009) were grown by estimated annual growth in persons receiving dialysis and health price inflation.[15] This was deemed appropriate since around 85% of allocated expenditure on CKD in Australia is spent on dialysis and kidney transplant (AIHW, 2009).

There are several limitations with AIHW (2009) data that may underestimate costs. AIHW (2009) estimated allocated expenditure according to CKD coding lists, involving various disease groups where CKD was the primary reason for medical care. While estimated expenditures overlap with health care costs for other co-morbid conditions where CKD was the primary condition for care, they also exclude a portion of CKD expenditure where CKD was not the primary reason for care.

In addition, cost estimates do not account for expenditure due to the complications of CKD on comorbidities such as cardiovascular disease (CVD). Complications on comorbidities due to CKD may create substantial additional expenditure costs (AIHW, 2009).

[15] The average annual inflation rate was estimated to be 3.2% using AIHW (2010). The annual increase in growth of persons on dialysis treatment was estimated for each year using Australian and New Zealand Dialysis and Transplant Registry data (ANZDATA, 2010).

AIHW (2009) did not allocate CKD expenditure to some non-admitted patient hospital services categories, over-the-counter pharmaceuticals, other health care practitioner services, aged care and research. However, expenditure estimates for these types of health care were included in prior expenditure estimates on CKD (AIHW, 2005). Consequently, estimates from AIHW (2005) were projected to 2009-10 to ensure these types of expenditure were included in the total cost of CKD.

Total health care expenditure on CKD was estimated to be $1.4 billion in 2009-10. Estimated health care expenditures by area and type of expenditure are presented in Table 2.1.

Hospital services incurred the greatest cost with approximately $1.1 billion in 2009-10. Of this, $842.0 million was on admitted patient hospital services, with 78.3% of this due to dialysis procedures. Non-admitted patient services incurred $243.5 million in costs, while out-of-hospital medical services including GPs, imaging, pathology and specialist costs comprised $52.9 million. Total expenditure on pharmaceuticals was $210.5 million, comprising $190.7 million on highly specialised drugs for kidney transplants, $13.5 million for pharmaceuticals requiring prescriptions and $6.3 million for over-the-counter drugs. Other costs in 2009-10 included aged care homes ($15.8 million), other health professionals ($5.7 million), and research ($11.7 million).

2.1.1 Expenditure on end-stage kidney disease (ESKD)

Health care expenditure specifically for end-stage kidney disease (ESKD) treated through renal replacement therapy (RRT) was also estimated based on AIHW data. Estimates are presented in Table 2.2, by type of RRT and area of expenditure.

Total expenditure on RRT in 2009-10 was estimated to be approximately $1.1 billion. This comprised 79.2% of total health care expenditure on CKD. Excluding nephrologists' fees from total expenditure (these were unable to be apportioned between dialyses and transplants), dialysis contributed to nearly 78.1% of expenditure on RRT. This can be attributed to higher unit costs for dialysis procedures (AIHW, 2009), higher frequency of dialysis treatment and a greater proportion of patients receiving dialysis treatment than transplants (Excell and McDonald, 2005). Three quarters of patients receiving RRT were aged 45 years and over (AIHW, 2009).

The total expenditure estimate for RRT is higher than that presented by Cass et al (2010), who estimated a total cost of $994.8 million for 2010. This is due to differences in methodology employed. This study used a top-down calculation approach utilising AIHW expenditure data and projecting this into the future. In contrast, Cass et al (2010) used a bottom-up approach, multiplying estimated per head dialysis and transplant costs by the prevalence of those on RRT.

Since treatment of earlier stages of CKD focuses mainly on monitoring signs of kidney damage through urine and blood tests and on managing co-morbid conditions via medications, CKD stages one to four are expected to contribute little to admitted patient hospital costs. Thus, it was assumed that admitted patient hospital costs not on dialysis and transplant ('other CKD expenditure' in Table 2.1) were on ESKD patients admitted to hospital for CKD but where care was not specifically related to RRT.

Table 2.1: Estimated health care expenditure on CKD, 2009-10

Area of expenditure	Type of expenditure			
	Dialysis [a]	Kidney transplant	Other CKD expenditure [b]	Total
	$ (million)	*$ (million)*	*$ (million)*	*$ (million)*
Hospital services	854.5	28.9	202.2	1,085.6
Admitted patient[c]	659.1	28.9	154.1	842.0
Non-admitted patient[d]	195.4	n/a	48.1	243.5
Aged care homes (high care component)[e]	n/a	n/a	15.8	15.8
Out-of-hospital medical services	n/a	n/a	n/a	52.9
Un-referred attendances (GPs)	0.03	0.3	14.5	14.9
Imaging and pathology[f]	0.0	0.1	16.8	16.9
Specialist	n/a	n/a	3.2	21.2
Pharmaceuticals	n/a	n/a	n/a	210.5
Pharmaceuticals requiring a prescription	0.4	2.0	11.2	13.5
Over-the-counter drugs[e]	n/a	n/a	6.3	6.3
Highly specialised drugs for kidney transplants	n/a	190.7	n/a	190.7
Other health professionals[e]	0.0	0.0	5.7	5.7
Research[e]	n/a	n/a	n/a	11.7
Total expenditure	**n/a**	**n/a**	**n/a**	**1,382.2**

Note: (a) Includes haemodialysis in hospitals and satellite centres, home dialysis and peritoneal dialysis and expenditure on treatment of infections and reactions from peritoneal dialysis. (b) Includes an estimated CKD portion of expenditure on AIHW burden of disease categories unrelated to RRT for diabetic kidney disease, hypertensive renal diseases, genitourinary system disease and genitourinary congenital malformations. (c) Includes private medical services to private admitted patients. (d) Estimate for 'Other CKD expenditure' was based of the ratio of 'Dialysis' expenditure to 'Other CKD expenditure' found in AIHW (2005). (e) Estimates were derived from allocated expenditure presented in AIHW (2005). (f) The cost of imaging and pathology for dialysis patients was assumed to be captured within the cost of hospital services.
Source: Deloitte Access Economics calculations using AIHW (2005; 2009) and ANZDATA (2010).

Table 2.2: Estimated health care expenditure for RRT, 2009-10

	Total hospital services	Out-of-hospital medical services[(a)]	Prescription pharmaceuticals	Highly specialised drugs	Total allocated expenditure
	$ (million)	*$ (million)*	*$ (million)*	*$ (million)*	*$ (million)*
Kidney transplant	28.9	n/a	2.0	190.7	n/a
Dialysis	854.5	n/a	0.4	n/a	n/a
Total expenditure on RRT	**883.4**	**18.5**	**2.4**	**190.7**	**1,095.0**

Note: (a) Includes expenditure on nephrologists' fees which were unable to be apportioned between dialysis and transplant. As such, the column does not add to the total.
Source: Deloitte Access Economics calculations using AIHW (2009).

Given hospitalisation rates unrelated to RRT are expected to be similar across all ESKD patients (Dr Tim Mathew, pers. comm. 4th February 2011), $154.1 million of admitted hospital costs attributed to 'other CKD expenditure' was apportioned to hospitalisations for people with ESKD receiving RRT but unrelated to RRT and conservative care by proportional prevalence.

In 2010, 82.7% of total ESKD patients were estimated to be receiving RRT, while 17.3% were estimated to be receiving conservative care (see Section 1.3.3). Thus, it was estimated that $127.4 million of admitted hospital costs were on ESKD patients who receive RRT but unrelated to RRT, and $26.7 million were on ESKD patients who receive conservative care. Other costs relating to conservative care were assumed to include $15.8 million for aged care homes (high care component).[16]

Total ESKD expenditure was estimated to be $1.3 billion in 2009-10, which comprises the cost associated with RRT, the cost associated with hospitalisations for people receiving RRT but not related to RRT, and the cost of conservative care. Accordingly, expenditure on ESKD is estimated to have accounted for nearly 91.5% of total expenditure on CKD.

2.1.2 Health care expenditure on CKD stages one to four

There is a substantial amount of expenditure each year to treat CKD stages one to four. However, the bulk of this expenditure occurs for people with stages three and four, where medications are used to reduce the decline in kidney function and manage symptoms from reduced kidney failure. There is also greater use of specialists such as nephrologists.

Health care expenditure for CKD stages one to four was estimated by calculating the residual amount of total health care expenditure presented in Table 2.1 once expenditure for RRT, hospitalisations for people on RRT but unrelated to RRT, and conservative care was removed. Consequently, expenditure items include:

- other CKD expenditure relating to non-admitted patient care;
- un-referred attendances (GPs);
- imaging and pathology;
- specialist;
- pharmaceuticals requiring a prescription;
- over-the-counter drugs; and
- other health professionals.

Total health care expenditure on CKD stages one to four was estimated to be $117.4 million in 2009-10.

[16] Although conservative care includes medication and specialists, no costs associated with pharmaceuticals requiring a prescription, over-the-counter drugs, or other health professionals were attributed to conservative care. Medications and services are used to manage symptoms and therefore would be recorded as such. Consequently they would not be included in AIHW (2009) estimates. This means the cost of conservative care presented in this report will be underestimated.

2.1.3 Health care expenditure projections

To estimate health care expenditure in 2015-16 and 2020-21, estimated expenditure for 2009-10 was further grown by the projected average annual growth in persons receiving dialysis and projected health price inflation.[17,18]

Projected total health care expenditure on CKD is presented in Table 2.3. It is estimated total health care expenditure will grow to around $1.8 billion by 2015-16, and then to $2.3 billion by 2020-21. This represents an increase of 65.5% between 2009-10 and 2020-21 or an equivalent annual increase of 4.7%, reflecting both increases in health care price inflation and resource use.

Table 2.3: Estimated and projected total health care expenditure on CKD

	2009-10	2015-16	2020-21
	$ (million)	*$ (million)*	*$ (million)*
CKD stages one to four	117.4	156.5	195.5
ESKD patients on RRT[(a)]	1,222.3	1,619.5	2,023.0
ESKD patients treated conservatively	42.5	57.3	71.6
Total ESKD patient expenditure	1,264.8	1,675.8	2,093.3
Total CKD	**1,382.2**	**1,831.2**	**2,287.5**

Note: (a) Includes expenditure on hospitalisations for people on RRT but unrelated to RRT.
Source: Deloitte Access Economics calculations.

Of total CKD expenditure in 2015-16, it is estimated that $1.6 billion will be spent on people receiving RRT and $57.3 million will be spent on people receiving conservative care. This is projected to grow to over $2.0 billion and $71.6 million by 2020-21 respectively.

Estimated and projected health care expenditure per person in 2009-10, 2015-16 and 2020-21 are shown in Table 2.4. Health care expenditure on people receiving RRT and people receiving conservative care was divided by prevalence estimates to calculate the average per-person health care costs. Average health care expenditure per person for treated CKD stages one to four could not be estimated as a substantial number of people with CKD stages one to four are undiagnosed.

The average per-person health care cost for RRT was estimated to be $64,189 in 2009-10. This is comparable to the annual per-person estimated cost presented by Cass et al (2010) (refer to the box on the next page). Cost is projected to increase to $70,641 by 2015-16 and $75,996 by 2020-21, representing a total increase of around 18.4%. For conservative care, per person costs are projected to increase from $10,628 in 2009-10 to $12,521 in 2015-16 and $13,796 in 2020-21.

[17] Analysis of ANZDATA for 1998 to 2009 (ANZDATA, 2010) shows that there has been an increase in people receiving dialysis but a downward trend in the annual growth rate. This downward trend is projected to continue into the future (see Appendix A).

[18] The average annual inflation rate was projected to be 3.2%, the annual rate of health inflation between 1998-99 and 2008-09 (AIHW, 2010).

Table 2.4 : Projected per-person health care cost for ESKD by treatment type

	2009-10	2015-16	2020-21
	$	$	$
ESKD patients receiving RRT	64,189	70,641	75,996
ESKD patients treated conservatively	10,628	12,521	13,796

Source: Deloitte Access Economics calculations.

The annual per person cost of RRT was estimated to be $64,189 in 2009-10. This is comparable to the estimated per person costs of dialysis presented by Cass et al (2010) as shown below (in 2008-09 dollars):

- In-centre haemodialysis - $85,128
- Satellite haemodialysis - $70,409
- Home haemodialysis - $53,268
- Peritoneal dialysis - $56,910

Different dialysis modalities are associated with different patterns of resource utilisation, infrastructure and staffing requirements, and therefore different per patient costs (Cass et al, 2010). Haemodialysis conducted outside the home is relatively more expensive than peritoneal dialysis, with in-centre haemodialysis being the most expensive treatment option. Home haemodialysis is the least costly form of treatment due lower infrastructure and staffing ratios than hospital or satellite haemodialysis (Cass et al 2010).

The large amount spent on dialysis in Australia reflects increasing service use over time due to a growing number of dialysis patients (AIHW 2009). Increasing demand for dialysis places pressure on a fixed quantity of health care resources. Furthermore, the majority of dialysis patients receive satellite or hospital haemodialysis, as compared to the less health care resource intensive and less expensive option of home haemodialysis (Cass et al 2010).

