Deloitte Access Economics

Socioeconomic cost of macular degeneration in New Zealand

Macular Degeneration New Zealand

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MACULAR DEGENERATION NEW ZEALAND

Deloitte.

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Glossary

AMD	age-related macular degeneration
ARM	age-related maculopathy
AREDS	Age-Related Eye Disease Study
AWE	average weekly earnings
CNV	choroidal neovascularisation
DALY	disability adjusted life year
DHB	District Health Board
EDS	early disease stage
PAF	population attributable fraction
PBS	Pharmaceutical Benefits Scheme
RPE	retinal pigment epithelium
VPDT	vertepofin-photodynamic therapy
VEGF	vascular endothelial growth factor
VSL(Y)	value of a statistical life (year)
YLD	year of healthy life lost due to disability
YLL	year of life lost due to premature death

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Executive summary

Age-related macular degeneration (AMD) is the most common cause of visual impairment in people over the age of 50 years in developed countries (Worsley and Worsley, 2015). In New Zealand, it is the most common cause of blindness contributing to 50% of all blindness. AMD is strongly associated with ageing, and as such, the prevalence of AMD has been projected to increase by more than 13% between 2014 and 2026 (Worsley and Worsley, 2015).

AMD progressively destroys the macula (the central portion of the retina), impairing central vision and affecting quality of life and independence. AMD can be classified into the early (typically not visually impairing) and late (visually impairing) stages.

- 'Early' AMD is defined by the development of soft drusen or pigment changes at the macula without atrophy or choroidal neovascularisation (CNV). Early AMD may be associated with early changes in reading or central vision, but does not typically result in vision loss.
- 'Late' AMD includes both neovascular (wet) AMD and geographic atrophy. Population-based studies indicate that approximately two-thirds of late cases are neovascular and one-third are atrophic.
    - Neovascular (wet) AMD is characterised by the appearance of blurring of the central vision and distortion with straight lines appearing crooked or wavy, with or without a dark or blank patch. Perception of colours is also often affected.
    - Geographic atrophy reduces capacity for near visual tasks as central vision becomes severely impaired.

For this report, the following definitions of visual impairment are used:

- blindness (severe vision loss) is defined as best-corrected visual acuity of <6/60 in the better-seeing eye.
- moderate vision loss is defined as best-corrected visual acuity of <6/18 to 6/60 in the better-seeing eye; and:
- mild vision loss is defined as best corrected visual acuity of <6/12 to 6/18 in the better seeing eye.

The report considers the socioeconomic impact of visual impairment resulting from late AMD. Furthermore, the distinction between neovascular AMD and geographic atrophy is only made for the cost-effectiveness of anti-vascular endothelial growth factor (anti-VEGF) treatments. The report also outlines the prevalence of early AMD to highlight the total population at risk of developing more advanced AMD.

Prevalence of AMD

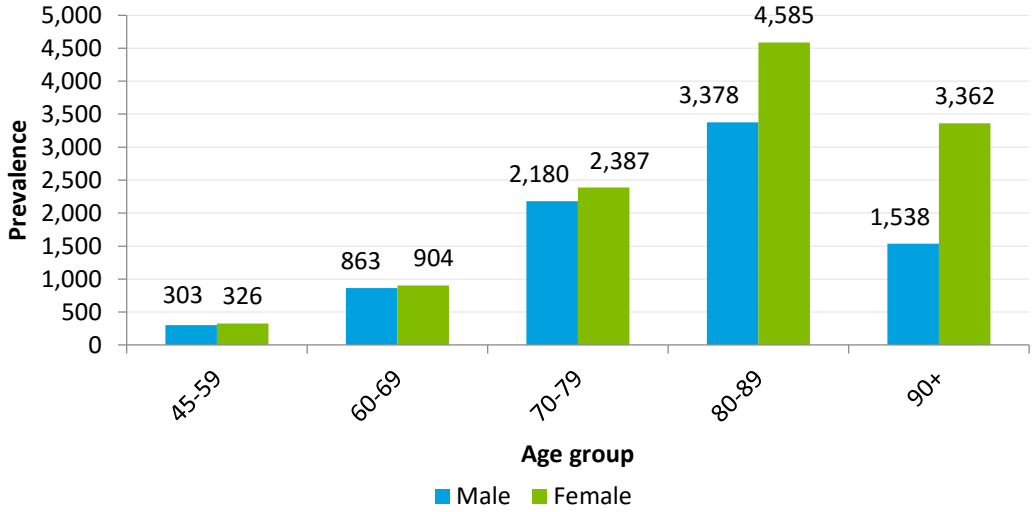
Both early and late types of AMD are relatively common in New Zealand.

The prevalence of any AMD was estimated to be present in 218,987 people in New Zealand in 2016, of which an estimated 199,140 cases were of early AMD (people at risk of developing vision loss from AMD).

Some 7.6% of people with any AMD in New Zealand have vision loss from it, an estimated 19,825 New Zealanders in 2016[1], of which around 24% are cases of blindness. The overall prevalence of vision loss from AMD represents 1.1% of all people who are 45 years or older.

Prevalence of vision loss from AMD was estimated to be higher among females (11,564 people) than males (8,262) – owing to the greater underlying female population in older age groups. Prevalence increases with age until around 7.6% of all people who are 80 years of age or older have at least mild vision loss from AMD. Prevalence by age and gender is shown in Chart i.

Chart i: Prevalence of vision loss from AMD by age and gender



Source: Deloitte Access Economics calculations based on Wong et al (2014).

Costs associated with vision loss due to AMD

The costs of vision loss due to AMD comprise economic costs (financial components of gross domestic product), as well as loss of wellbeing (healthy life). Economic costs comprise health system costs, productivity losses, informal care costs, other financial costs such as aids, modifications and equipment, and deadweight losses associated with transfer payments. New Zealand estimates specific to AMD were used to estimate these costs wherever possible, although it was also necessary to rely on some international literature.

[1] Throughout this report, 2016 refers to the period July 2015 through June 2016. Components of early and late AMD do not sum to the total reported due to slight revisions in the Statistics NZ population estimates – noted in chapter 2.

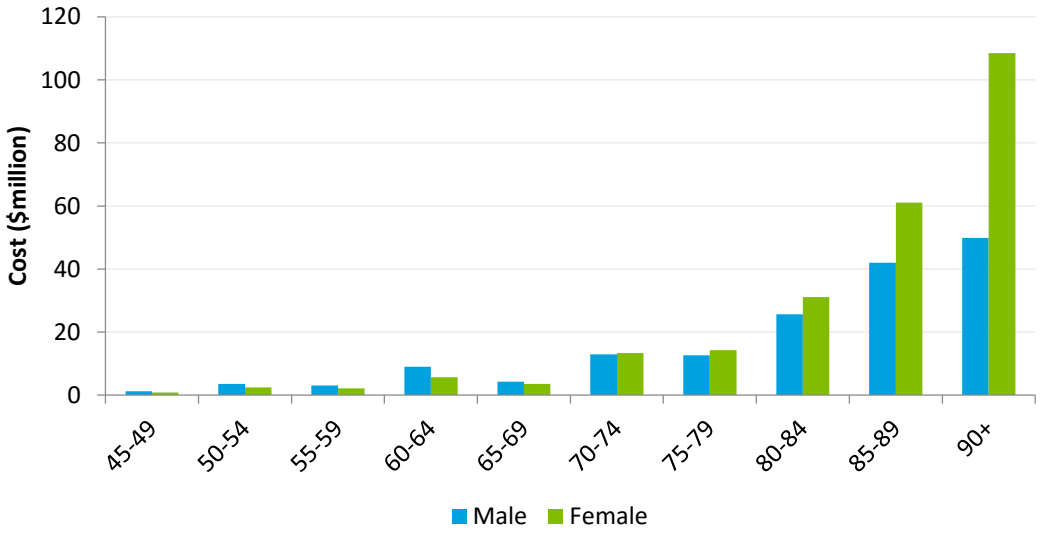
The total cost of vision loss from AMD was estimated to be $391.1 million in 2016, or $19,727 per person with AMD. Of the total cost, the economic costs were $89.6 million ($4,521 per person), and the value of lost wellbeing was $301.5 million ($15,207 per person). Health system expenditure represented the largest component (63%) of economic costs.

Blindness from AMD was estimated to contribute $216.6 million, or $45,677 per person with blindness. This represented 55% of the total costs due to AMD in 2016, and was comprised of $28.2 million in economic costs as well as $188.4 million in loss of wellbeing.

In addition to economic costs, the loss of wellbeing was estimated to cost an additional 1,800 disability adjusted life years (DALYs). The loss of wellbeing costs account for around 77% of the total costs associated with vision loss from AMD in New Zealand in 2016.

Females bore the highest costs associated with vision loss from AMD largely due to the higher underlying population, and therefore prevalence, in older age groups (Chart ii).

Chart ii: Total costs associated with vision loss from AMD in New Zealand, 2016



Source: Deloitte Access Economics.

Cost effectiveness of anti-VEGF treatments

Cost effectiveness of treatment

The total cost of anti-VEGF treatment was estimated using the number and cost of injections in 2016. For all age groups, the total cost of anti-VEGF injections was estimated to be $3.3 million. After receiving appropriate treatment, individuals in each vision loss severity classification would have improved visual acuity, reducing the number of cases of vision loss.

Deloitte Access Economics estimated the potential savings associated with anti-VEGF treatments for AMD. Overall:

- the total benefit of using anti-VEGF treatment if all neovascular AMD was treated was estimated to be $125.6 million;
- the cost effectiveness of using anti-VEGF treatments was estimated to be $5,803 per DALY averted, which is considered very cost effective based on World Health Organization benchmarks; and
- it is noted that the overall cost may be higher than estimated due to time spent administering injections, which are not included in this analysis or for the subsequent analyses.

Cost effectiveness of timely and adequate treatment

Timely treatment is essential to slow the progression of disease to prevent associated costs that may affect an individual's quality of life. For example, timely and adequate treatment can prevent substantial healthcare and other costs from medical events such as falls, hip fractures, depression and social dependence. Timely treatment is estimated using data on optimal treatment intervals, which found that injections should be administered less than 5.3 weeks apart (Gillies et al, 2015). When this occurs, the number of injections is halved compared to treatment intervals greater than 5.3 weeks.

Deloitte Access Economics estimated the benefits associated with timely and adequate anti-VEGF treatment for AMD. Overall:

- the total benefit of timely and adequate anti-VEGF treatment of individuals was estimated to be $75.1 million in 2016; and
- the cost effectiveness of timely and adequate anti-VEGF treatment regimes was estimated to be $8,210 per DALY averted, which is considered to be very cost effective on World Health Organization benchmarks.

AMD imposes substantial economic and loss of wellbeing costs on New Zealand society, estimated to be $391.1 million in 2016. Ensuring all New Zealanders with neovascular (wet) AMD are able to access timely and adequate treatment has a relatively small cost – approximately $3.3 million given current treatment patterns. This can be less costly than allowing AMD to progress, worsening visual acuity, which results in increased healthcare costs and other costs for individuals including carer time.

Overall, New Zealand society could expect to avert around 340 DALYs, and receive benefits of approximately $75.1 million if timely and adequate treatment occurs. Noting that only mild and moderate cases can receive timely and adequate treatment, the costs were estimated to be around $2.8 million. With current treatment patterns, society may forgo as much as $72.3 million in net benefits.

Cost effectiveness of awareness raising campaigns

Cost effectiveness of awareness

Awareness raising campaigns are aimed at increasing the number of individuals with AMD receiving timely treatment, which can prevent further degradation of visual acuity. Historically, awareness and education of AMD has been driven by Macular Degeneration New Zealand, who are the national charity for AMD.

Total costs of awareness raising campaigns were derived from Macular Degeneration New Zealand accounts and were estimated to be $1.2 million for the two years 2015 and 2016, including pro-bono support. The benefits of awareness were based on an efficacy rate of 11%. In other words, an 11% increase in awareness was assumed to translate to an 11% increase in early treatment. The 11% increase in awareness was based on the Galaxy survey results provided by Macular Degeneration New Zealand. Overall:

- the total benefits of awareness raising campaigns were estimated to be $6.4 million; and
- the cost effectiveness of awareness raising campaigns was estimated to be $42,062 per DALY averted, which is considered cost effective based on World Health Organization benchmarks.