2.2 Health care expenditure on CKD patients with type 2 diabetes

Both health care service utilisation and health care costs per patient are likely to be significantly higher for CKD patients with diabetes than those without (Arora et al, 2000; Fried et al, 1999; Levin et al, 2009; Murphy et al, 2000; Smith et al, 2007; Vaiciūniene et al, 2005; Yang et al, 2001). This has been found for all stages of CKD.

There is a complex interaction between the costs of health care for CKD and related comorbidities such as diabetes. This can result in health care costs being greater than the simple expected additive cost of care for comorbidities (Smith et al, 2004).

Various factors contribute to higher health care utilisation for CKD patients with diabetes. Diabetes management may be complicated in ESKD patients on dialysis due to its effects on glycaemic control. ESKD and dialysis may exert opposing forces on insulin secretion, action

and metabolism and lead to high, low, unstable or fluctuating glucose levels (Dasgupta 2004; Shrishrimal 2009).

In particular, hyperglycaemia (high sugar levels) may be related to peritoneal dialysis treatment using conventional glucose-containing solutions, and may necessitate the need for higher insulin dosages and combination therapy with both oral agents and injections (Dasgupta, 2004). Peritoneal dialysis may accelerate changes in peritoneal membrane structure and function in people with diabetes, with conventional solutions containing high glucose and glucose degradation products implicated in peritoneal dialysis technique failure (Lee et al, 2001).

Both dangerously low and dangerously high blood sugar levels are associated with diabetic complications which can require hospitalisation. Additionally, safety and efficacy complications can arise with the use of some oral anti-diabetic agents in patients with diabetes and impaired kidney function (Dasgupta, 2004). This is related to the decreased clearance of drugs by the kidneys and prolonged exposure to the drug or its metabolites, which may result in adverse side effects (Cavanaugh, 2007). For example, thiazolidinediones can improve peripheral insulin sensitivity in dialysed patients but safety is limited because they can induce edema with congestive heart failure in elderly patients with diabetes (Dasgupta, 2004).

CKD patients with diabetes also have an increased risk of other co-morbidites such as cardiovascular disease (AIHW 2007; Dronovalli et al 2009). When ESKD patients with diabetes commence RRT, their morbidity and survival may continue to be poor owing to their high morbidity from cardiovascular causes (Yang et al, 2001).

Patients with CKD and diabetes also have a higher rate of physical complications during dialysis than other CKD patients. A Taiwan study found that major causes behind frequent hospitalisation of dialysis patients with CKD and diabetes were cardiovascular disease, poorly controlled hyperglycaemia (high blood sugar levels), sepsis and failure of vascular access (Yang et al, 2001). A US study found up to 48% of all haemodialysis patient hospitalisations in people with diabetes could be attributed to access-related problems (Ifudu et al, 1996).

A higher cardiovascular risk profile for CKD patients with diabetes means they are more likely to take medications such as angiotensin-receptor blockers (ARBs), angiotensin-converting enzyme (ACE) inhibitors and statins than those patients with CKD only (Levin et al, 2009). Tight control of hypertension and achievement of target blood pressure is a national evidence-based guideline for preventing the progression of kidney disease in people with type 2 diabetes (Chadban et al, 2009).

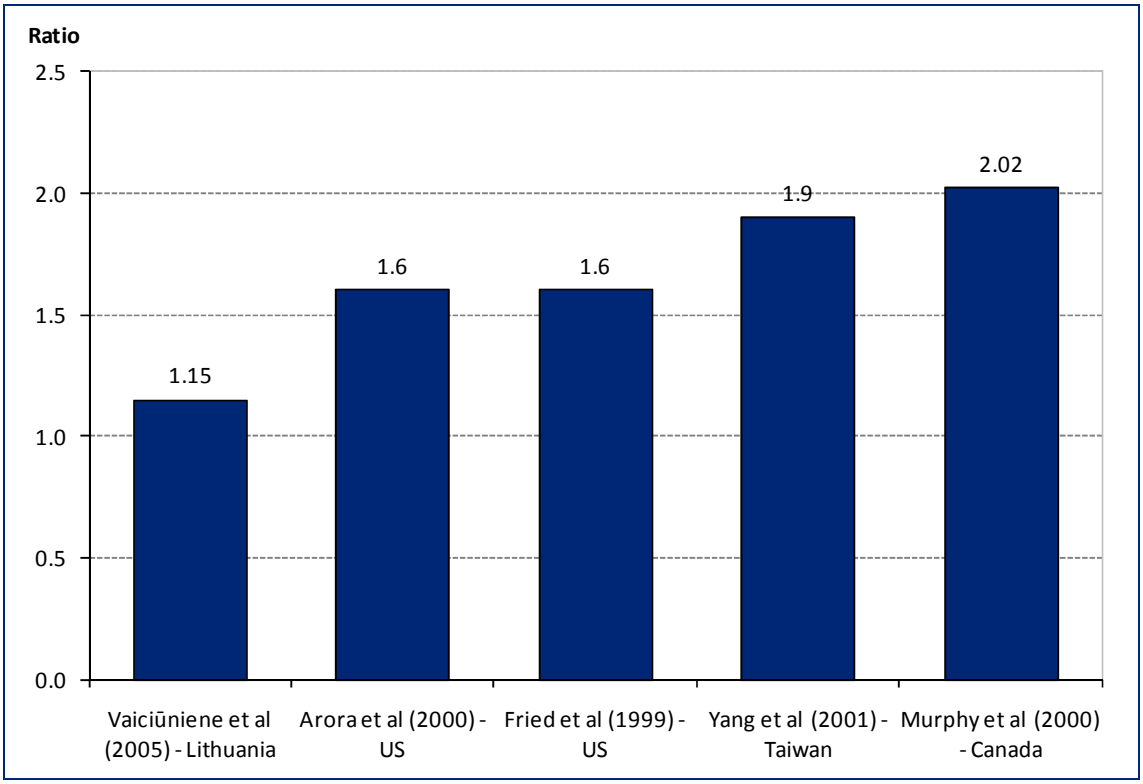
2.2.1 Health care utilisation by CKD patients with diabetes

A number of past studies have found that dialysis patients with diabetes have more frequent hospitalisations and longer hospital stays than dialysis patients without diabetes (Arora et al, 2000; Fried et al, 1999; Murphy et al, 2000; Vaiciūniene et al, 2005; Yang et al, 2001). However, there have not been any Australian studies that have quantified health care resource use of CKD patients by diabetes status. As such, this study uses international studies on the health care utilisation levels between CKD patients with and without diabetes.

A Taiwan study of dialysis patients found inpatient costs for people with diabetes were 3.5 times greater than people without diabetes due to more frequent hospitalisations and longer

hospital stays (Yang et al, 2001). Similar results were found for studies of dialysis patients in Canada (Murphy et al, 2000), the United States (Arora et al 2000; Fried et al 1999) and Lithuania (Vaiciūniene et al, 2005). A summary of hospitalisation frequency ratios between dialysis patients with and without diabetes are presented in Chart 2.1. Ratios are relatively similar across countries, ranging from a low of 1.15 for Lithuania to 2.02 for Canada.

Chart 2.1: Ratio of hospitalisation rates in dialysis patients with and without diabetes

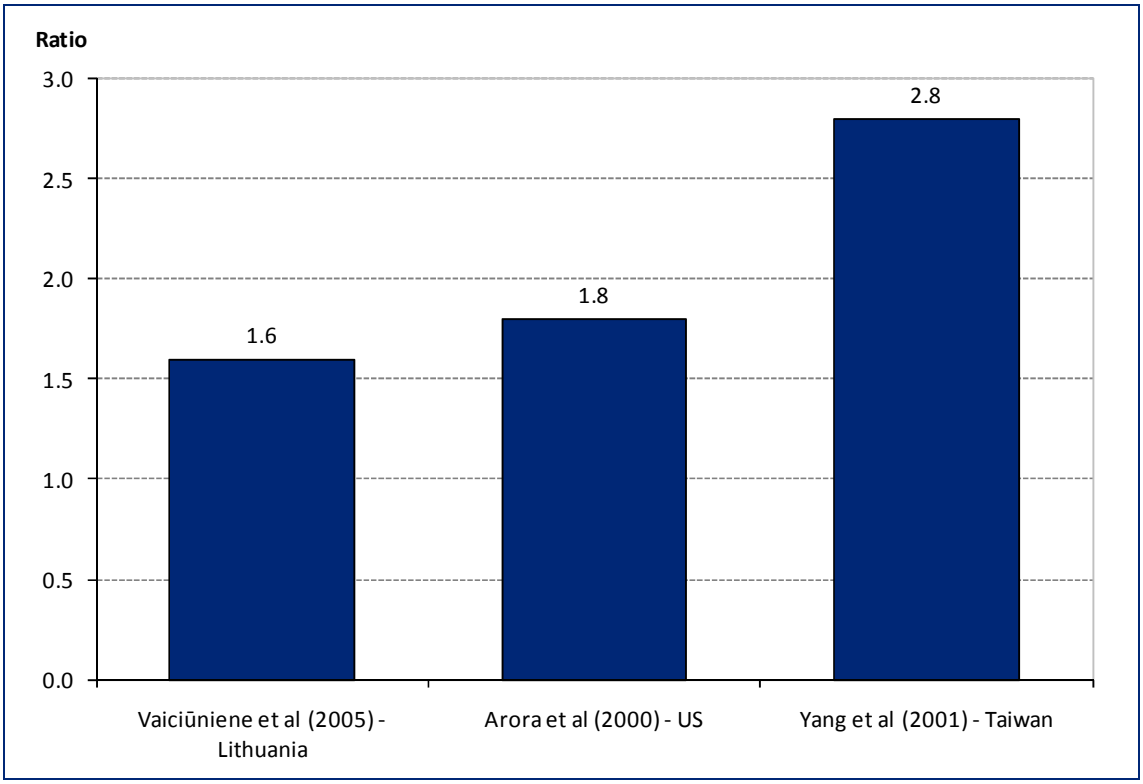


Note: (a) Ratio of hospitalisations per patient for each study (b) Arora et al (2000) and Yang et al (2001) reported hospitalisations for kidney disease patients with diabetes, while Murphy et al (2000), Fried et al (1999) and Vaiciūniene et al (2005) reported hospitalisations for CKD patients with diabetes (not necessarily diabetes-caused).
Source: Vaiciūniene et al (2005), Arora et al (2000), Fried et al (1999), Yang et al (2001) and Murphy et al (2000).

Differences in hospital length of stay between dialysis patients with and without diabetes have also been found (Arora et al 2000; Vaiciūniene et al 2005; Yang et al 2001), with the length of stay for the former greater by between 1.6 and 2.8 times. Ratios are presented in Chart 2.2.

Health care utilisation is also higher in patients with diabetes at other CKD stages. In a Canadian study of CKD patients not on renal replacement therapy, median general practitioner and specialist visits per year were found to be 1.3 times higher for the CKD group with diabetes than for the CKD only group (Levin et al, 2009). Additionally, those with diabetes spent a median of six days in acute or rehab inpatients units per year, compared to four days for patients with CKD only. A US study of Health Maintenance Organisation members with CKD stages two to four found diabetes made CKD more costly to manage, including inpatient, outpatient and prescription costs. The relative affect of diabetes on health care costs increased with worsening renal function (Smith et al, 2007).

Chart 2.2: Ratio of hospital length of stay for dialysis patients with and without diabetes



Note: (a) Ratio of hospital length of stay per patient for each study (b) Arora et al (2000) and Yang et al (2001) reported length of stay for kidney disease patients with diabetes, while Vaiciūniene et al (2005) reported length of stay for CKD patients with diabetes (not necessarily diabetes-caused).
Source: Arora et al (2000), Vaiciūniene et al (2005) and Yang et al (2001).

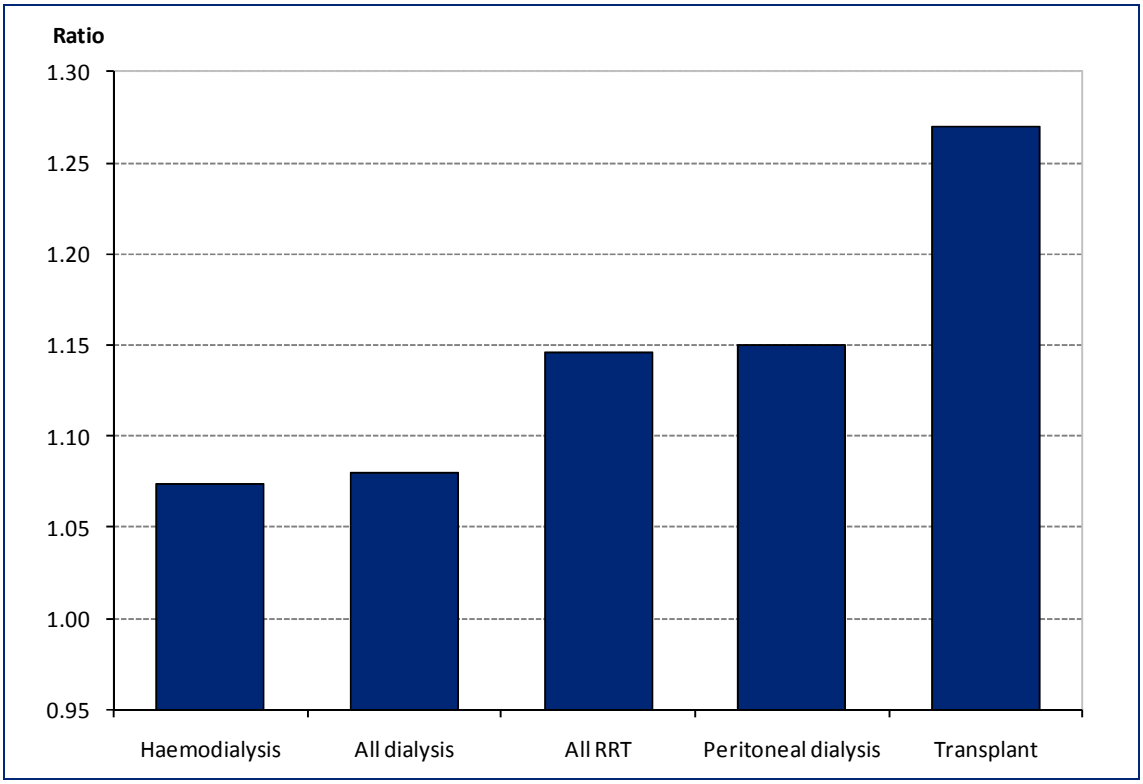
2.2.2 Health care costs for CKD patients by diabetes status

The United States Renal Data System (USRDS) publishes information representing ESKD and CKD Medicare expenditures in the US, with the most recent data available for 2008 (USRDS, 2010). Health care costs were derived from Medicare inpatient/outpatient and physician/supplier claims data in the US with analysis conducted via an actuarial, as-treated model. Ratios of per person health care costs between diabetes-caused ESKD and all ESKD patients are presented in Chart 2.3.