Net benefits and cost savings from increased awareness to Australian levels

By increasing the level of awareness in New Zealand to that of Australia, it is possible that additional cases of AMD will be detected earlier than before, meaning that damage to the eyes can be minimised.

An increase in awareness and education of AMD to the level of awareness in Australia was estimated to provide total benefits of $13.5 million in 2016. Macular Degeneration New Zealand estimates that it will cost around $4.9 million to increase awareness levels to Australian levels, based on the awareness and education campaigns conducted by their Australian counterparts. Investing $4.9 million in awareness and education would require substantial funding from other parties, including government and private sector.

> Investing $4.9 million in awareness and education would require substantial funding from other parties, including government and private sector. An increase in awareness and education of AMD would lead to reduced burden of AMD through timely and adequate provision of treatments.
>
> Investing $4.9 million is expected to increase awareness of AMD in New Zealand by approximately 23%, which is estimated to provide benefits of $13.5 million in 2016. As such, current levels of awareness and investment would forgo approximately $8.5 million of net benefits for New Zealand society.

1 Background

AMD is the late stage of age-related maculopathy (ARM) and the most frequent cause of major visual impairment in people aged over 50 years in developed countries (The Eye Disease Prevalence Research Group, 2004). This chapter presents a formal definition of AMD and categorises AMD into four distinct categories based on the clinical presentation and severity of AMD features.

1.1 Definition and symptoms of AMD

AMD is an eye disease that usually develops in people aged 50 years or older. AMD progressively destroys the macula (the central region of the retina) and thereby impairs central vision. Deterioration of the macula will cause progressive vision loss in the centre of the field of vision. AMD may affect one or both eyes.

AMD can be classified as either 'early AMD' or 'late AMD'. Early AMD is defined by the presence of soft drusen of pigment changes at the macular without atrophy or CNV while late AMD includes geographic atrophy and neovascular (wet) AMD. These classifications are based on the disease progression and characteristics of the disease within the eye (National Health Committee, 2015).

In early AMD, abnormalities develop in the retinal pigment epithelium (RPE) and lipid deposits (drusen) form underneath the RPE and within Bruch's membrane[2]. As AMD progresses, the macula deteriorates and may break down. Patients with early AMD either have drusen at least 125 microns in diameter present in the central retina, or have RPE abnormalities, or both. Early AMD is more common than late AMD, and only a small proportion of early AMD patients will progress to late AMD.

Late AMD is caused by abnormal growth of choroidal blood vessels (CNV) under the retina which leak blood and proteins into the macular region. This leads to detachment of either the RPE or sensory retina by blood and fluid, and subsequently to scarring and eventual atrophy, mostly with severe vision loss or blindness.

Two types of late AMD are neovascular AMD and geographic atrophy. **Neovascular (wet) AMD** is characterised by the appearance of central visual blurring or distortion (metamorphopsia), with straight lines appearing crooked or wavy with or without blank areas (scotoma) (American Academy of Ophthalmology, 2008). Colour perception can also be affected. **Geographic atrophy**, the alternate form of late AMD, is characterised by light-sensitive cells in the macula slowly breaking down (located directly under the RPE) and becoming atrophic with complete loss of the RPE and of adjacent choroidal elements with marked choroidal thinning. People with geographic atrophy usually also have extensive medium-sized drusen, often with a crystalline or calcified appearance, and at least one or

[2] Bruch's membrane is the innermost layer of the choroid. The choroid is the layer between the white of the eye (sclera) and the inner surface of the eye (retina).

more large drusen (125 microns in diameter) in one or both eyes (American Academy of Ophthalmology, 2008).

A person with early AMD may not experience any vision loss. However, a person with late AMD will experience visual symptoms including distortion of straight lines, a dark or greyish patch in the central visual field (scotoma), a sudden change in vision or a significant decrease in visual acuity in the affected eye.

1.2 Visual impairment and blindness

Visual impairment can be broadly defined as a limitation in one or more functions of the eye or visual system, most commonly impairment of visual acuity (sharpness or clarity of vision), visual fields (the ability to detect objects to either side, or above or below the direction of vision) and colour vision.

One measure used to determine visual impairment is the Snellen scale which defines normal vision as 6/6, (20/20 in Imperial/US measures). The first number is the furthermost distance at which the person can clearly see an object, and the second number is the distance at which a person with normal vision could see the same object. For example, 6/12 vision means that the person can clearly see at six metres (but not more), an object that a person with unimpaired vision could see at 12 metres (but not more) (Taylor et al, 2005).

LogMAR is another scale that is expressed as the logarithm of the minimum angle of resolution. It measures visual acuity loss, where positive values indicate vision loss, while negative values denote normal or better visual acuity. This scale is most frequently used in statistical calculations (and cost savings) because it provides a more scientific equivalent for the traditional clinical statement of 'lines lost' or 'lines gained', which is valid when all steps between lines are equal. Each increase of 0.1 units on the logMAR scale indicates a one line loss on the visual acuity chart. (Mallah et al, 2000). LogMAR charts are now increasingly preferred to the traditional Snellen chart because they are more sensitive to small changes, have an ordered progression of letter size (with five equally readable letters per line), are more reproducible and enable close comparisons with published trial data.

Table 1.1 shows the typical severity stages of visual impairment mapped to the different stages of AMD. As noted in the table, blindness is defined as those who have greater than or equal to 6/75 on the Snellen scale, greater than or equal to +1.1 on the LogMAR scale and less than or equal to 45 on the letter count scale.

The legal definition of vision loss varies internationally, however it is generally accepted that vision loss refers to best-corrected visual acuity of <6/12 in developed countries (Dandona and Dandona, 2006; Taylor et al, 2005; Congdon et al, 2004).

For this report, the following definitions of visual impairment are used:

- blindness (severe vision loss) is defined as best-corrected visual acuity of <6/60 in the better-seeing eye.
- moderate vision loss is defined as best-corrected visual acuity of <6/18 to 6/60 in the better-seeing eye; and:
- mild vision loss is defined as best corrected visual acuity of <6/12 to 6/18 in the better seeing eye.

Blindness can also be characterised by visual field defects close to central vision (within the central 5 degrees), which is not accounted for by measuring visual acuity (NZ Transport Agency, 2015). Mild and moderate vision loss can also be defined by limitations in the field of vision. The limitation for mild vision loss is greater than 60 degrees, but worse than 100 degrees in diameter, while the limitation for moderate vision loss is worse than 60 degrees but greater than 10 degrees in diameter (International Council of Ophthalmology, 2002).

Table 1.1: Comparison of AMD stages with Snellen measure of visual impairment

Classification	Severity	Snellen (6 m)	LogMAR	Letter count
No AMD and early stage AMD	Normal	6/3.0	-0.3	-
		6/3.8	-0.2	110
		6/4.8	-0.1	105
		6/6.0	0	100
		6/7.5	+0.1	95
		6/9.5	+0.2	90
Late stage AMD	Mild	6/12	+0.3	85
		6/15	+0.4	80
	Moderate	6/19	+0.5	75
		6/24	+0.6	70
		6/30	+0.7	65
		6/38	+0.8	60
		6/48	+0.9	55
		6/60	+1.0	50
	Severe (Blindness)	6/75	+1.1	45
		6/95	+1.2	40
		6/120	+1.3	35

Source: Deloitte Access Economics (2011).
Note that the categorisation of AMD stages is not based on visual acuity. Many individuals have different levels of visual impairment (or even no impairment) at different stages.

1.3 Treatment and prevention

This section discusses the treatment options available for patients who have AMD as well as potential prevention strategies.

1.3.1 Progression and prevention

Progression from early to late AMD can occur rapidly in some people (Wang et al, 2007). On average, about 4% of people with early AMD progress to late AMD each year, while about 10-15% of geographic atrophy cases progress to neovascular AMD (National Health Committee, 2015). The progression rate from mild to moderate visual impairment is around 32% and from moderate to severe visual impairment is around 46% over two to three years, without treatment (Wang et al, 2007).

It is well recognised that delayed treatment can increase the risk of vision loss due to AMD (Schalnus et al, 2010; Gonzales et al, 2005; Arias et al, 2009; Oliver-Fernandez et al, 2005). As some people with AMD may experience vision loss within three months, it is critical that treatment can be accessed early as this can stabilise vision and prevent further vision loss (Rosenfeld et al, 2006).

Several factors have been identified in the literature that can increase the risk of developing AMD and increase the speed at which the disease progresses. This includes ageing, genetics, smoking and dietary factors. Control of modifiable risk factors could reduce the risk of developing AMD by up to 45% (Tomany et al, 2004).

Dietary antioxidants also play an important role and there is recent evidence to suggest that diets with lower than average dietary glycaemic index may reduce the risk of developing early and late AMD. Since there is currently no effective treatment for geographic atrophy, prevention is the first approach to reducing vision loss and the associated burden on society (Coleman et al, 2008).

1.3.2 Treatment of early, intermediate AMD

People with early or intermediate AMD are primarily cared for by optometrists. There are no treatment options for early AMD; instead, the main focus for people with early AMD is to modify diet and other lifestyle factors, such as smoking cessation. Patients with early AMD are encouraged to regularly monitor their symptoms and present to a medical professional if they have deterioration in their vision.

People with geographic atrophy (late, atrophic AMD) may be recommended Age-Related Eye Disease Study (AREDS) supplements, which are antioxidant vitamins and minerals that are known to reduce the risk of progression to a more advanced stage of geographic atrophy or wet AMD (Yu et al, 2014).

Antioxidant supplement therapy can also be useful for people with intermediate AMD (presence of soft drusen) in reducing the progression to more advanced AMD. This is dependent on screening and early detection of AMD – i.e. while the patient is still asymptomatic (Chew et al, 2015). The main reason people reported for not using antioxidant therapy was that they were unaware that it was available (Yu et al, 2014).

Therapies are not yet available for geographic atrophy; however, some novel therapies such as 2RT laser are under evaluation, including in phase 3 trials. The 2RT trial uses ultra-short duration laser to slow or halt the progression of AMD (Macular Disease Foundation Australia, 2015).

People with advanced or symptomatic late geographic atrophy are normally provided low vision or Blind Foundation services (National Health Committee, 2015).

1.3.3 Treatment of wet AMD

Treatment for wet AMD needs to commence rapidly after a wet AMD diagnosis has been made due to the quick progression of wet AMD which can result in vision loss. Treatment will be offered to wet AMD patients if there is evidence of CNV activity or progression.

Treatment is not beneficial if there is permanent structural damage with atrophy to the central macular retinal photoreceptors and/or subretinal scarring.

For patients with wet AMD, the first-line treatment is intravitreal injection of anti-VEGF agents. These injections slow the loss of vision and can improve vision for some patients.

Three anti-VEGF agents are funded in New Zealand[3], these are ranibizumab (Lucentis) bevacizumab (Avastin), and aflibercept (Eylea). These treatments bind to and neutralise the biological activity of human VEGF. Aflibercept (Eylea) is a fully human fusion protein that binds all forms of VEGF-A and the related Placental Growth Factor, which also contributes to the development of abnormal blood vessels. Ranibizumab and aflibercept were developed specifically to treat wet AMD, while bevacizumab was primarily developed for treatment in cancer patients.

PHARMAC provides recommendations on the use of the anti-VEGF agents. Currently, bevacizumab is recommended as first line of treatment because it is substantially cheaper than ranibizumab or aflibercept – bevacizumab costs less than $100 per injection compared to $1,250 for ranibizumab or $1,650 for aflibercept (PHARMAC, 2016a).

Ranibizumab and aflibercept will only be used if treatment with bevacizumab proves ineffective following at least three intraocular injections, the patient has a severe inflammatory response following treatment with bevacizumab, or if the patient recently had a stroke or myocardial infarction. Aflibercept would only be used if ranibizumab has also proved ineffective after three intraocular injections (PHARMAC, 2016a).

All three agents have been found to have similar degrees of effectiveness (CATT Research Group, 2011; Heier et al, 2012). Michels et al (2005) evaluated the short-term safety of systemic bevacizumab and its effects on visual acuity and CNV in patients with neovascular AMD. Significant increases in visual acuity were evident within one week of treatment, and by 12 weeks, the median and mean visual acuity letter scores increased by eight letters ($P = 0.011$) and 12 letters ($P = 0.008$), respectively. While in major randomised clinical trials, ranibizumab has been shown to be a safe and clinically effective treatment for wet AMD with around 95% of the participants who received monthly injections maintaining their vision (Bradley, 2007).

If the patient responds to a particular anti-VEGF agent and is improving, the treatment will be continued until the lesion becomes atrophic or an inactive scar. If the patient does not respond to a particular anti-VEGF agent, then they will be trialled on other anti-VEGF agents. If the patient does not respond to any anti-VEGF treatment and it is deemed unlikely they will benefit from treatment, they will be discharged and receive low vision rehabilitation or blindness support.

Historically laser photocoagulation and vertepofin-photodynamic therapy (vPDT) were used to treat wet AMD; however, these two treatments are no longer part of the standard model of care (National Health Committee, 2015). vPDT involves two steps; firstly, the drug Visudyne (verteporfin) is injected into the bloodstream which targets the abnormal area of retina. The second step is activating the drug with a laser. Once the drug is activated it blocks

[3] At the time of writing this report, ranibizumab and aflibercept would be listed as second and third line treatments from 1 November 2016 pending finalisation by PHARMAC.

the abnormal blood vessels. On some occasions, vPDT will be used in addition to anti-VEGF treatments, to treat the polypoidal choroidal vasculopathy variant of AMD.

Laser photocoagulation involves use of a concentrated light beam of high-energy thermal light at the retina. This will then destroy any abnormal blood vessels, along with any adjacent blood vessels. This treatment will only be used when there is a small, well-defined lesion well away from the fovea (National Health Committee, 2015).

1.4 Risk factors

A number of risk factors have been identified which increase the risk of AMD, including age, genetics, and smoking, which are the strongest risk factors in that order. Although people may have one or more risk factors, this does not mean they will develop AMD. Conversely, AMD can arise even in the absence of known risk factors. In general; however, the more risk factors a person has, and the greater severity of each risk factor, then there is an increased likelihood of developing AMD.

Age is the strongest risk factor for both geographic atrophy and wet AMD, a universal finding in all AMD studies (e.g. Mitchell et al 1995; Smith et al, 2001; Bird et al, 1995; Klein et al, 1992; Klein et al, 2004; Wong et al, 2006; Schmidt et al, 2006).

The proportion of variation in AMD across populations also appears to be influenced more by **genes** rather than environmental (non-genetic) factors. For example, a family history of AMD was found to result in approximately a four times greater risk of late AMD (Smith and Mitchell, 1998). Genetic factors hypothesised to increase the risk of developing AMD include: genes associated with the complement cascade (Edwards et al, 2005); the chromosome 10q locus (DeWan et al, 2006); other major genetic loci (Chen et al, 2010); gene-environment interactions (specifically with smoking, Schmidt et al (2006)); and pharmacogenetic relationships (Brantley et al, 2009).

Smoking is the main modifiable (able to be changed) risk factor for AMD (Klein et al, 1993; Smith and Mitchell, 1996; Vingerling et al, 1996; Klein, 2007). A dose-response relationship has been observed in many studies whereby increasing odds are associated with a greater number of pack-years[4] smoked (Klein et al 2002; Tan et al 2008). This and other data suggest that cessation of smoking may be associated with a reduced subsequent risk. Some studies (Mitchell et al 2002; Tan et al 2008; Klein et al 2002) have also shown that current smokers develop late AMD 5 to 10 years earlier than never (or past) smokers.

Another identified risk factor for AMD is **suboptimal nutrition**. Many consistent studies now support the concept that suboptimal nutrition is an important, modifiable risk factor for the development of AMD, and a large randomised clinical trial has confirmed the benefits of reducing AMD progression from a high dose zinc and antioxidant supplement (AREDS 2001). Research confirms a role for dietary antioxidants, particularly for zinc, but also potentially for Vitamin C and Vitamin E (van Leeuwen et al, 2005). Dietary antioxidants play an important role in the occurrence, prevention and treatment of AMD. Some foods such as spinach, egg yolks, seafood (especially oysters), seeds, nuts, whole grains and fatty fish can potentially decrease AMD risk by up to 65% (Tan et al, 2008).

[4] The total time smoked (years) by the usual daily cigarette-equivalent intake, divided by 20.

Other factors that are thought to increase the risk of AMD include alcohol consumption (Smith et al, 1996), hypertension (Klein et al, 2003), obesity (Peeters et al, 2008) and ocular factors such as iris colour, and various types of cataract and cataract surgery (Lavanya et al, 2010). Although extensive research has been conducted on each of these risk factors, the relationship between each of them and AMD is not firmly established.

2 Epidemiology of AMD

This chapter outlines the prevalence and mortality estimates for AMD in New Zealand. As AMD is a relatively common condition, there are high quality studies available which provide detailed prevalence estimates. That said, few sources were found to be specific to New Zealand and international literature providing ethnicity breakdowns was used to estimate the prevalence of AMD in New Zealand.

Key findings:

- The prevalence of visual impairment due to AMD was estimated to be 19,825 people in New Zealand in 2016, or 1.1% of all people who are 45 years or older. Prevalence increases with age until approximately 7.6% of all people have at least mild visual impairment due to AMD (80+ years old).
- It is estimated that visual impairment due to AMD may have contributed to 61 deaths in New Zealand in 2016. These deaths result from factors such as an increased risk of falls, isolation and depression in those with visual impairment.

2.1 Prevalence of AMD

There are no recent population-based prevalence studies of AMD in New Zealand (Worsley and Worsley, 2015). As such, it is necessary to extrapolate prevalence from international literature. The prevalence estimated in this report uses the same methodology as that employed by Worsley and Worsley (2015), with a few minor differences, which are outlined in the following sections.

The most recent analysis of the prevalence of AMD was conducted by Wong et al (2014). Wong et al (2014) conducted a systematic review of population-based studies to estimate the prevalence of AMD. Their analysis provided breakdowns by four major ethnic groups, six regions, and gender.

Wong et al (2014) used the following definitions of early and late AMD:

> *"Early disease was defined as either any soft drusen (distinct or indistinct) and pigmentary abnormalities or large soft drusen 125 µm or more in diameter with a large drusen area (>500 µm diameter circle) or large soft indistinct drusen in the absence of signs of late-stage disease. Late age-related AMD was defined as the presence of any of the following: geographic atrophy or pigment epithelial detachment, subretinal haemorrhage or visible subretinal new vessel, or subretinal fibrous scar or laser treatment scar." (pp. e107)*

The total prevalence was estimated for people who were 45 to 85 years old during the study period. The global prevalence of late AMD was estimated to be 0.37%, and early AMD was estimated to be 8.01%. Prevalence was estimated to be higher for European ancestry and Oceania or European regions.

The prevalence rates by ethnicity and by 10 year age group to age 79 and for the 5-year age group 80-84 were taken from the supplement to Wong et al (2014). As the meta-analysis by

Wong et al (2014) did not provide sufficient detail to estimate the prevalence rates in people who are 85 years old or older, literature was used to impute unadjusted odds ratios for 85-89 and 90+ age groups which could be applied to these age groups. Applying unadjusted odds ratios from literature to these age groups may result in discrepancies between the true and estimated number of people with AMD in these age groups. However, it is important to estimate the overall impact of AMD from a socioeconomic perspective as prevalence approximately doubles in this age group.

Data from Owen et al (2012) show that the prevalence of any type of AMD in these age groups is approximately 1.89 and 3.85 times greater than the prevalence rate for the 80-84 age group, respectively. The application of these ratios is shown in Table 2.1. These imputed rates should be treated with some caution.

Table 2.1: Proportion (%) of people with AMD by ethnicity group

Type	European	Asian	All groups
Early AMD			
45-49	3.67 (2.28 - 5.76)	2.89 (1.67 - 4.80)	3.53 (2.34 - 5.25)
50-59	5.86 (3.83 - 8.83)	4.29 (2.60 - 6.98)	5.39 (3.64 - 7.93)
60-69	10.40 (7.06 - 14.95)	7.01 (4.36 - 11.12)	9.04 (6.20 - 12.92)
70-79	17.68 (12.32 - 24.42)	11.27 (6.97 - 17.46)	14.71 (10.18 - 20.83)
80-84	24.91 (17.58 - 33.65)	15.44 (9.43 - 23.56)	20.26 (14.10 - 28.33)
85-89	47.09 (33.23 - 63.61)	29.19 (17.83 - 44.54)	38.3 (26.65 - 53.56)
90+*	95.89 (67.67 – 100.00)	59.43 (36.3 - 90.69)	77.99 (54.28 – 100.00)
Late AMD			
45-49	0.03 (0.02 - 0.06)	0.06 (0.03 - 0.11)	0.05 (0.03 - 0.08)
50-59	0.10 (0.06 - 0.16)	0.14 (0.08 - 0.24)	0.13 (0.08 - 0.18)
60-69	0.41 (0.27 - 0.60)	0.41 (0.27 - 0.63)	0.42 (0.30 - 0.57)
70-79	1.71 (1.17 - 2.44)	1.26 (0.79 - 1.96)	1.41 (1.00 - 1.92)
80-84	4.56 (2.96 - 6.73)	2.69 (1.56 - 4.61)	3.25 (2.21 - 4.60)
85-89	8.62 (5.60 - 12.72)	5.09 (2.95 - 8.71)	6.14 (4.18 - 8.70)
90+	17.55 (11.39 - 25.91)	10.35 (6.00 - 17.75)	12.51 (8.51 - 17.71)

Source: Deloitte Access Economics calculations based on Wong et al (2014) and Owens et al (2012).
Note: Credible intervals are reported by Wong et al (2014) for 45 to 84 year old age groups. For 85 and over, the credible intervals represent the same odds ratios applied to the upper and lower credible intervals of the 80-84 age group. This may lead to statistical discrepancies; although, these would be immaterial for the findings and conclusions that are based on these results. * It is not possible for the proportion to exceed 100%, so the upper credible intervals assume this maximum.

These prevalence rates were applied against the New Zealand population by age, gender and ethnicity group (Statistics NZ, 2015). The targeted literature review conducted for this study did not identify any population-based studies in New Zealand that specifically estimated prevalence of AMD in Māori or Pacific Islander people.

Prevalence in Māori and Pacific Islander people was therefore assumed to be zero, or insignificant against the totals presented here. This follows the methodology of Worsley and Worlsey (2015), which noted that there are no published or anecdotal cases of AMD in Māori or Pacific Islander people.

Table 2.2 presents the prevalence of early AMD and late AMD by age and gender. **There were estimated to be 19,847 cases of late AMD and 199,140 cases of early AMD.** This was derived by multiplying the European or other and Asian population in New Zealand by the respective rates shown in Table 2.1.

Table 2.2: Prevalence of AMD by type, age and gender

Age/ gender	Early AMD	Late AMD	Overall
Male			
45-59	18,600 (11,933 - 28,498)	303 (182 - 505)	18,903 (12,115 - 29,003)
60-69	21,226 (14,332 - 30,714)	863 (568 - 1,268)	22,088 (14,900 - 31,982)
70-79	22,382 (15,519 - 31,080)	2,180 (1,485 - 3,124)	24,561 (17,004 - 34,205)
80-89	18,479 (12,990 - 25,056)	3,378 (2,186 - 5,008)	21,857 (15,177 - 30,064)
90+	8,453 (5,954 – 8,874)	1,546 (1,002 - 2,287)	9,999 (6,956 – 11,162)
Total	89,139 (60,728 – 124,222)	8,270 (5,424 - 12,193)	97,409 (66,152 – 136,415)
Female			
45-59	19,787 (12,679 - 30,353)	326 (195 - 544)	20,112 (12,874 - 30,897)
60-69	22,179 (14,968 - 32,114)	904 (595 - 1,330)	23,083 (15,563 - 33,443)
70-79	24,507 (16,992 - 34,032)	2,387 (1,626 - 3,421)	26,893 (18,618 - 37,453)
80-89	25,076 (17,640 - 33,981)	4,585 (2,969 - 6,792)	29,661 (20,609 - 40,773)
90+	18,453 (13,000 - 24,969)	3,376 (2,188 - 4,992)	21,828 (15,188 - 29,961)
Total	110,001 (75,278 – 149,838)	11,577 (7,574 - 17,079)	121,579 (82,852 – 166,917)
Person	**199,140 (136,007 – 274,060)**	**19,847 (12,998 - 29,271)**	**218,987 (149,004 – 303,331)**

Source: Deloitte Access Economics calculations based on Wong et al (2014) and Owens et al (2012).
Note: components may not sum exactly to totals due to rounding. Credible intervals are reported by Wong et al (2014) for 45 to 84 year old age groups. For 85 and over, the credible intervals represent the same odds ratios applied to the upper and lower credible intervals of the 80-84 age group. This may lead to statistical discrepancies; although, these would be immaterial for the findings and conclusions that are based on these results.