Expenditure data reveals that expenditure ratios vary by RRT treatment modality. Transplant patients with diabetes-caused ESKD had 25% higher health care costs per person compared to all ESKD patients. Peritoneal dialysis patients with diabetes-caused ESKD had 15% higher health care costs per person than all ESKD patients. The relative cost difference for haemodialysis was smaller than for peritoneal dialysis. This may be related to the hyperglycaemic implications of peritoneal dialysis. On average, patients with diabetes-caused ESKD had nearly 15% higher per person health care costs than all ESKD patients across all RRT modalities.

The USRDS (2010) also reported on the per-person annual Medicare expenditure for those with other stages of CKD (excluding ESKD) who were aged 65 years and older. Overall, costs per person were 9.3% higher for CKD patients with a co-morbidity of diabetes than for all CKD patients.

Chart 2.3: Ratios of health care costs for treating diabetes caused ESKD versus all ESKD



Source: Deloitte Access Economics calculations using USRDS (2010).

2.2.3 Estimated health care cost associated with CKD and type 2 diabetes

To estimate the cost associated with CKD in people with type 2 diabetes, the ratio of health care costs between patients with and without diabetes derived from USRDS (2010) was applied to the Australian context. Thus costs for CKD stages one to four were multiplied by 1.093 and ESKD costs were multiplied by 1.15.

While absolute health care expenditures per person will differ between Australia and the US, it is assumed that the same *relative* differences in expenditures between CKD patients with and without diabetes will apply to both countries.

Average treatment costs per person with CKD stages one to four could not be calculated due to a lack of data on the number of people being treated. Average per-person health care costs for people with ESKD are presented in Table 2.5. The annual per person cost of RRT for people with type 2 diabetes was estimated to be $73,527 in 2009-10, while the cost of conservative care was estimated to be $12,174.

In comparison to other cardiovascular disease conditions, RRT for patients with type 2 diabetes is expensive. For example, the cost of a heart attack is estimated to be around $25,000 per patient (Access Economics 2009). This means the annual per patient cost of RRT for patients with type 2 diabetes is around three times greater.

Table 2.5: Estimated health care cost per person for ESKD and type 2 diabetes[(a)]

	2009-10	2015-16	2020-21
	$	*$*	*$*
ESKD with RRT	73,527	80,917	87,051
ESKD with conservative care	12,174	14,343	15,803

Note: (a) Estimated by adjusting average per person costs upward by 1.15 (ratio derived from USRDS, 2010).
Source: Deloitte Access Economics calculations.

The majority of health care costs for RRT in patients with type 2 diabetes and heart attacks are attributed to costly inpatient care. However, the cost of RRT in people with type 2 diabetes is much greater because hospital costs are incurred at a higher frequency with regular ongoing treatment until a successful kidney transplant or death. In comparison, the majority of health care costs associated with a heart attack are incurred at the time of an event when hospital care is needed, and generally only occur once within a year.

Multiplying adjusted cost estimates for people with type 2 diabetes by the prevalence of CKD and type 2 diabetes, it is estimated that $466.8 million was spent on CKD in patients with type 2 diabetes in 2009-10. This is projected to be $682.7 million by 2015-16 and $914.3 million by 2020-21. The estimated and projected health care expenditures on CKD patients with type 2 diabetes are presented in Table 2.6.

Table 2.6: Projected health care expenditure on CKD in patients with type 2 diabetes

	2009-10	2015-16	2020-21
	$ (million)	*$ (million)*	*$ (million)*
CKD stages one to four	20.5	27.3	34.1
ESKD patients receiving RRT	431.3	633.0	850.2
ESKD patients treated conservatively	15.0	22.4	30.1
Total ESKD	**466.8**	**682.7**	**914.3**

Source: Deloitte Access Economics calculations.

The total health care cost associated with CKD in people with type 2 diabetes is significant when compared to health care costs associated with type 2 diabetes. For example, allocated direct health care expenditure for all of type 2 diabetes is estimated to be $969.3 million in 2009-10.[19]

However, it is expected that the costs for CKD stages one to four presented in Table 2.6 are significantly underestimated. Data from AIHW (2009) used to estimate costs do not account for expenditure on health care due to the complications of CKD on comorbidities. AIHW (2009) noted that complications will increase expenditure substantially. This is supported by Smith et al (2004), who found among people in the US in CKD stages two to four:

- people with CKD related comorbidities had costs double that of people with CKD but without comorbidities;
- there is an interaction between CKD and some comorbidities that incurs costs greater than the sum of the two parts; and
- estimated cost of CKD related comorbidities was greater than the estimated cost of CKD.

[19] Based off AIHW (2008) and an average annual health care inflation rate of 3.2% derived from AIHW (2010).

Furthermore, AIHW (2009) cost data excludes a portion of CKD expenditure where CKD was not the primary reason for care. This is expected to significantly underestimate the cost of pharmaceuticals for CKD stages one to four as ACE inhibitors and ARBs, which are generally allocated to the cost of CVD, are used to reduce both the risk of CVD and the progression of CKD.

3 Indirect economic costs of diabetic kidney disease

The greatest cost burden associated with diabetic kidney disease is incurred at the later stages of the disease when complications associated with both the loss of kidney function and poor glycaemic control become more pronounced.

This chapter explores the indirect financial costs of CKD in people with type 2 diabetes. Unlike health care costs, these do not reflect the costs of treating CKD in people with type 2 diabetes. Rather, they reflect economic losses that result from indirect impacts of the illness on society.

3.1 Overview

In its earlier stages, CKD has few or no symptoms. It is usually when patients reach ESKD that symptoms arise. At this stage, health-related quality of life diminishes considerably, due to lifestyle changes from associated symptoms, comorbidities and treatments (Evans et al, 1985; Fukuhara et al, 2003; Valderrabano et al, 2001). Although RRT may alleviate some symptoms, others may persist, and treatment may impose lifestyle restrictions. Physical complaints identified by dialysis patients include muscle, bone and joint aches, sleep disturbances, itchy/dry skin, concentration problems, dizziness and shortness of breath (Cass et al, 2006).

In a Spanish study, Moreno et al (1996) found that over a quarter of dialysis patients indicated severe quality of life restrictions, with adverse effects on work, recreation, home management and sleep. Dialysis patients also have significantly lower employment and workforce participation rates (Hirth et al, 2003; Kutner et al, 2008; Van Manen et al, 2001; Zelmer, 2007) and those receiving in-centre haemodialysis are likely to incur significant transport costs (Cass et al, 2006). There may be differences in quality of life dependent on dialysis modality, with conflicting data on impacts (Cameron et al, 2000; Maiorca et al, 1998; Merkus et al, 1999). While peritoneal dialysis may cause more continuous physical discomfort than haemodialysis, it may provide greater independence than haemodialysis which is undertaken for longer hours per week and usually in-centre (Cass et al, 2006).

Transplant patients have significantly improved quality of life scores after successful transplant and fewer restrictions on daily activities (Gorlen et al, 1993; Laupacis et al, 1996). However, immunosuppressive medication regimens, the risk of graft failure and comorbidities may still lead to a diminished quality of life (Cass et al, 2006). In particular, transplant patients with diabetes face an increased risk of premature graft failure and major cardiovascular events after transplantation than other transplant patients (Chadban et al, 2010).

Other indirect costs of ESKD include informal care provided by family and friends of patients, who may assist with home-based dialysis therapy (Peeters et al, 2000) and other daily activities. A percentage of dialysis patients may require 24-hour, long-term care (Manns et al, 2002).

Thus ESKD in patients with type 2 diabetes can impose indirect impacts and costs on both patients and society through lost productivity, transport costs and informal care costs. These are associated with the diminished health, lower quality of life and lifestyle restrictions. In this report, the following indirect costs are estimated:

- productivity losses from reduced labour market participation through lower employment and premature mortality associated with ESKD;
- costs to informal carers from providing care to someone with ESKD and type 2 diabetes; and
- deadweight losses associated with raising additional tax revenue to publicly fund health care services and direct payments to people with ESKD and type 2 diabetes.

It is important to distinguish between real costs and transfer costs. A real cost is incurred when economic resources (such as land, labour and capital) are used in the production process of goods and services. When resources are put to a certain productive use, this reduces the opportunity for production in other areas of the economy. This is known as an opportunity cost, and includes productivity and informal care costs.

Transfer payments are payments from one economic agent to another, without a good or service being provided in return and include taxes, subsidies and pensions. These are not a net cost to society as they represent a shift in consumption power from one group of individuals to another. Transfer payments in the context of this study include living allowances and welfare payments associated with CKD. Transfer payments have not been presented as an economic cost within this report. Rather, they have been used to estimate associated deadweight losses (lost efficiency) to the economy.

3.2 Productivity loss

People with CKD generally do not present with symptoms until they have reached ESKD, when they require RRT. As such, labour productivity will not be adversely affected in people with type 2 diabetes until ESKD.

A loss in productivity of a person with ESKD will only equate to a loss in productivity to the economy under fairly strict conditions. These are:

- the economy is at full employment so any reduction in hours worked due to ESKD, or any permanent reduction in labour force participation through early retirement or death, cannot be replaced by employing or increasing hours of other workers; and
- the income of an individual is proportional to the total value added to production.

The first condition will fluctuate over time as the economy moves into, and out of, full employment. A reduction in labour when labour is scarce will have a greater impact on productivity compared to an economy with an abundant labour supply. In this situation, a temporary or permanent reduction in working hours due to ESKD cannot be replaced by hiring another worker. Consequently, a loss in productivity due to ESKD in patients with type 2 diabetes is expected to represent a real cost to an economy operating at a low level of unemployment.

The second condition will occur if there is a perfect labour market such that the marginal benefit from an additional hour of work (the value added) is equal to the marginal cost (the

wage). In reality, labour markets are imperfect for a number of reasons, for example asymmetric information in the market, and labour market restrictions imposed by government regulation and natural barriers. In addition, synergy created between labour, capital and land means a reduction in working hours may also impact the productivity of other factors of production.

Consequently the value of productivity from labour will be larger than the wage provided to an individual so using lost income as a proxy for lost productivity will tend to underestimate the true cost. It is likely that in the absence of their condition, people with ESKD and type 2 diabetes would participate in the labour force and obtain employment at the same rate and average weekly earnings as others. The implicit assumption is that the numbers of such people would not be of sufficient magnitude to substantially influence the overall clearing of labour markets, and average wages remain the same.

In this report, productivity losses are estimated using lower than average employment rates for people with type 2 diabetes unemployed due to ESKD, and lost lifetime earnings due to premature death attributed to ESKD in people with type 2 diabetes.

Productivity losses may also occur as a result of higher absenteeism, and lower productivity at work ('presenteeism costs'). However, these components could not be estimated due to lack of available data. Thus, productivity losses presented in this report are conservative, and do not reflect the full magnitude of lost productivity from ESKD in people with type 2 diabetes.

3.2.1 Productivity loss from unemployment

A number of studies have examined the employment and workforce participation effects of ESKD and RRT (Blake et al, 2000; Bremer et al, 1989; Evans et al, 1985; Gorlen et al, 1993; Gutman et al, 1981; Hirth et al, 2003; Holley and Nespor, 1994; Julius et al, 1989; Laupacis et al, 1996; Manninen et al, 1991; Matas et al, 1996; Russell et al, 1992; Van Manen et al, 2001). However, no studies have been conducted in an Australian context. This section examines international studies to collate data on the employment and workforce participation effects of ESKD.

An Irish study (Blake et al, 2000) of ESKD patients aged 18 to 65 years in the labour force, found that 51% were employed, compared to the concurrent national employment rate of 90% at the time. This translates to an employment gap of 43.3%.[20]

Dialysis treatment of ESKD patients is associated with reduced physical functioning, with the majority of patients unable to work (Cass et al, 2006). However, employment may be affected in ESKD patients, even prior to the commencement of RRT.