It is important to note that the prevalence of AMD by type, age and gender are estimates, and the intervals surrounding this may also be plausible estimates. For the purposes of this report, the intervals surrounding the estimates provided by Wong et al (2014) were not used in subsequent sections. Consequently, the results presented in subsequent sections and chapters should be interpreted with this in mind.

2.2 Prevalence of vision loss from AMD

Not all early and late AMD results in vision loss, and the resulting socioeconomic costs of vision loss. **It was assumed that no vision loss occurs in early stages of AMD as per Deloitte Access Economics (2011).**

As such, it was necessary to adjust the prevalence of all types of AMD to vision loss resulting from AMD. Owen et al (2003) provided rates of vision loss for partial sight (<6/18 and >6/60), partial sight/blindness (<6/60 and >3/60) and blindness (<6/60). Overall, these categories represented around 50% of total late AMD cases. The remaining cases were assumed to

represent mild vision loss (<6/12). The shares calculated from Owen et al (2003) are presented in Table 2.3.

Table 2.3: Severity share (%) of total vision loss from AMD by age

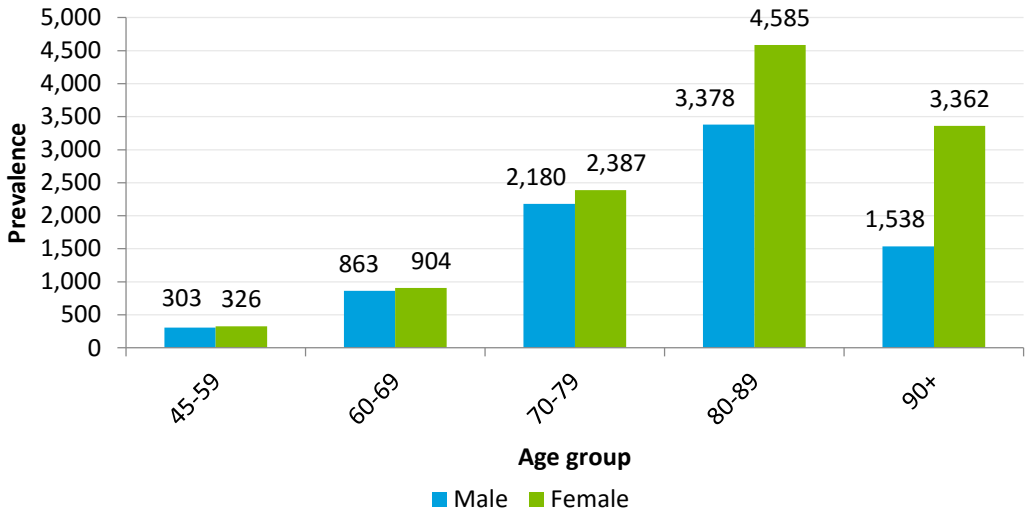
Age	Mild (<6/12)*	Moderate (<6/18 and >6/60)	Severe (<6/60)
45-49*	100	0	0
50-54*	100	0	0
55-59*	100	0	0
60-64	100	0	0
65-69	77	23	0
70-74	75	16	9
75-79	56	27	17
80-84	52	25	22
85-89	38	30	32
90+	30	30	40

Source: Deloitte Access Economics calculations.
* Calculated as the residual of total prevalence of late AMD minus the sum of partial sight (<6/18 to 6/60) and blindness (<6/60) based on Deloitte Access Economics (2011).

Prevalence rates of vision loss from AMD were calculated from the data in Table 2.1, Table 2.2 and Table 2.3 and these rates were then applied to the New Zealand population for 2016 (Statistics NZ, 2016), which are slightly different from the demographic data used to calculate cases of AMD in Table 2.2 as there have been small revisions to the population estimates since the projections by ethnicity were published. Hence the revised estimate is slightly lower for late AMD than the 19,847 cases estimated in Table 2.2.

Overall, there were estimated to be 19,825 people who have some form of vision loss associated with AMD in New Zealand in 2016. The overall prevalence and number of people who have vision loss from AMD in New Zealand is shown in Chart 2.1. Vision loss from AMD increases with age in line with late AMD prevalence. There are substantially more cases of vision loss for females who are more than 90 years of age, which reflects the greater number of females who are alive in this age group.

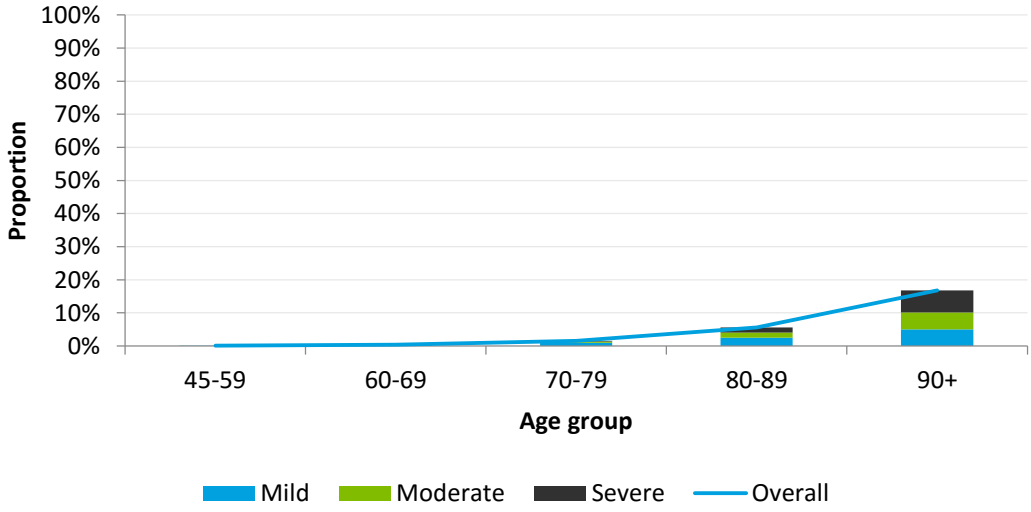
Chart 2.1: Prevalence and rates of vision loss from AMD by age and gender



Source: Deloitte Access Economics calculations based on Wong et al (2014).

The prevalence rates for mild, moderate and severe vision loss from AMD are shown in Chart 2.2. The total prevalence of vision loss from AMD was estimated to be 1.1% – mild, moderate and severe (blindness) were estimated to be 0.5%, 0.3% and 0.3%, respectively.

Chart 2.2: Prevalence rates of vision loss from AMD by age and severity



Source: Deloitte Access Economics calculations based on Wong et al (2014) and Owens et al (2003).

Table 2.4 summarises the number of cases by severity, age and gender. There were estimated to be 8,262 males who have some form of vision loss from AMD and 11,564 females who have some form of vision loss. There were estimated to be 4,743 people with AMD who are blind as a result of the condition in New Zealand in 2016.

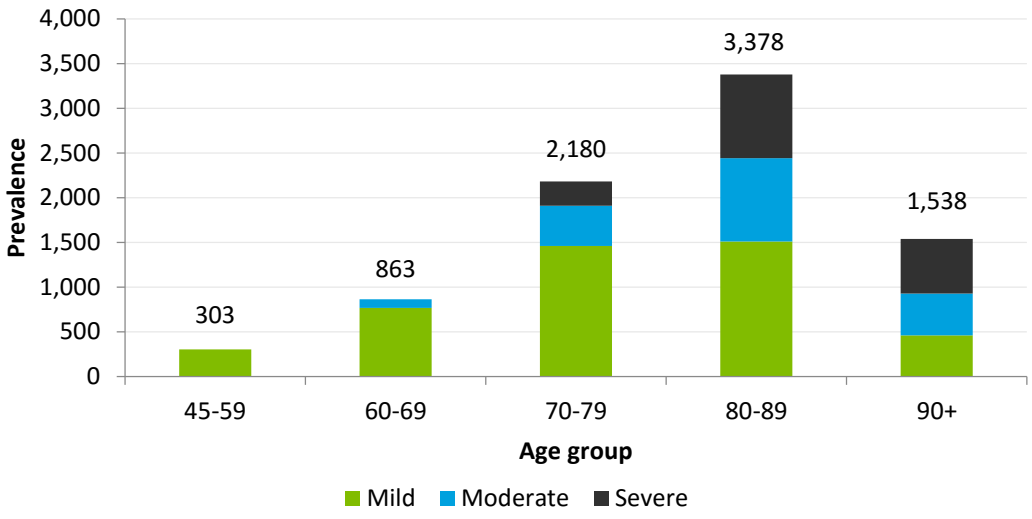
Table 2.4: Prevalence of vision loss from AMD by age, gender and severity

Age/gender	Mild	Moderate	Severe	Overall
Male				
45-59	303	0	0	303
60-69	767	95	0	863
70-79	1,459	449	272	2,180
80-89	1,509	933	936	3,378
90+	460	467	611	1,538
Male total	4,499	1,945	1,818	8,262
Female				
45-59	326	0	0	326
60-69	805	99	0	904
70-79	1,591	495	300	2,387
80-89	2,021	1,275	1,289	4,585
90+	1,006	1,021	1,335	3,362
Female total	5,748	2,891	2,925	11,564
Persons total	**10,247**	**4,836**	**4,743**	**19,825**

Source: Deloitte Access Economics calculations based on Wong et al (2014), Owens et al (2003) and Owens et al (2012).
Note: components may not sum exactly to totals due to rounding.

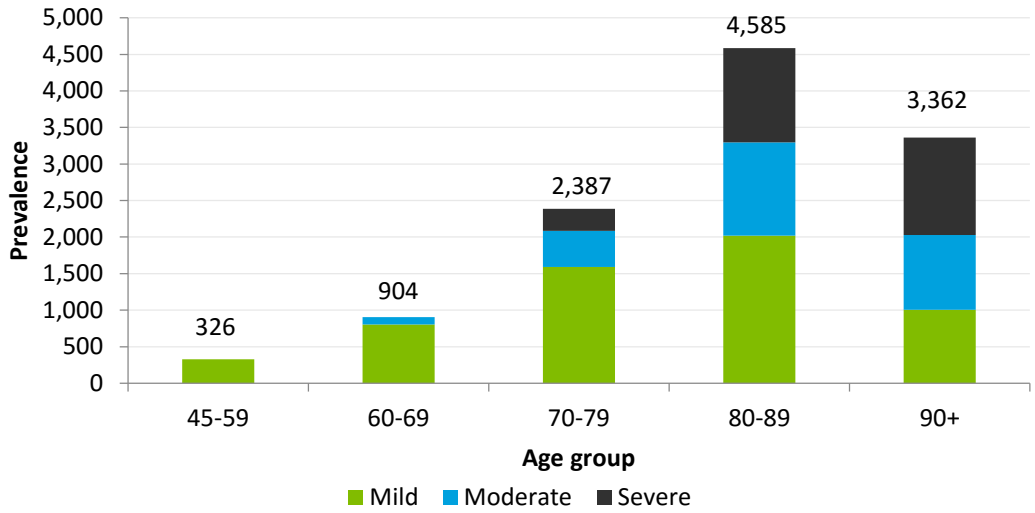
Chart 2.3 and Chart 2.4 show the prevalence by severity for males and females based on observed severity breakdowns reported in Owens et al (2003). Visual impairment appears to increase in severity over time – reflected in older age groups. The severity distributions may differ with changing access to treatments that can prevent blindness (severe vision loss).

Chart 2.3: Prevalence of vision loss from AMD by age and severity, male



Source: Deloitte Access Economics calculations based on Wong et al (2014), Owens et al (2003) and Owens et al (2012).

Chart 2.4: Prevalence of vision loss from AMD by age and severity, female



Source: Deloitte Access Economics calculations based on Wong et al (2014), Owens et al (2003) and Owens et al (2012).