A Dutch study of patients aged between 18 and 65 years found that 35% of pre-dialysis patients were employed compared to 61% of the general population (Van Manen et al, 2001). Calculated employment gaps by age group and gender are presented in Table 3.1, using the study's pre-dialysis employment rates and comparable general population employment rates. The overall employment gap derived from this study for all age-gender groups was 42.6%. This is comparable to the employment gap from Blake et al (2000). The largest employment gap

[20] [90%-51%] / 90% = 43.3%

was found for the 45 to 65 years age group, and female employment was found to be relatively more affected than male employment.

Table 3.1: Estimated employment gap for people on pre-dialysis in The Netherlands

	Pre-dialysis employment rate (a)	General population employment rate (b)	Employment gap
	%	*%*	*%*
18-25 years	41	41	0.0
25-45 years	56	75	25.3
45-65 years	27	51	47.1
Total (18-65 years)	35	61	42.6
Male	45	74	39.2
Female	21	47	55.3

Note: Employment gap = [(b)-(a)]/(b).
Source: Deloitte Access Economics calculations using Van Manen et al (2001).

Within one year of commencing dialysis, proportion of employed haemodialysis patients fell from 35% to 25%, and employed peritoneal dialysis patients fell from 48% to 40% (Van Manen et al, 2001).

Some studies have found that patients on continuous ambulatory peritoneal dialysis have higher employment rates than persons on in-house haemodialysis (Julius et al, 1989; Van Manen et al, 2001). For example, Julius et al (1989) found a significantly higher percentage of patients undergoing continuous ambulatory peritoneal dialysis were in the labour force than those undergoing in-centre haemodialysis (27.4% versus 9.6%, respectively).

However, not all studies concur (Evans et al, 1985; Holley and Nespor, 1994) there is conflicting evidence on the effect of dialysis modality on employment. Hirth et al (2003) suggest that higher employment in peritoneal dialysis patients is largely explained by patient selection, with employed persons having a greater probability of selecting peritoneal dialysis than haemodialysis. Thus, while the relatively more flexible modality of peritoneal dialysis may facilitate employment, the effect is less than that found by many studies due to endogenous selection of peritoneal dialysis by patients wishing to maintain their prior employment.

Kutner et al (2008) found that facility level characteristics also had an effect on dialysis patient employment. In their US study, the authors found that across all facilities, 18.9% of prevalent patients aged 18 to 54 years were employed, but facility employment rates ranged from 0 to 100%. After controlling for other factors, facility employment rate was positively associated with availability of 5pm or later dialysis shifts, availability of peritoneal dialysis or home haemodialysis training, and provision of frequent haemodialysis.

Persons with functioning kidney transplants have a lower risk of mortality and morbidity than those on dialysis with studies finding similar quality of life to the general population (Zelmer, 2007). In a US study, Evans et al (1985) controlled for case-mix and found that 79% of transplant recipients functioned at near-normal levels versus 45% of centre haemodialysis and 25% of peritoneal dialysis patients. For this reason, compared to dialysis patients, a higher percentage of transplant recipients are able to undertake employment and participate in the workforce (Bremer et al, 1989; Evans et al, 1985, Manninen et al, 1991; Russell et al, 1992).

Manninen et al (1991) reported on 226 kidney transplant recipients who were followed two and a half to three and a half years post-transplant. Of these, 47% worked full-time and another 15% part-time. Ability to work was related to graft status, with 64% of those with functioning primary grafts able to work compared to 32% who returned to dialysis.

A Canadian, hospital-based study following pre-transplant patients for up to two years post-transplant found employment rates increased by 50% with a functioning transplant (Laupacis et al, 1996). The proportion of individuals employed increased from 30% at pre-transplantation to 45% two years after transplantation. A ten-year follow-up Norwegian study found 72% of surviving transplant recipients continued or resumed full-time work (Gorlen et al, 1993). However, this study excluded diabetic transplant patients.

Comorbidities such as diabetes can further influence an RRT patient's ability to work. Gutman et al (1981) found that the physical activity of dialysis patients without diabetes was significantly greater than patients with diabetes. Of the former, 20% were judged to be completely unable to take care of themselves in comparison to over 50% of the latter. This was reflected in relative employment abilities between the study's two groups. The study found that 18% of men with diabetes were employed compared to 34% of men without diabetes and 6% of women with diabetes were employed compared to 16% of women without diabetes.

Similarly, Matas et al (1996) found that the employment rates after successful kidney transplant were significantly lower for recipients with diabetes, with nearly 31% employed compared to nearly 38% of recipients without diabetes. Additionally, a higher percentage of recipients with diabetes stopped working full-time post-transplant (26% of recipients compared to 14.8% respectively). Another study also found that diabetic kidney transplant patients were less likely to work than patients without diabetes (Manninen et al, 1991).

Evans et al (1985) examined labour force participation rates across all RRT modalities. Derived labour force participation gaps are presented in Table 3.2, calculated using the study's quoted general population participation rate of 63.8%. The authors found that adverse workforce effects are substantially lower for transplant recipients than for dialysis patients. However, contrary to other studies (Julius et al, 1989; Van Manen et al, 2001), it found a larger workforce participation gap for peritoneal dialysis than haemodialysis.

Table 3.2: Estimated employment gap for people on dialysis in the United States

	RRT patient participation rate (a)	General population participation rate (b)	Employment gap
	%	*%*	*%*
Home haemodialysis	39.6	63.8	37.9
In-centre haemodialysis	23.7	63.8	62.9
Continuous ambulatory peritoneal dialysis	16.2	63.8	74.6
Kidney transplant	53.5	63.8	16.1

Note: Participation gap = [(b)-(a)]/(b).
Source: Deloitte Access Economics calculations using Evans et al (1985).

Most studies that have evaluated the employment impacts from CKD have focused specifically on either dialysis patient employment or transplant patient employment. Furthermore, dialysis studies differed on whether people undertaking haemodialysis or peritoneal dialysis patients were more likely to be employed.

Blake et al (2000) examined employment for ESKD patients for all types of ESKD patients, including all types of dialysis patients and transplant patients. The authors found an employment gap of 43.3% for patients aged 18 to 65 years on RRT in Ireland (Blake et al, 2000). Due to the absence of Australian data on employment of patients with ESKD, the employment gap estimate from Blake et al (2000) was applied to estimate productivity losses from lower employment in people with type 2 diabetes with ESKD in Australia.

Although some studies have found a difference between the employment of ESKD patients by diabetes status (Gutman et al, 1981; Matas et al, 1996; Manninen et al, 1991), the employment gap was not adjusted to account for this difference. The mechanics of dialysis is one of the primary reasons patients are restricted in ability to work (Cass et al, 2006). Since dialysis and the physical restrictions it imposes are similar regardless of diabetes status, the employment gap found for all ESKD patients has been applied to ESKD patients with type 2 diabetes.

Furthermore, CKD patients with diabetes are at an increased risk of other comorbidities such as cardiovascular disease (AIHW, 2007). It is therefore problematic to separate the difference in employment found in studies to the effect of diabetes.

The derived employment gap of 43.3% was applied to the estimated number of patients receiving RRT with type 2 diabetes in the working age group of 15 to 64 years in 2009-10. It was estimated there were 5,866 dialysis and transplant patients with type 2 diabetes in 2010. Of these, 3,024 were estimated to be of working age (15 to 64 years). Due to the older age structure of patients with type 2 diabetes receiving conservative care and their reduced probability of work due to comorbidities, it was assumed people with diabetes receiving conservative care for CKD do not incur a productivity loss.

People receiving RRT who are unable to work may not have been employed even in the absence of their condition. For this reason, the number of people with type 2 diabetes who are unable to work due to CKD was multiplied by the employment-to-population ratio by age group (employment probability) derived from ABS (2010a) and population data from the Deloitte Access Economics Demographic Model (AE-Dem).

Wages were applied as a proxy for the value of lost production. Estimated average weekly earnings by age group in 2009 were adjusted upwards for the labour price index between 2009 and 2010 (ABS, 2010b; 2010c) and converted into an annual wage.[21]

The components of annual earnings, employment probabilities, number of people receiving RRT and the employment gap were used to estimate the productivity losses from lower employment. Estimates are presented in Table 3.3. There were approximately 1,310 people

[21] ANZDATA is structured in ten-year age groups, while earnings data in Australia is by five-year age groups. In the absence of a more detailed age-breakdown of ANZDATA, it was assumed that the prevalence of RRT patients in broad ten-year age groups was split equally between the two five-year age group components.

unemployed due to CKD and type 2 diabetes. Total productivity loss from lower employment was estimated to be approximately $49.3 million in 2009-10.

Table 3.3: Estimated productivity loss for people with RRT and type 2 diabetes, 2009-10

Age group	Prevalence [(a)]	Average annual earnings	Employment-population ratio	Employment gap	Productivity loss
Years	*people*	*$*	*%*	*%*	*$ (million)*
15–19	0	14,840	46	43.3	0.0
20–24	0	34,465	76	43.3	0.0
25–29	23	51,617	80	43.3	0.4
30–34	23	58,016	75	43.3	0.4
35–39	110	61,672	77	43.3	2.3
40–44	110	60,650	78	43.3	2.3
45–49	472	61,511	84	43.3	10.6
50–54	472	63,070	74	43.3	9.5
55–59	907	59,682	63	43.3	14.8
60–64	907	54,951	42	43.3	9.0
Total	**n/a**	**n/a**	**69**	**43.3**	**49.3**

Note: (a) Total prevalence in broad ten-year age groups was split equally between component five-year age groups.
Source: Deloitte Access Economics calculations using ANZDATA (2010), ABS (2010; 2010; 2010) and Blake et al (2000).

3.2.2 Productivity loss from premature mortality

Patients with ESKD and type 2 diabetes experience higher mortality rates than the general population (Villar et al, 2009). The premature death of those with ESKD results in a future stream of productivity losses that can be approximated through lost potential earnings up to retirement age, which is assumed to be 65 years.

There were 127 deaths attributable to CKD and type 2 diabetes in 2009-10.[22] Of these, around 53 were estimated to occur in the working age population of people aged between 15-64 years (see Section 1.6).

The productivity lost due to premature death was calculated by multiplying the number of deaths resulted from CKD in patients with type 2 diabetes by the remaining expected lifetime earnings at the time of death. Productivity losses from premature mortality were adjusted by the likelihood of employment. Assuming a retirement age of 65, the remaining years of employment were calculated by using the midpoint age of each age group at the time of death.

The annual productivity loss from premature death was valued using 2009 average annual earnings data by workforce age group (ABS, 2010b) adjusted to 2010 using the labour price index (ABS, 2010c). Future streams of income were discounted to a present value using a 7% real discount rate, which is consistent with the federal government's choice of discount rate for assessing regulatory interventions (OBPR, 2010).

[22] This is considered an underestimate due to the reasons outlined in Section 1.6.

Around 34 people with type 2 diabetes would have been employed except for premature mortality due to CKD. Accounting for their age at the time of death, productivity loss due to premature mortality was estimated to be approximately $16.5 million in 2009-10. A breakdown of cost is presented in Table 3.4.

Table 3.4: Estimated productivity loss associated with premature mortality, 2009-10

Age group	Deaths	Employed [(a)]	Time to retirement [(b)]	Productivity loss [(c)]	Total cost
	No.	*people*	*years*	*$ per person*	*$ (million)*
15-24	0.3	0.2	45.5	543,289	0.1
25-34	2.8	2.1	35.5	781,233	1.7
35-44	2.8	2.2	25.5	714,207	1.6
45-54	23.4	18.5	15.5	562,034	10.4
55-64	23.4	11.0	5.5	253,685	2.8
Total	**52.6**	**34.0**	**n/a**	**n/a**	**16.5**

Note: (a) Estimated by applying the gender-specific employment-to-population ratio in 2009 (ABS, 2010) to the number of people who die due ESKD and type 2 diabetes in 2010. (b) Estimated as the difference between the midpoint of the age group and 65 years. (c) Discounted to present day at a 7% discount rate (Australian Government, 2010), derived from 2009 average weekly earnings data adjusted to 2010 (ABS 2010; 2010).
Source: Deloitte Access Economics calculations using ABS (2010a; 2010b; 2010c), Australian Government (2010), ANZDATA (2010).

3.3 Informal carer costs

Informal carers provide care to others in need of assistance or support on an unpaid basis. Generally, informal care is provided by family or friends of the person receiving care. While informal care is provided free of charge, it is not free in an economic sense, as time spent caring is time that cannot be directed to other activities such as paid work, unpaid work or leisure.

The level of informal care associated with type 2 diabetes and ESKD depends on whether a person is able to live independently while maintaining an appropriate quality of life. With the onset of ESKD, patients may become frail and lose functional independence, requiring greater physical support from family members (Low et al, 2008).

Informal care needs of ESKD patients increase at older ages. A UK study of 171 dialysis patients aged over 70 years found that 94% received some form of informal care (Grun et al, 2003). However, it is problematic to distinguish care for ESKD from care provided for other age-related comorbidities and frailty.