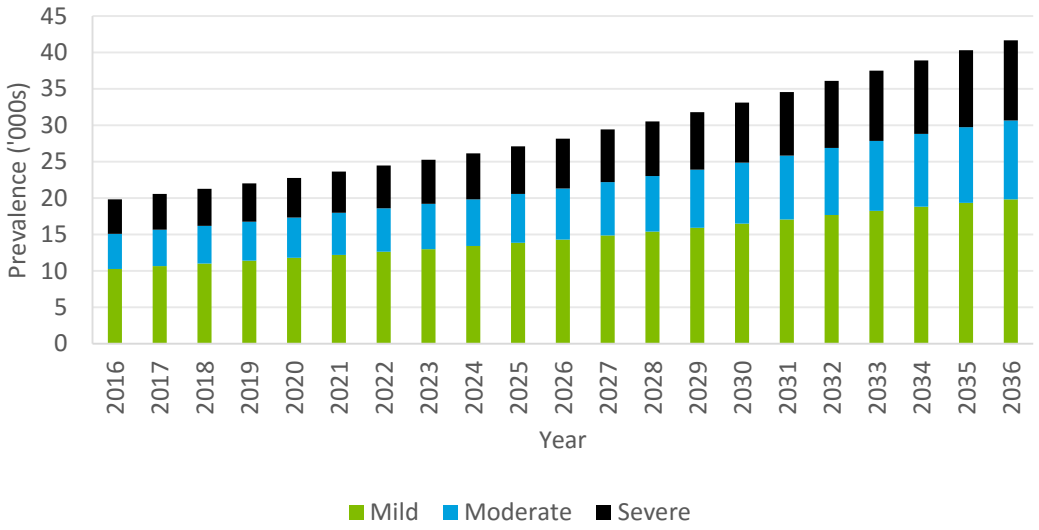
2.3 Projected vision loss and blindness due to AMD

The prevalence of vision loss and blindness due to AMD can have important implications for future healthcare resource planning. To model the prevalence between 2016 and 2036, the prevalence rates derived for 2016 – which represented the weighted prevalence rates based on the Asian and European subpopulations – were applied to population projections published by Statistics NZ (2014). Statistics NZ presents a range of alternate population projections, including varying fertility, migration and deaths in the future. The scenario considered most likely to occur is published with a probability distribution. The median series was used to project vision loss and blindness due to AMD.

Chart 2.5 shows the projected number of people with vision loss and blindness due to AMD between 2016 and 2036. Overall:

- the prevalence of severe vision loss (blindness) due to AMD is expected to grow from approximately 4,743 people in 2016 to 11,021 people in 2036; and
- the prevalence of mild and moderate vision loss due to AMD is expected to grow from approximately 15,083 people in 2016 to 30,648 people in 2036.

Chart 2.5: Prevalence of vision loss from AMD by severity, 2016-2036



Source: Deloitte Access Economics calculations.

Again, these projections are estimates and may or may not occur. There are a wide range of population estimates that may occur and these estimates for AMD are subject to that inherent variability. Furthermore, these projections represent the status quo, or in other words, no change in treatment, risk factor patterns, or a changing mix of ethnic groups over the projection period. As such, caution should be used when interpreting and using these results.

2.4 Mortality due to AMD

A number of population-based longitudinal studies have shown that **the presence of visual impairment is a predictor of mortality** (Wang et al, 2001; Karpa et al, 2009; Cugati et al, 2007). Mortality associated with AMD is not caused by the condition itself but by the **higher risk of other complications such as accidental falls, other accidents (e.g. motor vehicle accidents), isolation and depression**.

The most recent study identified assessed mortality over a 13-year period, and found the mortality risk associated with visual impairment was between 30-116% higher than the matched controls after adjusting for other factors, and was predicted by both direct and indirect pathways (Karpa et al, 2009). **The increased mortality risk was higher for individuals under 75 years of age (hazard ratio of 2.16) than those who are more than 75 years of age (hazard ratio of 1.30)**.

To estimate the number of deaths due to AMD, the hazard ratios from Karpa et al (2009) were converted to a population attributable fraction.[5] The deaths attributable to AMD were

[5] The population attributable fraction (PAF) measures the contribution of a risk factor to a death. This is the proportional reduction in population mortality that would occur if vision loss did not occur. The population attributable fraction is calculated using the formula:

estimated by applying the population attributable fraction to the general population mortality rates for people with visual impairment due to AMD.

General population mortality rates were derived by dividing deaths by total population for each age and gender group, which were both sourced from Statistics NZ (Statistics NZ, 2015b; 2015d). The mortality rates for 2016 were then modelled by applying an exponential curve across each single year age and gender group based on the data from 1999 to 2015.

Overall, it was estimated that there were 61 deaths due to visual impairment caused by AMD in New Zealand in 2016. The number of deaths was estimated to be higher for females (40, 0.35%) than it was for males (21, 0.25%), which largely reflects the higher number of females alive in the 90+ age group. The mortality attributable to visual impairment associated with AMD is shown in Table 2.5.

$$PAF = P_{VL} \cdot \frac{HR_{VL} - 1}{1 + P_{VL} \cdot (HR_{VL} - 1)}$$

Where P_{VL} is the prevalence of vision loss and HR_{VL} is the hazard ratio of mortality.

Table 2.5: Mortality attributable to visual impairment associated with AMD, by age and gender

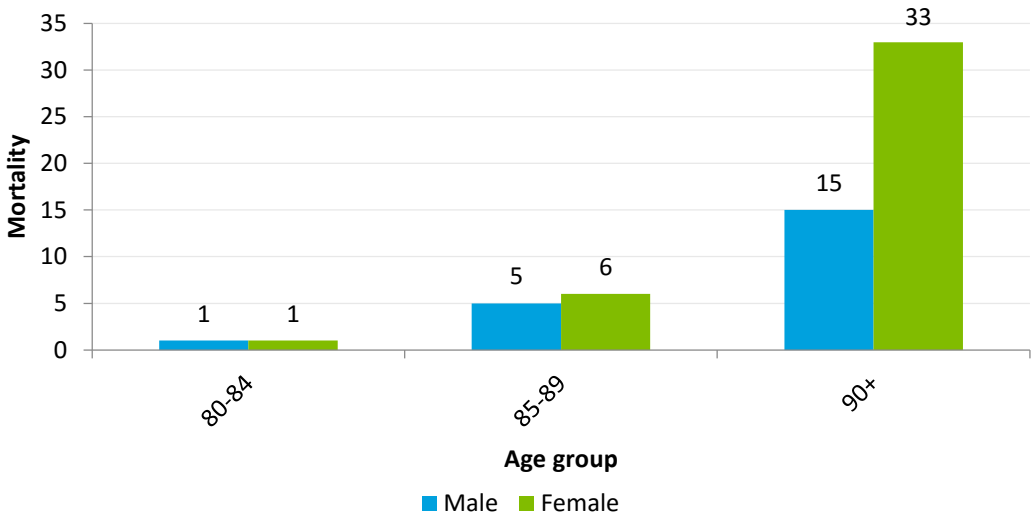
Age/ gender	Additional mortality rate, %	Estimated deaths
Male		
45-49*	0.000	0
50-54*	0.000	0
55-59*	0.001	0
60-64	0.003	0
65-69	0.006	0
70-74	0.038	0
75-79	0.017	0
80-84	0.085	1
85-89	0.293	5
90+	1.004	15
Male	0.254	21
Female		
45-49*	0.000	0
50-54*	0.000	0
55-59*	0.000	0
60-64	0.002	0
65-69	0.004	0
70-74	0.026	0
75-79	0.012	0
80-84	0.061	1
85-89	0.227	6
90+	0.988	33
Female	0.346	40
Persons	**0.308**	**61**

Source: Deloitte Access Economics calculations.

* Additional mortality is expected to occur in all age groups, however, the change in rates is very small (but still greater than zero) in younger age groups. This reflects low general population mortality rates in these groups, but over a number of years it is possible that a death may occur.

The mortality attributable to visual impairment for each age and gender group is presented graphically in Chart 2.6.

Chart 2.6: Mortality attributable to vision loss from AMD, by age and gender



Source: Deloitte Access Economics calculations.

3 Health system expenditure

The New Zealand health system faces a number of direct financial costs. This chapter estimates the direct health system costs of AMD (including early AMD where available) in New Zealand for the year 2016. Total costs are disaggregated into separate cost components.

Health system costs comprise hospital costs (including inpatient and outpatient costs), costs for other health professionals (including allied health services such as optometrists), pharmaceutical costs, research costs and aged care costs. These costs are estimated using a combination of a bottom-up and top-down approaches.

Key findings:

- The total health system costs associated with vision loss due to AMD were estimated to be $56.5 million in 2016, or $2,849 per person with vision loss due to AMD.
- The largest component of health system expenditure was estimated to be aged care ($21.1 million), followed by admitted hospital expenditure ($16.1 million) and non-admitted hospital services ($9.2 million).
- New Zealand Government bore the majority of health system costs (83.2%), while individuals bore 10.5%, and other parties (such as private health insurers and charities) bore the remaining 6.3%.

3.1 Hospital inpatient costs

Hospital expenditure data in New Zealand includes general public and private hospital admissions, as well as outpatient clinics.

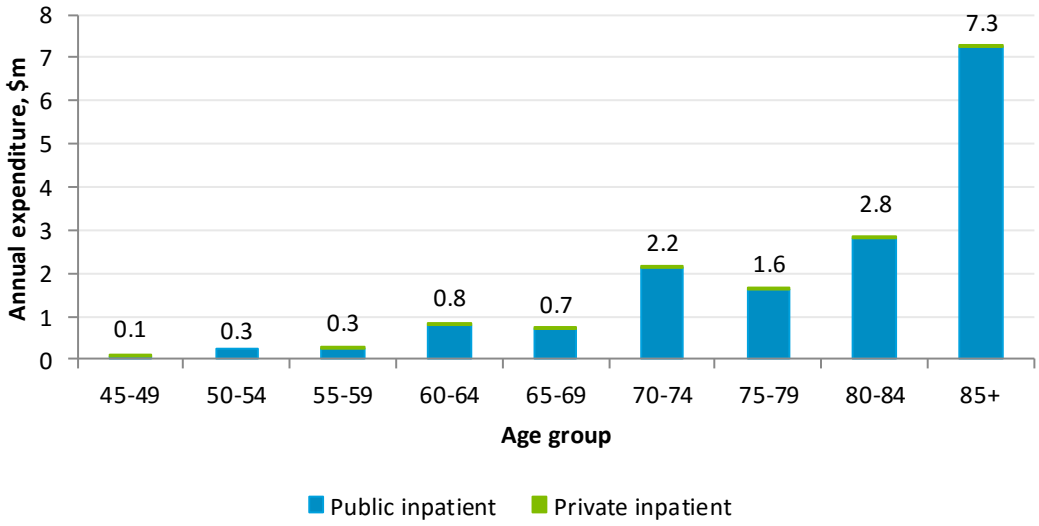
Public hospital inpatient data is based on the National Health Committee (2015) study, which noted that 1,500 New Zealanders received inpatient or day patient care for AMD in 2012-13. Adjusted to the 2016 population, this equates to a total of 1,660 individuals of AMD in the public sector.

Based on the National Health Committee (2015), the average public hospital inpatient cost in 2016 for AMD was calculated as $9,514.75. Total expenditure for public hospital AMD inpatients was estimated to be $15.8 million in 2016.

To calculate **private hospital inpatient data**, it was necessary to estimate this from total inpatient data. The ICD-10 code for AMD is H35.3. The Ministry of Health does not publicly report hospital separation data down to this level. Consequently, private hospital separations were calculated by applying the ratio of total inpatients who have AMD estimated above to public hospital separations for H35 conditions (Ministry of Health, 2016). This ratio was then applied to the number of private hospital separations listed for H35 conditions from the Ministry of Health (2016a). In 2016, it was estimated that only 26 individuals utilised private hospital inpatient services for AMD.

Applying the average hospital inpatient cost for AMD ($9,514.75), total expenditure for private hospital AMD inpatients was estimated to be $0.3 million in 2016. Chart 3.1 details annual public and private hospital inpatient expenditure by age group.

Chart 3.1: Public and private hospital inpatient expenditure, 2016



Source: National Health Committee (2015) Ministry of Health (2016), and Deloitte Access Economics calculations.

In 2016, total hospital related expenditure was estimated to be $16.1 million. Table 3.1 details the cost breakdown by public and private hospitals.

Table 3.1: Total hospital costs associated with vision loss from AMD, 2016

Hospitals	Expenditure ($m)
Public hospitals	15.8
Private hospitals	0.3
Total	**16.1**

Source: Deloitte Access Economics calculations.