Treatment modality may influence level of care required by those with ESKD and type 2 diabetes. Two Australian studies found dialysis treatment increased a carer's sense of responsibility for the patient (Wellard and Street, 1999; White and Grenyer, 1999). Additionally, older patients receiving in-centre haemodialysis may require assistance with transportation to treatment centres (Gayomali et al, 2008). A Greek study of 200 haemodialysis patients reported 40.3% of patients were accompanied to hospital by a family member (Kaitelidou et al, 2004). Of these, 50.9% had a paid job and reported a loss of 2.4 hours from work per haemodialysis treatment, three times a week.

In-centre haemodialysis is associated with recovery times during which patients may also need assistance. Gayomali et al (2008) found that it takes an average of six hours for haemodialysis patients to recover post-treatment with elderly patients reporting difficulties until the following day.

A Canadian study found that approximately 7.0% of haemodialysis patients (including home dialysis) and 5.1% of peritoneal dialysis patients required full-time care (Manns et al, 2002). A further 31.0% of haemodialysis and 35.9% of peritoneal dialysis patients required part-time home care. Overall, 7.6% of dialysis patients required full-time care and 30.6% required part-time home care. However, the authors do not clarify the source of care and whether it was informal care.

While providing some autonomy to ESKD patients, home dialysis may require the assistance of relatives to process the dialysis (Peeters et al, 2000). With the introduction of newer, simpler techniques to home dialysis, caregiver burden associated with this modality may be alleviated. A UK study suggests that one hour of carer time is required per home haemodialysis session (Roderick et al, 2005).

Gayomali et al (2008) note comorbidities may further increase the need for informal care if they compromise patients' overall functional and cognitive capacity. For example, Gutman et al (1981) found that dialysis patients without diabetes were more active than dialysis patients with diabetes. Consequently, type 2 diabetes may further increase the need for informal care by CKD patients.

3.3.1 Estimating the cost of informal care

To estimate the cost of informal care for people with CKD and type 2 diabetes, the opportunity cost method was used as it is considered the benchmark (Van den Berg et al, 2006). The opportunity cost method measures the value in alternative use of time spent caring, which is typically valued by productivity losses (or value of leisure time) associated with caring. This is based on the assumption that time spent providing informal care could be alternatively used within the paid workforce or in leisure activities. The value of informal care using the opportunity cost method can be represented as $t_i \times w_i$, where t_i is the time provided by individual i on providing care, and w_i is the net market wage rate of individual i (Van den Berg et al, 2006).

For those who provide informal care but are not in paid work (e.g., children, unemployed or those who have retired) the value of providing informal care is the value of the lost opportunity of undertaking leisure time. This can be approximated by the willingness to pay to undertake leisure, or to avoid work. The value of leisure time is often proxied by an average age and sex specific wage rate (Brouwer and Koopmanschap, 2000; Heitmueller, 2007). If the value of non-work is more (or less) than the average wage rate, the opportunity cost method will under (or over) estimate the value of informal care.

It is problematic to separate the level of informal care attributable to ESKD when the recipient has other comorbidities. Australian Bureau of Statistics (ABS) data from the Survey of Disability Ageing and Carers (SDAC) (ABS, 2004) estimates the level of informal care where a recipient has a 'kidney and urinary system disorder (except incontinence)'. However, available data is based on whether this condition was reported for the care recipient regardless of whether or not it was the main disabling condition. As such, these estimates would not

provide a realistic indication of the level of informal care provided for ESKD and were not employed in this study to value informal care.

To estimate the level of informal care provided to ESKD patients with type 2 diabetes in Australia, results from a Canadian study was employed. Manns et al (2002) estimated the proportion of dialysis patients (including home dialysis) receiving full-time and part-time care. Results are summarised in Table 3.5.

Table 3.5: Care received by dialysis patients

Level of care	Haemodialysis	Peritoneal dialysis	All dialysis
	%	%	%
Full-time care	7.0	5.1	7.6
Part-time care	31.0	35.9	30.6

Source: Manns et al (2002).

There were an estimated 4,378 patients with type 2 diabetes on dialysis in 2010. According to ANZDATA (2010), around 19% of dialysis patients with type 2 diabetes are on peritoneal dialysis and 81% are on haemodialysis. Applying these proportions, there were 827 people with type 2 diabetes on peritoneal dialysis and 3,551 people with type 2 diabetes on haemodialysis.

Kidney transplant recipients may also have reduced physical functioning and need informal care (Matas et al, 1996). However, due to a lack of data and studies on the percentage receiving informal care and hours of care, transplant recipients were excluded from this valuation. This was also on the basis that functioning kidney transplant recipients have significantly improved quality of life and lower restrictions on daily activities and mobility and thus may be less likely to need care than dialysis patients. However, the exclusion of transplant recipients may result in an underestimate of informal care costs.

Manns et al (2002) did not clarify whether care outlined in their study was formal or informal care. From Australian data, 46% of people with severe or profound restriction from disability receive help only from family and friends, 48% receive assistance from family and friends supplemented by formal care services, and 3% receive assistance only from formal services (AIHW, 2004). These ratios were applied to the number of peritoneal and haemodialysis patients with type 2 diabetes to estimate the number receiving informal care (on its own or supplemented with formal care). Estimates are presented in Table 3.6. Overall, there were an estimated 1,587 dialysis patients with type 2 diabetes receiving some informal care in 2009-10.

Table 3.6: Estimated dialysis patients with type 2 diabetes receiving care, 2009-10

	Full-time informal care	Part-time informal care	Full-time formal and informal care	Part-time formal and informal care	People receiving care
	No.	*No.*	*No.*	*No.*	*No.*
Haemodialysis	114	506	119	528	1,268
Peritoneal dialysis	19	136	20	142	319
Total	**134**	**643**	**140**	**671**	**1,587**

Source: Deloitte Access Economics calculations using ANZDATA (2010), Manns et al (2002) and AIHW (2004).

Full-time care was assumed to consist of 40 hours per week, while part-time care was assumed to consist of 16 hours per week. These are the estimated average weekly hours for full-time and part-time work in Australia (ABS, 2010d). Since the split between formal and informal care time was not known for recipients receiving a mixture of formal and informal care, for these recipients it was assumed that care time was split equally between formal and informal care.

Estimated hours of care were valued at the average hourly wage rate for full-time workers in Australia. This rate was estimated by dividing the average weekly full-time wage in Australia in 2009 ($1,219) by estimated full-time weekly hours and inflating to 2009-10 at the labour price index (ABS, 2010b; 2010c). The estimated hourly wage rate was $31.51 in 2009-10.

Estimates of the number of people with type 2 diabetes that are receiving informal care, total hours of care and informal care costs are presented in Table 3.7. Overall, it is estimated that around $38.9 million was incurred in informal care costs in 2009-10.

Table 3.7: Informal care costs for dialysis patients with type 2 diabetes, 2009-10

	People [(a)]	Amount of care [(b)]	Cost
	No.	*Hours (000s)*	*$ (million)*
Haemodialysis	1,268	1,000.4	31.5
Peritoneal dialysis	319	233.7	7.4
Total dialysis	**1,587**	**1,234.1**	**38.9**

Note: (a) Includes both recipients of informal care only and recipients of informal care supplemented with formal care. (b) Estimated by multiplying average weekly hours for full-time and part-time work in Australia (ABS, 2010) by the estimated number receiving informal care only (556) and 0.5 times the number receiving a mixture of formal and formal care (581).
Source: Deloitte Access Economics calculations using Manns et al (2002), ANZDATA (2010), AIHW (2004), ABS (2010b; 2010c; 2010d).

3.4 Transport costs associated with dialysis

International costing studies have included the cost of dialysis transportation (Peeters et al, 2000). A recent Australian survey of 3,250 patients reported on the travel experiences of dialysis patients (KHA, 2011). Of survey respondents who dialyse outside the home, 73% travel to dialysis by car, either driven by themselves or another person. Public transport and volunteer vehicle services were rarely utilised by survey respondents.

Of survey respondents, 1,971 reported on their average weekly spend on dialysis transport. Due to the structure of the survey question (KHA, 2011), it was assumed that reported amounts were out-of-pocket expenditures by dialysis patients and did not include amounts reimbursed by the Patient Assisted Travel Scheme (PATS). Nonetheless, only 1% of survey respondents travelling to dialysis reported living more than 100 kilometres away from dialysis facilities and thus the majority are unlikely to have drawn on the PATS (KHA, 2011). Responses on weekly spend are summarised in Table 3.8.

From ANZDATA, approximately 69.8% of dialysis patients receive hospital or satellite dialysis (ANZDATA, 2010). In the absence of available dialysis location data for people with type 2 diabetes, this distribution was assumed to also apply to these patients.

Table 3.8: Average weekly spend on transport associated with dialysis

Amount	People	Proportion
	No.	*%*
<$10	551	28
$10 - $20	660	33
$20 - $50	538	27
>$50	222	11
Total	**1,971**	**100**

Source: KHA (2011).

Using the estimated number of people with type 2 diabetes on dialysis (4,378 patients) around 3,057 people are estimated to have received hospital or satellite dialysis in 2009-10. The proportion of patients in each spend category (see Table 3.8) was applied to these patients to estimate the number of patients in each category. Transport costs were valued at the midpoint of each spend category, except for the >$50 category, where a weekly spend of $55 was assumed.

Annual transport costs were estimated by multiplying the estimated number of patients with type 2 diabetes and CKD in each weekly spend category by the assumed weekly spend and then multiplying by 52 weeks to derive an annual spend. Calculated transport costs are presented in Table 3.9. It is estimated that just over $3.5 million was incurred in private transport costs for dialysis patients with type 2 diabetes in 2009-10.

Table 3.9: Estimated transport costs for dialysis patients with type 2 diabetes, 2009-10

Average weekly spend	Assumed weekly spend	Proportion of dialysis patients (a)	Estimated number with type 2 diabetes (b)	Total annual transport costs
	$	*%*	*No.*	*$ (million)*
<$10	5	28	855	0.2
$10-$20	15	33	1,024	0.8
$20-$50	35	27	834	1.5
>$50	55	11	344	1.0
Total	**n/a**	**100**	**3,057**	**3.5**

Note: (a) Derived from KHA (2011). (b) Estimated by multiplying the assumed proportions of dialysis patients in each weekly spend category by the estimated number of dialysis patients with type 2 diabetes on satellite and hospital dialysis in 2009-10.
Source: Deloitte Access Economics calculations using ANZDATA (2010) and KHA (2011).

3.5 Deadweight loss

Public funding of direct health care system costs and welfare payments related to CKD in people with type 2 diabetes means that the government must increase tax revenue to achieve a budget neutral position[23]. Consequently taxation rates including income and indirect taxation rates must be higher than they would have otherwise been.

[23] This implicitly assumes funds have not been directed from some other area of the health care system.

Tax and subsidy revenue is not an economic cost but a transfer of payments from one individual to another. It has therefore not been included in this study. However, increasing tax revenue is not frictionless as tax reduces the efficiency with which the economy's resources are used. For example, an increase in income tax rates will increase the relative price of work compared to leisure and therefore create a disincentive to work. Alternatively an increase in sales tax increases the price of goods and services and results in a loss in sales. Consequently there is an associated reduction in consumer and producer surplus, which is known as the deadweight loss (DWL), or excess burden, of tax.

While the costs associated with deadweight loss will depend on the method used to raise additional taxes,[24] the social cost will not be zero and should therefore be included as a cost of CKD for people with type 2 diabetes. The usual assumption in program evaluation is to assume that additional taxes are raised through income tax rate changes, and this is what has been assumed in this study.

Seminal studies that have evaluated the marginal welfare cost of raising additional tax revenue, known as the marginal cost of public funds, mostly relate to the United States (Browning, 1976; Stuart, 1984; Ballard, 1985; Browning, 1987). Estimates have ranged from zero marginal cost to well over 100%. This wide range has been due to alternative models used (partial versus general equilibrium), alternative parameter estimates, and assumptions on the adjustment of employment relative to changes in tax rates (labour supply elasticities).

The rate of deadweight loss used in this report is 27.5 cents per dollar of tax revenue raised plus 1.25 cents per dollar of tax revenue raised for Australian Taxation Office administration, based on Productivity Commission estimates (2003). This equates to a total rate of 28.75%.

In order to calculate the deadweight loss associated with CKD in people with type 2 diabetes, the rate of deadweight loss was applied to the additional revenue raised by government to fund public health care system costs. Approximately 69.7% of health care expenditure is funded publically in Australia (AIHW, 2010). Applying this funding ratio to health care expenditure on CKD patients with type 2 diabetes in 2009-10, this equates to $325.3 million. Applying the DWL rate of 28.75%, the deadweight loss associated with public expenditure was estimated to be $93.5 million in 2009-10.

However, deadweight loss also occurs through raising additional taxation revenue to fund welfare payments. Welfare payments may be received by people with CKD and type 2 diabetes due to their condition. These can include the following.