3.2 Outpatient costs

Outpatient costs include the cost of specialist assessment, treatment and advice. The National Health Committee (2015) estimated the total number of publicly-funded hospital discharges to be 3,700. This is equivalent to approximately 15% of all discharges for diseases of the eye and adnexa derived from publicly funded hospital discharges (Ministry of Health, 2016). The most common outpatient services are listed in Table 3.2.

Table 3.2: Ophthalmology outpatient services used by patients with AMD

Purchase unit code	Description	Cost 2016 ($)
S40002	First opthalmological attendance for specialist assessment	191.11
S40003	Follow-up opthalmological attendances for specialist assessment	158.66
S40004	Attendance for minor eye procedures (including administration of anti-VEGFs)	225.33
S40005	Argon or YAG laser eye procedures	216.94
S40006	Additional opthalmological consults and treatment resulting from increased fundus screening procedures	327.32
S40007	From 2014/15 replaces S40004 for intraocular injections of pharmacological agents	N/A
S4000	From 2014/15 replaces S40004 for outpatient eye procedures not covered under S40005 and S40007	N/A

Source: The National Health Committee (2015).

Based on the approach taken by the National Health Committee (2015), it was estimated that 42,000 people with AMD received outpatient ophthalmology services in 2016, with a per person cost of $220 in 2015. **Adjusted for 2016 costs, the total cost of outpatients for AMD was estimated to be $9.2 million in 2016.**

3.3 Other health professionals

For AMD, the category of other health professionals primarily involves optometrists. Community based optometrists are involved in assessing the eye health of the general population. Additional screening regarding the health of the macular is typically provided at an additional cost. The cost per visit of seeing an optometrist for early AMD is described below. Low vision rehabilitation may also be provided for patients with late AMD. There are a number of clinics in New Zealand that provide these services. Low vision rehabilitation service costs are estimated in section 4.3.

In 2015, the National Health Committee (2015) reported that between 115,000 and 165,000 individuals have early AMD and see a community optometrist once every two years. Calculations were based on a 2016 cost per visit of $75.01 and the midpoint of the number of individuals estimated to see an optometrist and the prevalence estimated in this report. The total cost of optometrist attendances for early and late AMD was estimated to be $6.6 million in 2016.

3.4 Aged care

The likelihood of being admitted to an aged care facility is increased given the presence of vision loss from AMD. Wang et al (2003) used data from the Blue Mountains Eye Study to derive a relative risk of aged care facility admission for a person with vision impairment due

to moderate and severe AMD (after best correction) to be 1.8 among persons with correctable vision loss. This relative risk was then applied to the general probability of being admitted to an aged care facility.

The Ministry of Health (2010) calculated the average price for rest home care to be $40,500 per year. Adjusting for inflation, this equates to $44,380 in 2016 dollars. This was used to calculate additional expenditure on aged care due to vision loss in 2016.

In 2010, the Ministry of Health estimated that approximately 10,000 new residents enter aged care each year[6]. Overall, an estimated $21.1 million is spent on aged care for those with moderate to severe vision loss due to moderate and severe AMD. Table 3.3 provides a breakdown of these estimates.

Table 3.3: Annual expenditure attributed to individuals in aged care due to moderate and severe AMD, 2016

Age group	Percentage of individuals in aged care due to vision loss	Number of individuals in aged care due to vision loss	Expenditure ($m)
60-64	0.000	0	0.0
65-69	0.000	0	0.0
70-74	0.000	0	0.0
75-79	0.000	1	0.0
80-84	0.003	5	0.2
85-89	0.018	50	2.2
95+	0.122	420	18.6
Total	**-**	**475**	**21.1**

Source: Wang (2003); Statistics New Zealand (2010); Ministry of Health (2010) and Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

3.5 Research

Research costs associated with AMD including research to improve on existing treatments should be attributed to AMD since, in the absence of AMD, research would not need to be conducted. Research costs are based on personal communications data sourced from the Health Research Council of New Zealand. Over the last six years, the Health Research Council reported that they funded $1.3 million worth of grants for projects specifically related to AMD – a yearly average of approximately $216,667.

[6] Personal communication from the Population Health Directorate, Ministry of Health.

This may be a conservative figure as it does not capture research expenditure from private research companies or from other institutions such as universities since data were not publicly available. While private companies are able to recoup research expenditure through the price of goods sold, until new treatments are developed, any AMD specific research would not be captured in pharmaceutical expenditure estimates.

For this report, research costs were conservatively estimated to be $216,667 during 2016.

3.6 Pharmaceuticals

There are currently three main anti-VEGF drug brands administered to patients with AMD. Bevacizumab (Avastin) is most commonly used in New Zealand, accounting for over 90% of AMD-related anti-VEGF use (National Health Committee, 2015). Ranibizumab (Lucentis) and aflibercept (Eylea) are also used as second line treatments in New Zealand.

The National Health Committee (2015) reported that bevacizumab accounts for 90% of all AMD related anti-VEGF treatments in New Zealand. The remaining 10% was allocated equally between ranibizumab and aflibercept (5% of treatments each). The total number of anti-VEGF injections provided in New Zealand is listed in Table 3.4.

A search for New Zealand cost data was conducted. The costs for ranibizumab and aflibercept were based on a recent proposal to use these drugs as second and third line treatment options, noting that this has yet to be finalised (PHARMAC, 2016a). Costs for an individual injection of bevacizumab were not identified and were therefore based on Australian Pharmaceutical Benefits Scheme (PBS) data (PBS 2016a), which was converted to NZ dollars using Purchasing Power Parity. The maximum dispensed price divided by the number of repeats is reported here. Table 3.4 provides the cost per injection of each drug in 2016 NZD.

To derive the total cost of anti-VEGF treatments for AMD, the cost per injection is multiplied by the number of injections administered. Table 3.4 provides a breakdown of these costs. **In 2016, the total cost of anti-VEGF treatments was estimated to be $3.3 million.**

Table 3.4: Number and cost of injections by treatment, 2016

	Bevacizumab	Ranibizumab	Aflibercept	Total
Number of injections	18,709	1,039	1,039	20,788
Cost per injection	15.44	1,250	1,650	
Total cost ($m)	**0.3**	**1.3**	**1.7**	**3.3**

Source: National Health Committee (2015), PBS (2016), Thompson (2015) and Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

3.7 Health system expenditure summary

Total health system costs associated with AMD in New Zealand were estimated to be $56.5 million in 2016. As per Table 3.5, the largest component was associated with aged care

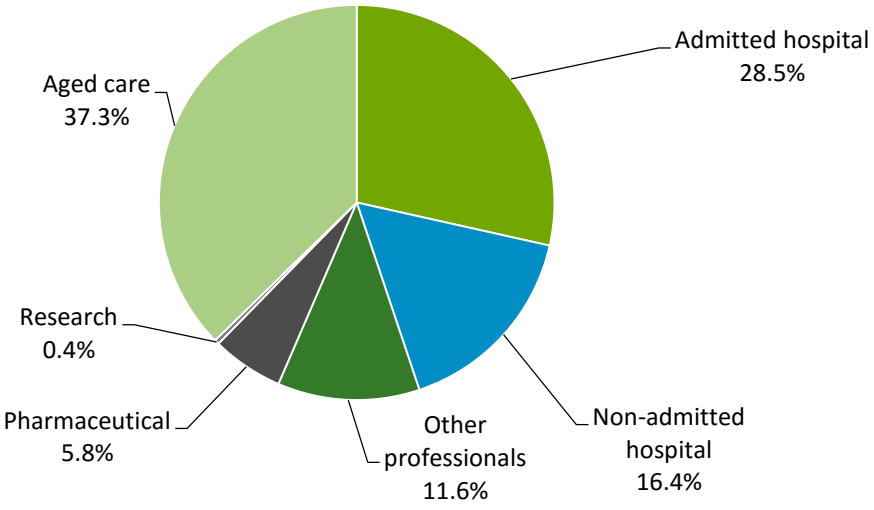
($21.1 million), followed by admitted hospital costs ($16.1 million). The relative shares of each component are illustrated graphically in Chart 3.2.

Table 3.5: Health system costs by sector, total and per person, 2016

Health expenditure sector	$ (million)	Per person ($)
Admitted hospital	16.1	812
Non-admitted hospital	9.2	466
Other professionals (optometrists)	6.6	331
Pharmaceuticals	3.3	167
Aged care	21.1	1,062
Research	0.2	11
Total health system expenditure	**56.5**	**2,849**

Source: Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

Chart 3.2: Health system expenditure by sector, 2016

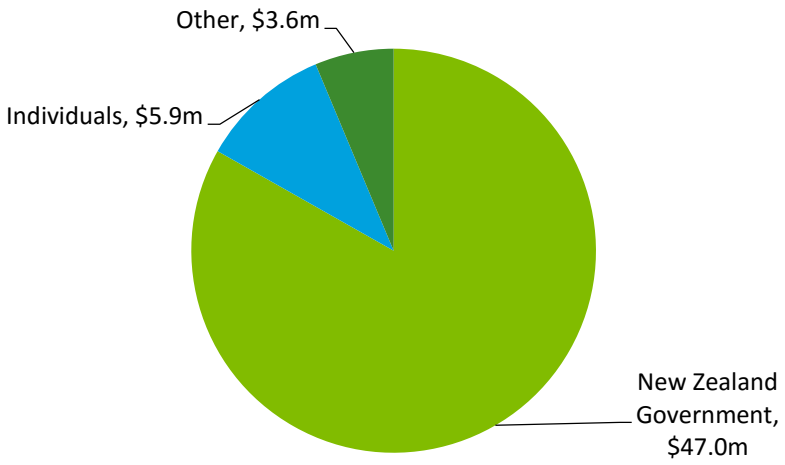


Source: Deloitte Access Economics calculations.

Chart 3.3 presents estimates of the cost for different sectors of society based on data from the Ministry of Health (2012). In 2016, vision loss due to AMD was estimated to cost:

- Government $47.0 million;
- individuals and families $5.9 million;
- other parties (such as private health insurers) $3.6 million.

Chart 3.3: Health system expenditure by who pays, 2016



Source: Deloitte Access Economics calculations using Ministry of Health (2012).

4 Other financial costs

This chapter describes the approach that was used to estimate productivity costs associated with vision loss from AMD in New Zealand. Broadly, the costs included here cover lost productivity for people with vision loss from AMD, and lost productivity for people who care for people with vision loss from AMD.

Key findings:

- The productivity loss in individuals with vision loss from AMD is $18.5 million in 2016, or $931 per person with vision loss. Individuals ($11.2 million) and government ($7.2 million) bear all of these costs. The productivity cost would be expected to be larger if absenteeism and presenteeism costs were included, although these were outside the remit of this report.
- The productivity loss due to informal care was $0.7 million in 2016, or $33 per person with vision loss from AMD. Each informal carer is estimated to provide, on average, 3.5 hours of care per week to people with vision loss from AMD.
- Expenditure on aids, equipment and modifications was estimated to be $3.0 million, while the overall deadweight losses associated with transfers was estimated to be $10.9 million.

4.1 Productivity losses

Vision loss from AMD can have a substantial effect on an individual's ability to work. This may include reduced chance of employment, early retirement, or exit from the workforce due to premature mortality. As such, vision loss may impose a range of productivity costs which affect individuals with vision loss, their employers and government (through reduced tax revenue).

This section provides an analysis of the productivity costs associated with vision loss, in particular the costs associated with reduced employment. A human capital approach is adopted to estimate productivity losses. This involves the calculation of the difference in employment between people with vision loss from AMD and that of the general population, multiplied by average weekly earnings (AWE). Productivity losses from premature mortality are estimated in terms of the net present value of the future income streams lost.

4.1.1 Reduced employment

Vision loss from AMD may have a considerable effect on an individual's chances of employment resulting in reduced employment either through disadvantages in job-seeking or self-selection out of the labour force. This can lead to substantial productivity losses, in the form of wages lost from employment that would otherwise have been gained, in addition to other costs to the individual, such as diminished social engagement.

In their study on disability and work participation in New Zealand, Jensen et al (2005) used data from Statistics NZ's 2001 Disability Survey to estimate the impact of people's disabilities on their employment outcomes. An additional procedure was utilised to estimate the size of "counterfactuals" (i.e. what the employment outcomes would have been for disabled people

if they had not had disabilities) in order to best gauge the magnitude of this impact. As part of this process, results were also controlled for the demographic variables that made the largest independent contribution towards explaining variation in the outcome variables. These variables were gender, marital status, having dependent children, age, ethnicity and qualifications.

Of people with a disability caused by vision loss, Jensen et al (2005) observed that 44% were employed on either a full-time or part-time basis. In the absence of vision loss, the expected employment for this group would have been 71%. **This reflects a significant decrease in the likelihood of employment, due to vision loss, of 27%.** While more recent data from Statistics NZ are available from the 2013 Disability Survey, in the absence of similar adjustments made to the 2013 results, the findings from Jensen et al (2005) represent the most up-to-date and country-specific estimates identified that control for confounding factors, including age and gender.

It was estimated that there were 479 people not employed due to vision loss from AMD in New Zealand in 2016, of whom slightly more than 65% were male.

> Applying this to the New Zealand general employment rates and AWE by age and gender (Statistics NZ, 2015; 2015c), the total economic cost associated with reduced employment was estimated to be $18.5 million – or $931 per person with vision loss from AMD.

4.1.2 Premature mortality

Other productivity costs include premature mortality and administrative costs such as search, hiring and training costs associated with replacing hiring a new worker earlier than planned. No mortality was estimated to occur in the working age population, and consequently, these costs would not occur as a result of vision loss from AMD in New Zealand in 2016.

4.1.3 Summary of productivity losses for people with vision loss from AMD

Productivity costs for those with vision loss from AMD are summarised in Table 4.1, and estimated to be $18.5 million in 2016. This is equivalent to $931 per person with vision loss. This only includes productivity costs associated with reduced employment opportunities for people with vision loss from AMD. This does not include the carer costs associated with informal care (discussed further in section 4.2 – although this is also a productivity loss).

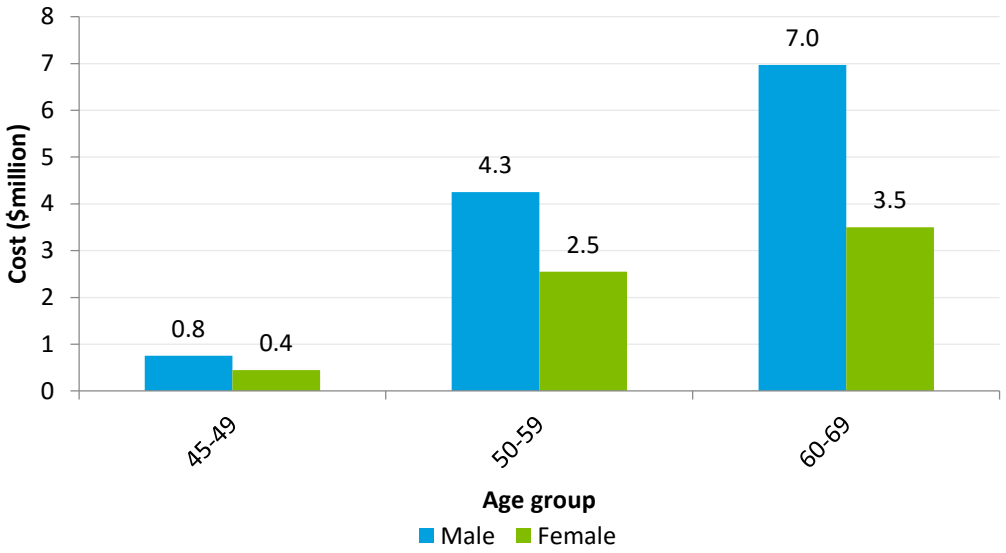
Table 4.1: Summary of productivity costs for people with vision loss

Source of productivity loss	2016 $m	Per person ($)
Reduced employment	18.5	931
Premature mortality	0.0	0.0
Total	**18.5**	**931**

Source: Deloitte Access Economics' calculations.

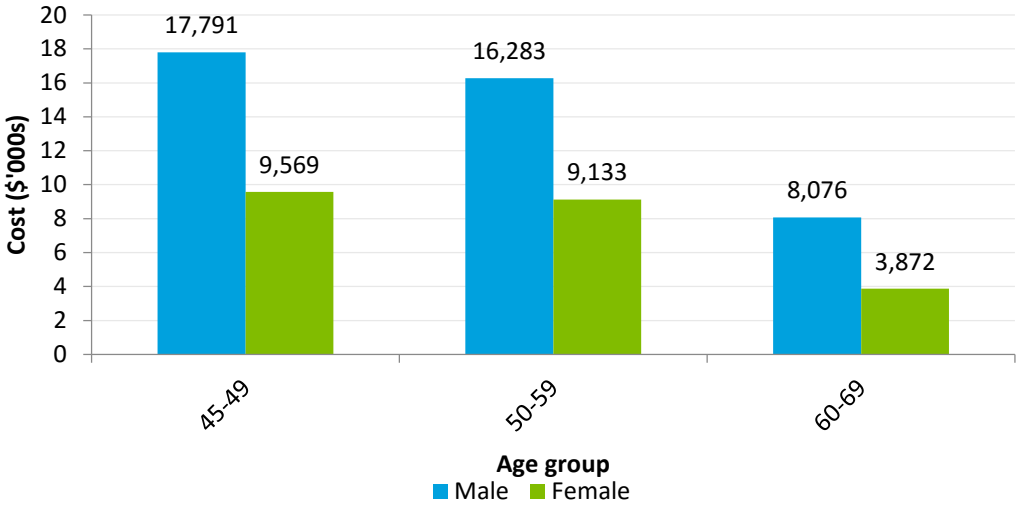
As shown in Chart 4.1 and Chart 4.2, the overall costs and the average productivity cost per person with vision loss differs vastly by age and gender. Males have higher associated productivity costs, which reflect their higher earnings.

Chart 4.1: Productivity costs, people with vision loss from AMD, by age and gender, 2016, $ million



Source: Deloitte Access Economics calculations.

Chart 4.2: Productivity cost per person, people with vision loss from AMD, by age and gender, 2016, $



Source: Deloitte Access Economics calculations.

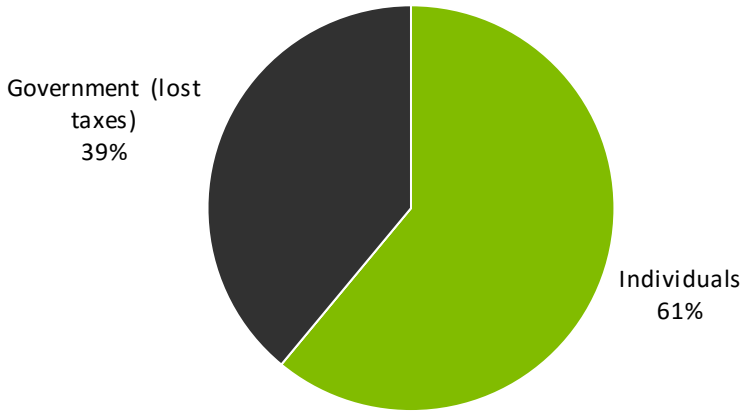
The productivity costs are shared between workers and government (through a reduction in taxable income). Post-tax, the shares of productivity losses are:

- workers: the productivity cost of vision loss borne by workers was $11.3 million in 2016; and

- government: the productivity cost of vision loss borne by government was $7.2 million, which again is the result of reduced employment for people with vision loss resulting in lower taxation revenue.

The shares of total productivity costs borne by each payer are shown in Chart 4.3. Employees bore the largest share of costs (61%), followed by government (39%).

Chart 4.3: Productivity costs for people with vision loss by who bears the cost, 2016



Source: Deloitte Access Economics' calculations.

It is important to note that these estimates are likely to be an underestimate of the true impact of productivity losses as there may be absenteeism and presenteeism components. These aspects of productivity loss refer to when an individual is absent from work more often, and are less productive while at work, due to vision loss. These additional components have not been estimated in this report.

4.2 Informal care costs

This section describes the approach that was used to estimate the costs of informal care for people with AMD in New Zealand. Carers are people who provide care to others in need of assistance or support, such as assistance with everyday activities of daily living. An informal carer provides this service free of charge and does so outside the formal care sector. An informal carer will typically be a family member or friend of the person receiving care, and usually lives in the same household as the recipient of care. As such, many people receive informal care from more than one person. The person who provides the majority of informal care is known as the primary carer.

While informal carers are not paid for providing this care, informal care is not free in an economic sense. Time spent caring involves forfeiting time that could have been spent on paid work or undertaking leisure activities. As such, informal care can be valued as the opportunity cost associated with the loss of economic resources (labour) and the loss in

leisure time valued by the carer. To estimate the dollar value of informal care, an opportunity cost approach was used. [7]

To determine the amount of, and costs associated with, informal care given by carers of people with AMD, a targeted literature search was undertaken to determine how many people with AMD receive care, the number of hours each carer provides on average, and who generally provides this care (i.e. a spouse or other family member). Who provides this care is important to ascertain to correctly value the carer's opportunity cost of time, which is calculated based on AWE for each age and gender group (Statistics New Zealand, 2015), and the chance of being employed (Statistics New Zealand, 2015).

4.2.1 Recipients of care

The most recent study to identify how many people with vision loss or AMD receive informal care was published following the 2006 Disability Survey in New Zealand (Statistics New Zealand, 2009). This survey showed that of people who had vision loss that imposed the main disability, **approximately 13% of those aged 0-64 years old and 38% of those aged 65 years old or older received informal care**. These rates are applied to the estimated prevalence of moderate and severe prevalence of AMD in New Zealand in 2016.

No studies specifically identified the relationship between carers and care recipients. For adults, it was assumed that any additional care is provided by the spouse or partner. This assumption means that the age distribution of carers is similar to the age distribution of people with AMD.

It was estimated that there were 7,148 people with vision loss from AMD who received informal care in New Zealand in 2016.

4.2.2 Hours of informal care provided

The Royal New Zealand Foundation of the Blind (2006) reported on the unpaid assistance provided by family members to people with moderate to severe vision loss (visual acuity worse than 6/24) for activities such as domestic tasks, shopping, leisure and recreation activities, attending medical appointments and participating in volunteer work. **The survey identified that people with moderate to severe vision loss required around 3.5 hours of care each week**. For people with moderate to severe vision loss from AMD, it is expected that the number of hours of care would be similar.

4.2.3 Cost of informal care

To estimate the cost of informal care, estimates of the number of people requiring care were multiplied by the annual hours of care provided (3.5 hours on average per week multiplied by 52.1 weeks), and the opportunity cost of carers' time. The total hours of care per year per person were then multiplied by the total number of people receiving care – which was estimated to be 7,148 people with moderate or severe vision loss from AMD. This represents

[7] It is also possible to use the replacement cost method (which measures the cost of 'buying' an equivalent amount of care from the formal sector if the informal care was not supplied), and the self-valuation method (which measures how much carers themselves feel they should be paid for undertaking their responsibilities. However, these options were not explored further in this report.

approximately 1.3 million hours of care provided to people with moderate to severe vision from AMD in New Zealand in 2016.

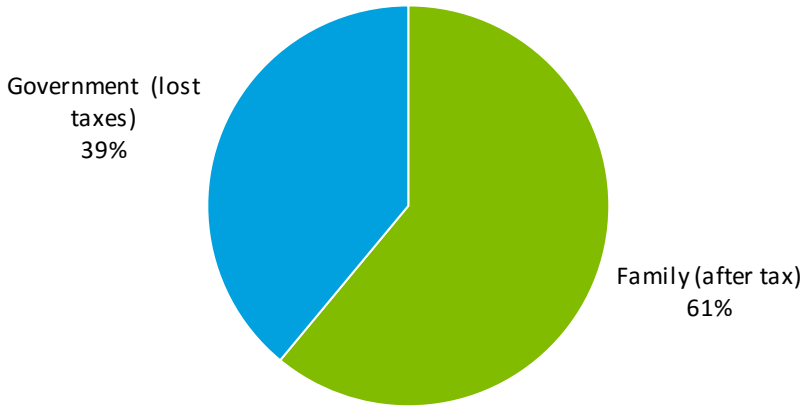
Multiplying these hours by the AWE for the carers leads to an estimate of the **cost of informal care provided to people with AMD of around $0.7 million in New Zealand in 2016. This represents $0.50 per hour of care of informal care based on the opportunity cost approach** – reflecting the low employment opportunities of the average carer in the general population based on the age distribution of prevalent cases. Using a replacement value approach the costs would be substantially higher.