- **Newstart Allowance (NSA)** which is an activity-tested income support payment for persons looking for work, aged 21 to 64
- **Disability Support Pension (DSP)** which provides income support for those with a physical or mental disability. It is designed for those who are unable to work at least 15 hours per week, at or above the relevant minimum wage, independent of a program or support.
- **Sickness Allowance** is an income support payment for persons aged 21 to 64 who are employed and temporarily unavailable to work due to a medical condition.
- **Travel concessions** include the Patient Assisted Travel Scheme (PATS), which provides assistance for patients in remote and rural areas with access to medical services

[24] In general it is more efficient to place taxes on markets that are relatively inelastic.

including dialysis. Out-of-pocket expenses to patients who travel long distances are reimbursed by this scheme (DoHA, 2010).

Fortnightly welfare payment rates for singles on the DSP, NSA and Sickness Allowance are presented in Table 3.10. In the absence of data on the number of recipients of the NSA, DSP and Sickness Allowance for people with CKD and type 2 diabetes, welfare payment expenditure was calculated based on the 1,310 patients unemployed due to CKD and type 2 diabetes (see Section 3.2.1).

Table 3.10: Centrelink fortnightly payment rates, 2010 [(a)]

Welfare payment	Rate per fortnight
	$
Disability Support Pension – single	644.2
Newstart Allowance – single, no children	462.8
Sickness Allowance – single, no children	462.8

Note: (a) For those aged 21 years and over between 20/03/10 and 30/06/10.
Source: Centrelink (2010).

All unemployed patients are assumed to receive welfare payments. Since the DSP rate is substantially higher than the NSA and Sickness Allowance rates, it was assumed people unemployed due to CKD and type 2 diabetes would apply and receive the DSP.

Multiplying the number of unemployed people by the DSP rate, it is estimated that approximately $22.0 million was spent on welfare payments. This is expected to have resulted in a deadweight loss of approximately $6.3 million in 2009-10.

Adding the deadweight loss associated with publically financing health care and welfare payments, the total deadweight loss due to CKD and type 2 diabetes was estimated to be $99.8 million in 2009-10.

4 Health burden associated with diabetic kidney disease

Diabetic kidney disease can significantly impact a patient's quality of life as the complications associated with both end-stage kidney disease and the progressive nature of type 2 diabetes lead to a loss of wellbeing and in some cases premature death.

This chapter presents a quantitative analysis of the loss of wellbeing and premature death from CKD in patients with type 2 diabetes. It uses a disability adjusted life year (DALY) approach to measuring the loss in the stock of health capital, and applies a value of a statistical life year (VSLY) to monetise the loss.

4.1 Methodology

The 'Burden of Disease' methodology developed by the World Health Organization (WHO) is a comprehensive measure of mortality and disability from diseases, injuries and risk factors for populations around the world in 1990, projected to 2020 (Murray and Lopez, 1996). It uses a non-financial approach, where pain, suffering and premature mortality are measured in terms of Disability Adjusted Life Years (DALYs).

DALYs are a measurement unit that quantify the morbidity aspect as well as the premature death associated with various diseases and injuries (Murray and Acharya, 1997). DALY weights are measured on a scale of zero to one, where a zero represents a year of perfect health and a one represents death. Other health states that result from specific diseases or injuries are given a weight between zero and one to reflect the quality of life that is lost due to a particular condition. For example, a disability weight of 0.2 for people with ESKD is interpreted as a 20% loss in the quality of life relative to perfect health. Disability weights are determined by a reference group convened at the WHO on the basis of a person trade-off method for measuring health state preferences (Murray and Acharya, 1997).

Under the DALY framework, the total burden of disease for an individual with a condition is the sum of the mortality and morbidity components associated with that condition over time, including the years of healthy life lost due to disability (YLDs), and the years of healthy life lost due to premature death (YLLs). Incorporating time preference for health (and thus discounting), this is represented by:

$$DALY_i = \sum_{t=a}^{a+L} \frac{Dw_{i,t}}{(1+r)^{t-a}}$$

where *Dw* is the DALY weight of the condition experienced by individual *i*, *L* is the residual life expectancy of the individual at age *a,* and *t* represents individual years within that life expectancy.

The total burden of disease from a condition on society can be calculated by aggregating DALYs of all individuals with the condition, which can be represented by:

$$DALY_t = \sum_{i=0}^{N_t} DALY_{i,t}$$

where *N* is the prevalence of the condition at time *t*.

In this study the DALY burdens for treated and conservative care are estimated for patients with type 2 diabetes.

Disability weights used to calculate the burden of disease were derived from previous studies on the burden of disease and injury in Australia (Mathers et al, 1999; Begg et al, 2007). These authors used estimated DALY weights by disease course for diabetic kidney disease derived from Murray and Lopez (1996) and Dutch disability weights (Stouthard et al, 1997). Disability weights are presented in Table 4.1 and range from 0.104 for conservative care to 0.29 for ESKD with dialysis or transplant. People with CKD stages one to four were assumed not to experience any disability due to the non-symptomatic nature of CKD in these stages.

Table 4.1: Disability weights for CKD

	Disability weight
ESKD in people with type 2 diabetes	0.290
Transplanted patient	0.110
Conservative care	0.104
CKD stages 1-4	0

Source: Mathers et al (1999).

4.2 Loss in the stock of health capital

YLDs from CKD in patients with type 2 diabetes were calculated by multiplying the appropriate disability weights by the prevalence of treated and conservative care in patients with type 2 diabetes, and the prevalence of transplanted patients with type 2 diabetes. Total YLD was estimated to be 1,561 DALYs in 2009-10 (see Table 4.2).

Table 4.2: Estimated YLDs from CKD in patients with type 2 diabetes in 2009-10

	Prevalence	Disability weight	YLDs
Dialysis patients	4,378	0.29	1,270
Transplant patients	1,488	0.11	164
Conservative care	1,232	0.104	128
CKD stages 1-4	275,048	0.0	0
Total CKD	**282,146**	**n/a**	**1,561**

Source: Mathers et al (1999) and Deloitte Access Economics calculations.

The number of YLLs due to CKD in people with type 2 diabetes was estimated for each age group, using the age distribution of deaths shown in Table 4.3. ABS life tables detail the estimated remaining years of life conditional on a specific age being reached (ABS, 2010). YLLs

were calculated by assuming the midpoint age within each age group as the age of death and discounting remaining years of life by 3%.[25] Total YLL was estimated to be 1,857 DALYs in 2009-10 and are presented in Table 4.3. Total DALYs (YLD and YLL) associated with CKD in patients with type 2 diabetes is therefore estimated to be 3,418 in 2009-10.

Table 4.3: Estimated YLLs from CKD in patients with type 2 diabetes, 2009-10

Age group	Mortality	Life remaining	Discounted YLL
	persons	*years*	*years*
0-4	0	80.0	0
5-14	0.1	73.1	0
15-24	0.1	63.2	7
25-34	2.8	53.5	73
35-44	2.8	43.9	67
45-54	23.4	34.5	503
55-64	23.4	25.4	416
65-74	35.3	17.1	471
75-84	35.3	9.9	301
85+	4.3	4.9	19
Total	**127.4**	**n/a**	**1,857**

Source: ABS (2010e) and Deloitte Access Economics calculations.

The DALY approach is not financial. In order to undertake a cost benefit analysis a monetary conversion of the loss in healthy life is usually performed. This allows the determination of the total cost of a condition and also the comparison of this cost to the benefit from a particular health intervention. The monetary conversion involves applying a value of a statistical life year (VSLY) in perfect health to the total number of DALYs estimated for a particular condition.

Typically, a VSLY is derived from estimates of a willingness to pay for a reduction in the risk of physical harm in the context of OHS policy, transport and airspace regulation and environmental policy. The VSLY essentially estimates how much society is willing to pay to reduce the risk of premature death, expressed in terms of a saving a statistical life year. In this report, a VSLY of $166,604 was used based of Department of Finance and Deregulation (DoFD) estimates (OBPR, 2008).[26]

The cost of the burden of disease due to CKD in patients with type 2 diabetes consists of the burden associated with YLDs and discounted YLLs, and the value society places on a year of perfect health. Using the estimated VSLY, the total cost is estimated to be $569.5 million. This is not a direct cost to the economy in the traditional sense (i.e., a loss in productivity). It is the value of a loss in the stock of health capital.

[25] To estimate the net present value of years of life lost, the Global Burden of Disease study applied a 3% real discount rate to years of life lost in the future (Murray, 1994). Murray (1994) states that this rate is consistent with the long-term yield of investment and was the rate used in the World Bank Disease Control Priorities study. This rate has been applied to discount years of healthy life in this report.

[26] As the recommended DoFD figure ($151,000) is expressed in 2007 prices, the VSLY was inflated to 2010 prices using an average inflation rate of 3% (ABS, 2010f).

5 Cost effectiveness of screening for CKD in patients with type 2 diabetes

The impact of diabetic kidney disease on a patient's quality of life can be reduced through early diagnosis and treatment. Although treatment cannot increase kidney function it can significantly slow the progression of diabetic kidney disease, thereby potentially avoiding end stage kidney (ESKD) and renal replacement therapy (RRT).

This chapter investigates the cost effectiveness of providing annual opportunistic general practitioner (GP) screening for CKD in patients with type 2 diabetes. Drawing on extensive Australian literature, it outlines the type and cost of screening that could be employed for people with type 2 diabetes, and the potential cost effectiveness of a screening program with subsequent treatment using ARBs or ACE inhibitors. Applying cost effectiveness results to the current population with diagnosed type 2 diabetes, the chapter provides an estimate of the potential initial and ongoing benefits and costs of an Australian wide screening program.

5.1 Screening for CKD

Although people are screened for CKD in Australia there is currently no systematic screening program. The asymptomatic nature of CKD in the early stages means the prevalence of early stage CKD is therefore severely underreported, and many people are not aware that they are suffering from CKD until they have end stage kidney disease (ESKD) when it is too late to undertake preventative treatment. For these people, renal replacement therapy (RRT), either through dialysis or kidney transplant, is their only treatment option. However, both options have high cost consequences through loss in patient quality of life, health care resources and economy at large.

Several tests can be used to screen for CKD. One is to use a dipstick to test for urine protein concentration (proteinuria), which is relatively cheap and quick. Proteinuria is a key marker of kidney damage and an increased level of protein in the urine directly relates to CKD progression (KHA, 2007). However the sensitivity of dipsticks may lead to a large proportion of false positives and the requirement for additional testing using other methods. For example, Craig et al (2002) report a sensitivity of around 90% at a specificity of 67%.[27]

Another method is to measure the ratio of protein to creatinine, which is recommended if the patient tests positive for proteinuria (KHA, 2007). This test is more expensive and more invasive than a urine dipstick test, however it has a higher sensitivity and specificity. For example, Craig et al (2002) found the protein to creatinine ratio test had a sensitivity and specificity of 95% and 91% respectively.

[27] Sensitivity refers to the capacity of the test to correctly identify people with CKD, while specificity refers to the capacity of the test to correctly identify people without CKD (Jaar et al 2008).

Screening for CKD in people with type 2 diabetes aims to determine the presence of abnormal levels of urine albumin excretion and declining glomerular filtration rate (GFR) (CARI, 2009), with the former assessed either through measuring the albumin excretion rate (AER) or the albumin creatinine ratio (ACR). People with diabetes should have at least one albumin to creatinine ratio test per year using an early morning spot urine sample (KHA 2007; CARI 2009). This is to test for microalbuminuria and macroalbuminuria, which is a strong predictive factor for progressive CKD and an increased risk of CVD.

If an initial screening test result is positive for microalbuminuria, one or two additional ACR or AER measurements should be performed within three months (CARI, 2009). If there is another positive result then microalbuminuria is confirmed. If the test result is positive for macroalbuminuria, a 24 hour urine collection test should be undertaken to quantify protein excretion.

Methven et al (2011) undertook a retrospective study that assessed patient records from a hospital kidney clinic in Glasgow, Scotland for a median of 3.5 years to test whether measuring proteinuria or albuminuria was more appropriate for detecting CKD. The authors found they had equally predictive power in measuring renal outcomes and mortality in patients with CKD. Furthermore, spot urine tests for proteinuria and albuminuria had the same predictive power for patient outcomes compared to the equivalent 24 hour urine protein and albumin tests. However, these results must be interpreted with caution as patients within the sample generally had non-diabetic kidney disease.

There are other tests for CKD. Serum creatine concentration can be used to measure the trend in kidney function over time, but it is unreliable for testing early stage CKD as patients can lose half of their kidney function before a serum creatine concentration detects a problem (KHA, 2007).

In 2005, the Australasian Creatinine Consensus Working Group recommended that the estimated glomerular filtration rate (eGFR) be reported with serum creatine test results for adults (Mathew et al, 2007). This has increased awareness of ESKD and increased the detection of early cases of people with high risk of developing ESKD (Mathew et al 2007; Mathew and Corso 2009). In Australia eGFR tests rely on the modification of diet in renal disease (MDRD) formula, which is based on a blood test result of serum creatinine and adjusts for age and gender.

Although the eGFR is seen as the best measure of kidney function, it may not provide an accurate indication of CKD in some groups. For example, Mathew et al (2007) note that a stable eGFR value between 45-59 mL/min/1.73m^2 in people aged 70 years and over may represent a typical eGFR if proteinuria and haematuria are not present. Furthermore, the MDRD formula has not been validated for some ethnic groups, such as Aboriginal and Torres Straight Islanders, Maori and Pacific Islanders.

There have been two pilot studies on CKD screening in Australia. Thomas et al (2006) evaluated data from the National Evaluation of the Frequency of Renal Impairment cO-existing with Non-insulin dependent diabetes (NEFRON) study. This study randomly selected 348 GPs who were asked to estimate kidney function and the severity of CKD in 10 to 15 consecutively presenting patients with type 2 diabetes. Data collection was undertaken between April and September 2005 and resulted in 3,893 patients.

The authors found that GPs were able to recognise a creatine clearance of <60mL/min in over 83% of the patients assessed (with a specificity of around 90%), and were able to identify impaired kidney function in over 70% of patients. However, only 24% of patients with type 2 diabetes had their kidney function routinely assessed by the GP, and those with impaired kidney function were no more likely to have their creatine clearance routinely monitored. This is despite evidence to suggest type 2 diabetes is a high risk factor in developing CKD, and that impaired kidney function leads to adverse outcomes. Thomas et al (2006) concluded there was an over-reliance on measuring unstandardised creatine clearance levels by GPs, resulting in the exclusion of age, sex and body mass in the assessment of impaired kidney function.

Mathew et al (2010) evaluated community and workplace screening for CKD through a pilot program known as Kidney Evaluation for You (KEY). This program provided free screening for kidney damage in three Australian communities (Townsville, Roxby Downs and Perth) over a week in 2007. In order to test for CKD, five point-of-care testing devices were used to determine blood cholesterol, creatinine, HbA1c, haemoglobin and urine ACR. The test required a trained operator, took 10 minutes and could test 30 people per day.

KEY program participants must have exhibited at least one specified CKD risk factor to be eligible for screening. This resulted in 402 study participants. Around 84% of the sample was aged greater than 50 years, while 18% and 35% had previously been diagnosed with diabetes and hypertension respectively. Approximately 85% reported having regular contact with a GP, while 90% had seen a GP in the last six months.

Mathew et al (2010) found approximately 20% of participants were found to have CKD that was previously undiagnosed. Of these people, 48% were categorised as having stage three CKD, 1% stage four CKD, and none were found to have ESKD. The results also suggest people are unaware of the asymptomatic symptoms of CKD. Only 14% of participants were aware that 90% of kidney function could be lost before symptoms occur.

The authors conclude that the screening program was successful in detecting undiagnosed CKD and providing the impetus to address management of CKD risk factors with the assistance of GPs. However, measuring the full impact of the screening program was problematic as health outcomes were not determined. Furthermore, results could not be generalised to the Australian population due to potential sample selection bias.

Mathew and Corso (2009) reviewed the World Health Organization's (WHO) principles of screening for disease, and applied these principles to justify establishing CKD screening in Australia. Table 5.1 shows that all WHO principles for screening disease would be satisfied if a CKD screening program were implemented in Australia. Similar conclusions have been found in the United States (Jaar et al, 2008).

Mathew and Corso (2009) conclude that a CKD screening program should target people with diabetes and hypertension aged 60 years and over to reduce screening costs without commensurate reductions in detected cases. Screening should be conducted using a urine dipstick for protein measurement, serum creatine measurement, urine albumin to creatine ratio, and blood pressure measurement. Treatment should aim to reduce urine albumin excretion and the risk of cardiovascular mortality. This is also supported by Thomas et al (2008). Mathew and Corso (2009) conclude that the best screening model seems to be opportunistic screening delivered within a general practice.

Table 5.1: WHO principles of screening applied to CKD in Australia

Principle	Justification
The condition should be an important health problem	CKD imposes a significant health care cost through direct health care system costs (e.g., RRT) and indirect costs (see Chapter 2 and 3). It also plays a role in premature CVD morbidity and mortality
There should be a recognisable latent or early symptomatic stage	CKD is asymptomatic until stage 5, but earlier stages can be detected through easy to administer tests.
The natural history of the condition should be adequately understood	Risk factors for CKD are well established, along with their incidence and prevalence. Factors that impact the progressive decline in kidney function are also well known.
There should be a suitable test or examination	Tests for identifying CKD are simple and relatively inexpensive. Examples include a urine dipstick test and a protein to creatine ratio test.
The test should be acceptable to the population	Tests for CKD are relatively simple. Collection of urine and blood samples is routine within diagnostic testing.
Systems should be in place for evidence based follow up for people with a positive result.	Management of CKD would be undertaken through primary health care (e.g. GPs), which are highly accessible to nearly all the population.
There should be an acceptable treatment for patients with recognised disease	Guidelines for management of CKD in general practice has already been determined and published (see KHA 2007).
There should be an agreed policy on whom to treat as patients	There is agreed consensus that people with CKD risk factors (e.g. diabetes and hypertension) should be screened. More work is needed in determining an appropriate treatment path for people aged 75 years and over with no risk factors and mild reduction in eGFR.
Facilities for diagnosis and treatment should be available	Treating CKD in the early stages requires treatment with ARBs or ACE inhibitors, which is similar to CVD treatment.
The cost of case findings should be economically balanced with possible expenditure on medical care	Cost-effectiveness for CKD screening has been found in three recent Australian studies (see Section 5.2).
Case findings should be a continuing process and not a 'once and for all' project	The risk of developing CKD increases with age. Furthermore, the increasing diabetes trend in Australia suggests the prevalence of CKD will continue to increase.

Source: Deloitte Access Economics based off Mathew and Corso (2009).

5.2 Potential cost effectiveness of CKD screening in people with type 2 diabetes

Early treatment using ACE inhibitors or ARBs can reduce the progression of CKD to ESKD, thereby avoiding significant health care costs, indirect costs, and poor health outcomes. This is especially the case for people with type 2 diabetes, as the likelihood of CKD is much greater. For example, Chadban et al (2003) found that the prevalence of proteinuria was four times greater in people with diabetes in the AusDiab study.

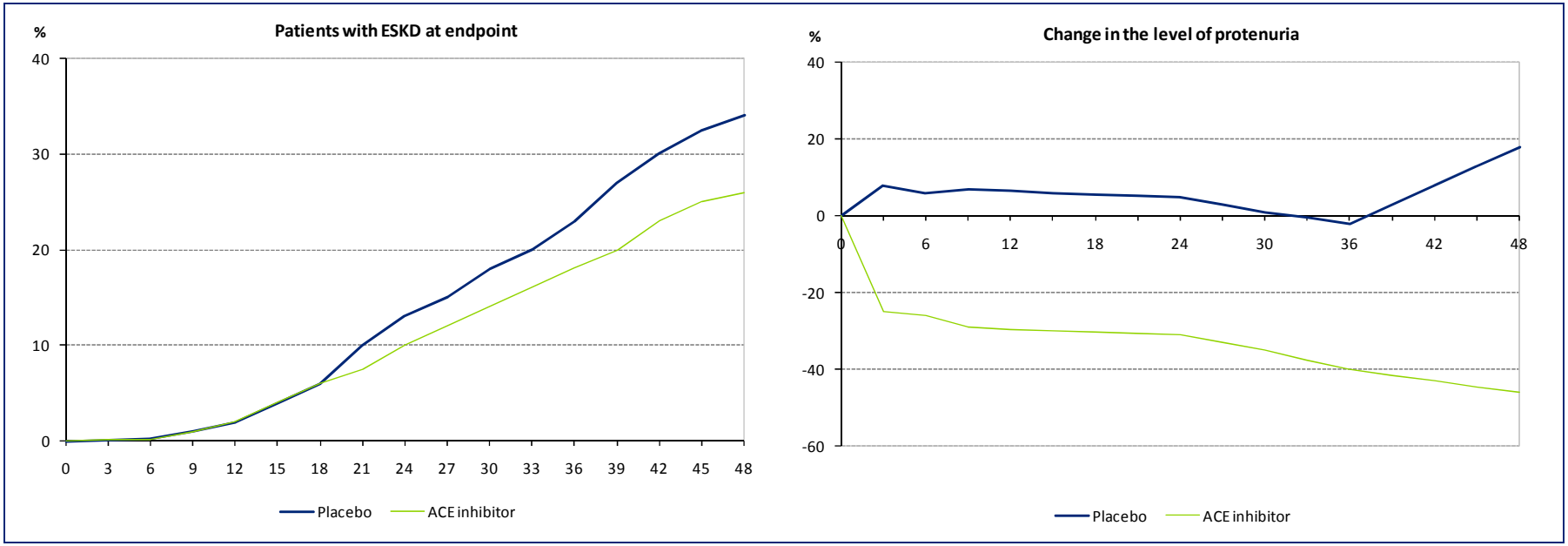
Reduced progression to ESKD in people with type 2 diabetes and nephropathy using ARBs was demonstrated by Brenner et al (2001). The authors used a double blind randomised placedo controlled study to randomly assigning losartan or a placebo once daily to 1,513 patients around the world. Study participants were followed for a mean of 3.4 years with a range of 2.3 years to 4.6 years. Primary outcomes were a doubling of serum creatine concentration, ESKD or death.

Brenner et al (2001) found that people with type 2 diabetes and nephropathy who received ARB treatment had a 28% reduction in the risk of developing ESKD after four years compared to the placebo group. Furthermore, the median change in the baseline level of proteinuria was around 35% for the group that received ARB treatment, and over 40% at end point, whereas the placebo group experienced an increase in the level of proteinuria. Overall, ARB treatment reduced the rate of decline in renal function by around 18%. The Kaplan-Meier curve for ESKD, and the median change in the baseline level of proteinuria are shown in Chart 5.1. Similar treatment effects have been found in other studies (Lewis et al 2001; Parving et al 2001).

The increase in CKD incidence and prevalence and the potential avoided costs associated with early detection and antihypertensive treatment has prompted several studies on the cost effectiveness of screening for chronic kidney disease in Australia (Craig et al 2002; Higashi 2010; Howard et al 2006; Howard et al 2010). All have found CKD screening to be extremely cost effective.

Craig et al (2002) estimated the cost effectiveness of screening in Australia using a single dipstick test applied to people over the age of 50 years. The authors assumed the screening test was opportunistic, and based their model on an assumed ESKD incidence of 200 per million. Those who returned a positive result were assumed to be treated with perindopril (4mg) for 20 years. They found that a one-off dipstick test would prevent 205 cases of ESKD. Given the cost of ESKD was estimated to be $50,000 per person per year, the authors concluded that the screening program would be cost effective up to a point where the cost of a dipstick test were $2, which was four times greater than their estimated true cost.

Chart 5.1: Impact on progression towards ESKD from early treatment using ARBs



Note: ARB treatment had a 28% reduction in the risk of developing ESKD after four years compared to the placebo group. Furthermore, the median change in the baseline level of proteinuria was around 35% for the group that received ARB treatment, and over 40% at end point, whereas the placebo group experienced an increase in the level of proteinuria.
Source: Brenner et al (2001).

Howard et al (2006) estimated the cost effectiveness of early detection and intervention to prevent the progression of CKD in Australia. The authors assumed the screening test was opportunistically applied to the Australian population aged 25 years and older, and those who tested positive for proteinuria were placed on an intensive treatment program using ACE inhibitors. The test initially involved a dipstick test, but a protein to creatinine ratio test was used if a positive result was found. It was also assumed that all known people with diabetes were placed on an intensive treatment program using ACE inhibitors.

Using the Australian Diabetes, Obesity and Lifestyle (AusDiab) sample to represent Australian population characteristics, a Markov model with Monte Carlo simulation, and transition probabilities extracted from randomised controlled trials, Howard et al (2006) estimated the mean incremental cost effectiveness ratio (ICER) to be $2,854 per life year saved (LYS) and $3,577 per quality adjusted life year (QALY). For screening up to 79 years, the authors estimated the mean cost effectiveness to be $4,146 per LYS and $5,152 per QALY. Assuming a cost effectiveness threshold of $50,000 per LYS, screening for proteinuria was 61% likely to be cost effective for screening people aged up to 69 years.

Howard et al (2006) also found that proteinuria screening and subsequent ACE inhibitor treatment for all know people with diabetes and people who tested positive to proteinuria prevents significant reductions in ESKD prevalence and deaths. On average over 46 years this includes:

- 2,149 cases of ESKD requiring RRT; and
- 13,391 deaths comprising:
  - 13,842 fewer deaths from CVD;
  - 1,244 more deaths from non-CVD causes due to longer life span and competing disease and conditions;
  - 778 fewer deaths from kidney failure; and
  - 21 fewer deaths due to complications with kidney transplants.

Howard et al (2010) updated their modelling and estimated the ICER to be $4,793 per QALY for screening 50-69 year olds with diabetes. They also calculated that for every 1,000 patients with diabetes screened for proteinuria and treated with an ACE inhibitor, and treating all people with diabetes with an ACE inhibitor, there would be:

- three less deaths from cardiovascular disease;
- one less death from non-cardiovascular disease; and
- three patients that would avoid RRT.

The authors concluded that testing for proteinuria should be ‘strongly considered’.

Higashi (2010) has also investigated the potential cost effectiveness of interventions for kidney disease. Among other interventions, the author specifically investigated the cost effectiveness of an opportunistic GP screening program for people aged 25 to 79 years. It was assumed the screening involved an initial urine dipstick test for proteinuria, and those returning positive results had their protein to creatinine ratio tested, along with an ultrasound of the kidneys and a full blood examination. Treatment for CKD positive

patients was assumed to involve life-long therapy using ACE inhibitors, which was also allowed to have a positive impact on the risk of heart attack and stroke.

Higashi (2010) applied a Markov model with Monte Carlo simulation to six target populations (general, indigenous remote and indigenous non-remote, with and without diabetes) with three age groups (25-39 years, 40-49 years and 50-79 years). The population was based on the Australian / Indigenous burden of disease study (Begg et al, 2003), while the prevalence of protein and albuminuria was derived from AusDiab (Dunstan et al 2001; Barr et al 2006).

Higashi (2010) estimated that targeting the population with diabetes or people aged 50 years and over has a 100% probability of being cost effective. Targeting the general population with diabetes who are aged between 50-79 years accrues more health benefits at a lower cost than standard treatment. Targeting the general population with diabetes who are aged between 40-49 years and 25-39 years was estimated to cost $4,000 per disability adjusted life year (DALY) and $8,000 per DALY respectively. Even better results were estimated for the non-remote indigenous population.

The author recommended that CKD screening to be implemented for people with diabetes at all age groups, and for indigenous people without diabetes at all age groups. It was also recommended that CKD screening to be implemented to people aged 50 years and over who do not have diabetes.

5.3 Potential benefits and costs of a CKD screening program in people with type 2 diabetes

Expected benefits and costs from a screening program if applied to the current population of people with type 2 diabetes was estimated from cost effectiveness results presented by Howard et al (2010). The authors developed a complex Markov model to determine the cost effectiveness in Australia of a screening program for proteinuria and an ACE inhibitor or ARB treatment in all known people with diabetes and people who screened positive to proteinuria. They estimated the cost per QALY as $4,781 for screening people with diabetes aged between 50-69 years. This included the cost of the screening program and the cost of treatment. The results are presented in Table 5.2, with costs updated to 2010 dollars.[28]

Although there is evidence to suggest a large proportion of people with diabetes are unaware of their condition (Dunstan et al, 2001), an opportunistic screening program would be delivered only to those people who have been diagnosed with type 2 diabetes. Thus the total benefit from a screening program will depend on the cost effectiveness of the program and the number of people diagnosed with type 2 diabetes but undiagnosed with CKD.

[28] The inflation rate applied was 3.2% per annum, the annual rate of health inflation between 1998-99 to 2008-09 (AIHW, 2010).

Table 5.2: Results of screening for CKD in people with type 2 diabetes, 2010

	Mean cost	QALY	ICER
	$	*No.*	*$ per QALY*
Intervention	18,078	12.763	5,092
Comparator	17,915	12.731	n/a
Difference	163	0.032	n/a

Note: Relates to screening people aged 50 to 69 years for proteinuria and an addition of an ACE inhibitor in all known people with diabetes and screen detected patients with proteinuria.
Source: Deloitte Access Economics calculations using Howard et al (2010).

To estimate diagnosed type 2 diabetes prevalence rates in 2010, average growth in diagnosed type 2 diabetes was applied to estimated prevalence rates from the National Health Survey (NHS) (ABS, 2009). Rates were multiplied by AE-DEM population estimates to determine prevalence.[29]

Prevalence rates and estimated prevalence for diagnosed type 2 diabetes by age and gender are presented in Table 5.3. The prevalence of diagnosed type 2 diabetes in people aged 50-69 years was estimated to be 452,642 in 2010. Of this, 289,122 were male and 163,521 were female. The age bracket with the largest number of people with diagnosed type 2 diabetes is 65-69 years for males (92,395 people) and 60-64 years for females (43,194 people).

Table 5.3: Estimated prevalence rate and prevalence of diagnosed type 2 diabetes, 2010

	Prevalence rate		Prevalence		
Age group	Males	Females	Males	Females	Persons
years	*%*	*%*	*No.*	*No.*	*No.*
50-54	6.8	5.1	49,033	38,034	87,066
55-59	9.6	6.4	62,873	42,970	105,843
60-64	14.0	7.1	84,821	43,194	128,015
65-69	20.5	8.6	92,395	39,323	131,718
Total	n/a	n/a	289,122	163,521	452,642

Note: Estimated diagnosed type 2 diabetes prevalence rates were derived by applying average annual growth rate of type 2 diabetes (between NHS 2001 and NHS 2007-08) to prevalence estimates from the 2007-08 NHS. Prevalence was derived by applying estimated prevalence rates to population estimates for 2010.
Source: Deloitte Access Economics calculations using ABS (2003; 2006; 2009).

Not all people with type 2 diabetes have CKD. Furthermore, a proportion of people with type 2 diabetes are already diagnosed with CKD, and therefore do not require CKD screening. For example, people already being treated for ESKD (either through RRT or conservatively) would not participate in a screening program, nor would people with a functioning kidney transplant. These people would already have their kidney function

[29] AE-Dem is an in-house population model created and maintained by Access Economics. Building up from the demographic 'first principles' of births, deaths, migration and household formation, the model projects population by age and gender for each State and Territory. Data is derived directly from publically available Australian Demographic Statistics, sourced from the Australian Bureau of Statistics (ABS).

routinely monitored. Furthermore, some people would be using ARBs or ACE inhibitors for comorbidities such as CVD, heart failure or an eye or foot condition. Finally, not people eligible for screening will be screened. Some people may decline to participate, while others may not be offered the screening program due to lack of awareness by their GP.

As Howard et al (2010) accounts for these factors in their Markov model, their cost effectiveness estimates were applied to the estimated diagnosed type 2 diabetes population. Using incremental cost and QALYs it is estimated that an opportunistic proteinuria screening program and subsequent ARB or ACE inhibitor treatment for diagnosed people with diabetes and people who tested positive to proteinuria aged 50-69 years would result in 14,485 QALYs. In addition, there is expected to be:

- 1,811 fewer deaths, consisting:
  - 1,358 fewer deaths from CVD causes; and
  - 453 fewer deaths from non CVD causes.
- 1,358 fewer people requiring RRT.

Australians with type 2 diabetes aged between 50-69 years should have their kidney function tested annually as a preventative measure to assist with delaying / reducing kidney function decline and to address the medical and economic burden associated with the progression of both chronic kidney disease and type 2 diabetes.

The improved health associated with avoiding ESKD would come at an additional health care system cost of $73.8 million. This represents a long term cost over the lifetime of people screened and not a screening cost as a large proportion of cost is associated with treatment. For example, Howard et al (2010) note the cost of a dipstick is $1, while the total cost of a GP consultation would be $34.90 (although it could be argued this should not be included as a cost of screening as the test is opportunistic, which means the cost effectiveness of screening would be even better).[30] For those who return a positive screening result, there is an additional consultation cost and a protein to creatine ratio test that cost $11.75.[31]

The only additional cost would occur from screening new people with diabetes each year. Using the incidence rates for people aged 50-69 years derived from the updated AusDiab study (Barr et al, 2006) there were approximately 47,378 new cases of diabetes in 2010.[32] Consequently, incremental costs for the screening program and subsequent treatment with ARBs or ACE inhibitors are estimated to be around $7.7 million, with an expected benefit of an additional 1,516 QALYs and 190 fewer deaths.

[30] Consultation cost is based on Medicare Benefit Schedule (MBS) Item 23 as at 14 February 2011.

[31] Protein to creatine ratio test is based on MBS Item 66500 as at 14 February 2011.

[32] Barr et al (2005) does not differentiate between type 1 and type 2 diabetes. However, a large majority of new diabetes cases are expected to be type 2 given the population is aged 50-69 years.

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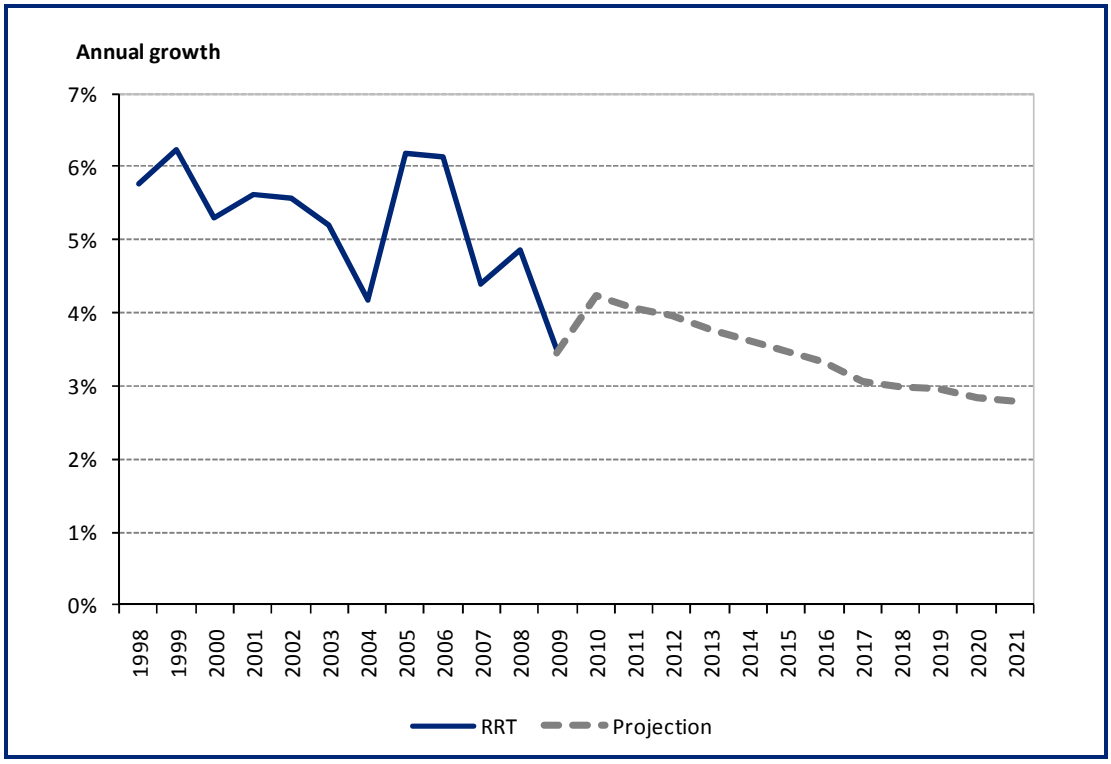
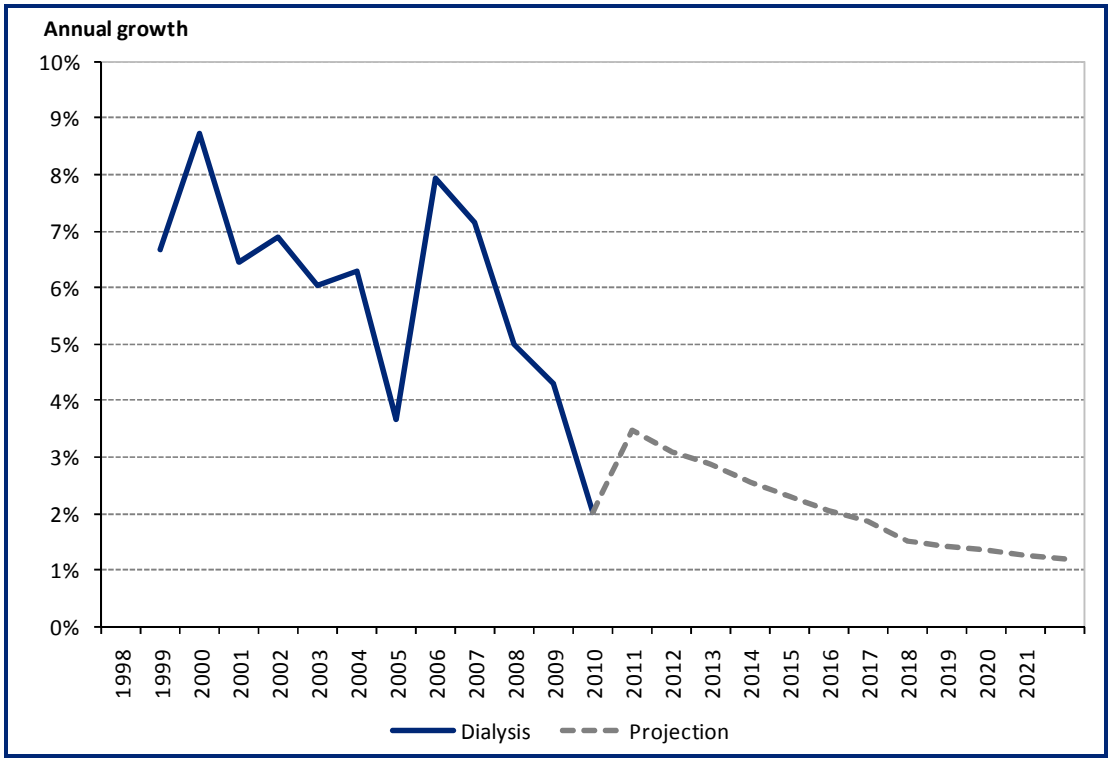
Appendix A – Projected growth in RRT and dialysis

Chart A.1: Estimates and projections of annual growth in people on RRT in Australia.



Note: Includes people on dialysis and people with a transplant.
Source: Deloitte Access Economics projections using ANZDATA (2010).

Chart A.2: Estimates and projections of annual growth in people on dialysis in Australia



Source: Deloitte Access Economics calculations based on ANZDATA (2010).

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