Of the total carer costs:

- carers (post-tax) bore around $0.40 million (61%) in the form of lost income; and
- government bore around $0.25 million (39%) in the form of lost taxes.

The distribution of informal care costs by the respective payer is shown in Chart 4.4.

Chart 4.4: Informal care costs by who bears the cost, 2016



Source: Deloitte Access Economics calculations.

4.3 Aids and home modifications

For people with vision loss from AMD, aids and modifications can become essential for everyday tasks and communication – allowing people with AMD to remain independent, at home and included in society.

Utilisation of aids, equipment and home modifications was derived from the Royal New Zealand Foundation of the Blind 2006 survey on the cost of blindness in New Zealand. The survey identified the utilisation of aids and equipment including reading devices, mobility canes, recording equipment and computers with special software which assist people with vision loss from AMD to remain independent. The usage is reported in Table 4.2. Cost of aids and modifications were sourced from local online stores, including Harvey Norman and the New Zealand Blind Foundation. It was assumed that computers and readers would last

for four years based on depreciation values published by New Zealand Inland Revenue (2015).

The usage rates from Royal New Zealand Foundation of the Blind survey New Zealand (2006) were applied to the total moderate to severe prevalence from AMD in 2016. Overall, almost 7,200 people (not necessarily unique) were estimated to use some type of aid or low vision rehabilitation service. These estimates were used to derive the cost of aids and modifications in this report.

Finally, the National Health Committee (2015) estimated that people with severe vision loss access two low vision rehabilitation services annually on average. The average cost of low vision rehabilitation services was estimated as $60 per session.

Table 4.2: Equipment, technology or services used by individuals with moderate or worse vision loss

Equipment	Utilisation (%)	Number of people using aids	Cost per year ($)	Total cost ($m)
Magnifiers	75	7,184	21	0.2
Readers and audio reading materials	67	6,417	56	0.4
Mobility canes	62	5,939	70	0.4
Computers, including voice synthesis computers	23	2,203	510	1.1
Recording equipment	29	2,778	130	0.4
Low vision rehabilitation services	-	4,743	120	0.6
Total				**3.0**

Source: Royal New Zealand Foundation of the Blind (2006).

Overall, the cost of aids, equipment or services used by individuals with moderate or worse vision loss was estimated to be $3.0 million in New Zealand in 2016.

4.4 Brought forward funeral expenses

The additional cost of funerals borne by family and friends of people with hearing loss is based on the number of deaths due to vision loss from AMD. However, as everyone will die eventually, and thus incur funeral expenses, the additional cost imposed by vision loss from AMD is the brought forward funeral cost adjusted for the likelihood of dying anyway. Citizens Advice Bureau (2016) estimates that the average funeral cost is likely between $8,000 and $10,000 in New Zealand. Taking the midpoint value ($9,000), **the discounted value of funeral expenses brought forward was estimated to be $0.2 million**.

4.5 Deadweight losses

Transfer payments represent a shift of resources from one economic entity to another, such as raising taxes from the entire population to provide welfare payments to people with AMD. The act of taxation and redistribution creates distortions and inefficiencies in the economy, so transfers also involve real net costs to the economy, referred to as efficiency losses.

Transfer costs are important when adopting a whole-of-government approach to policy formulation and budgeting. Transfer costs also allow us to examine the distribution of the costs of AMD across different parts of society.

4.5.1 Taxation revenue forgone

People with vision loss from AMD and their carers in paid employment, who have left the workforce temporarily due to caring responsibilities, or permanently due to premature retirement, will contribute less tax revenue to the government. As presented in the relevant sections throughout this report:

- people with AMD missed out on $18.5 million in wage income due to reduced employment; and
- carers lost $0.7 million in wage income due to caring for a person with vision loss from AMD.

In 2016, the average personal income tax rate was 24% (New Zealand Treasury, 2016), and the average indirect tax rate was modelled as 15% using the current Goods and Services Tax (Inland Revenue, 2016).

By applying the total lost wage income to the marginal income tax and indirect tax rate, **the total loss of tax revenue was estimated to be $7.5 million in 2016**. This represents taxation revenue that must be collected from other parts of the economy (e.g. those that remain in the workforce) given a "no change in expenditure" assumption. That is, small tax changes are unlikely to change the level of demand for expenditure.

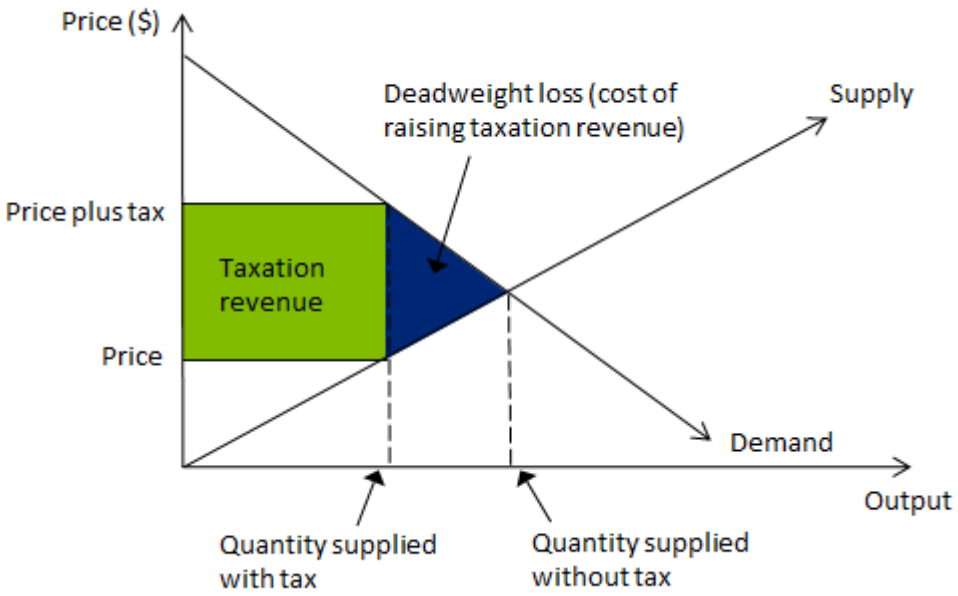
4.5.2 Efficiency loss of taxation payments and administration

Transfer payments (government payments and taxes) are not a net cost to society, as they represent a shift of consumption power from one group of individuals to another in society. If the act of taxation did not create distortions and inefficiencies in the economy, then transfers could be made without a net cost to society. However, these distortions do impose an efficiency loss on the economy.

An efficiency loss is the loss of consumer and producer surplus, as a result of the imposition of a distortion to the equilibrium (society preferred) level of output and prices (Figure 4.1). Taxes alter the price and quantity of goods sold compared to what they would be if the market were not distorted, and thus lead to some diminution in the value of trade between buyers and sellers that would otherwise be enjoyed. The principal mechanism by which efficiency losses occur is the price induced reduction in output, removing potential trades that would benefit both buyers and sellers. In a practical sense, this distortion reveals itself

as a loss of efficiency in the economy, which means that raising $100 of revenue requires consumers and producers to give up more than $100 of value.

Figure 4.1: Deadweight loss of taxation



Source: Deloitte Access Economics.

The rate of efficiency loss used in this report is 20 cents per $1 of tax revenue raised (New Zealand Treasury, 2015). The efficiency loss rate is applied to:

- lost tax revenue from forgone earnings of people with AMD, their carers and employers (which must be raised from another source); and
- government services provided (for example, the public health system, grants and programs), since in a budget neutral setting, government expenditures require taxation to be raised and thus also have associated distortionary impacts.

4.5.3 Summary of deadweight losses

Using the rate of efficiency losses (20%), the expected total efficiency loss associated with vision loss from AMD was estimated to be $10.9 million in 2016, or $549 per person with vision loss from AMD. The components of efficiency loss and the overall cost are summarised in Table 4.3.

Table 4.3: Components of efficiency loss, 2016

Component of efficiency loss	2016 ($million)
Health system costs borne by government	47.0
Lost taxes	7.5
Total transfers	54.4
Rate of efficiency loss	20%
Resulting efficiency loss	**10.9**

Source: Deloitte Access Economics calculations.
Note: components may not sum due to rounding.

4.6 Summary of other financial costs

Overall, productivity losses for the individual, informal care losses for family members and other financial costs associated with vision loss due to AMD were estimated to be $33.1 million in 2016, or $1,672 per person with AMD. It is not surprising that the main cost component was productivity losses (56%) – owing to the high employment impacts of moderate and severe vision loss. The next largest component was the deadweight loss (33%), which was followed by aids, equipment and modifications (9%). That said, there may be more expenditure through government programs that provides assistance to people with vision loss due to AMD such as for return to work programs, which was beyond the remit of this report.

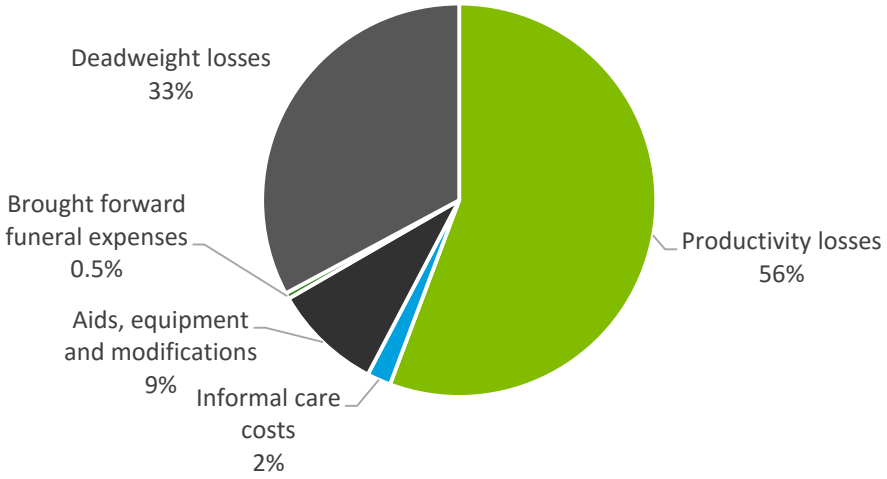
The estimated expenditure associated with other financial costs is outlined in Table 4.4. Chart 4.5 presents the other financial costs associated with vision loss from AMD graphically.

Table 4.4: Other financial costs of vision loss from AMD, 2016

Financial cost	Annual cost ($m)	Per person ($)
Productivity losses	18.5	931
Informal care costs	0.7	33
Aids, equipment and modifications	3.0	150
Brought forward funeral expenses	0.2	8
Deadweight losses	10.9	549
Total	**33.1**	**1,672**

Source: Deloitte Access Economics' calculations.

Chart 4.5: Other financial costs of vision loss from AMD, 2016



Source: Deloitte Access Economics calculations.

5 Loss of wellbeing

This chapter adopts the 'loss of wellbeing' methodology in order to quantify the impact of vision loss from AMD on wellbeing. This methodology is used to calculate non-financial costs and instead assesses reduced health and premature mortality in terms of **DALYs.**

Key findings:

- The economic value of lost wellbeing due to vision loss from AMD was estimated to be $301.5 million in 2016. Approximately 82% of the total loss of wellbeing was due to YLDs (the disability burden).
- Overall, people with vision loss from AMD experienced 1,470 YLDs, 330 YLLs (the mortality burden) and 1,800 DALYs in 2016.

5.1 Methodology

Life and health can be measured in terms of DALYs, which are based on disability weights where a weight of 0 represents a year of perfect health and a weight of 1 represents death. The DALY approach has been adopted and applied in New Zealand by the Ministry of Health. The Ministry of Health (2013) separately identify the premature mortality (years of life lost due to premature death - YLLs) and morbidity (years of healthy life lost due to disability - YLDs) associated with disability due to a condition:

$$DALYs = YLLs + YLDs$$

In any year, the disability weight of a health condition reflects a relative health state. For example, the disability weight for a broken wrist is 0.18, which represents losing 18% of a year of healthy life because of the injury, for the duration of the condition.

The loss of wellbeing as measured in DALYs can be converted into a dollar figure using the concept of the **value of a statistical life (VSL).** The VSL is an estimate of the value society places on an anonymous life. As DALYs are enumerated in years of life rather than in whole lives it is necessary to calculate the **value of a statistical life year (VSLY)** based on the VSL. This is done using the formula:[8]

$$VSLY = VSL / \Sigma_{i=0,\ldots,n-1}(1+r)^n$$

Where: n = years of remaining life, and
r = discount rate

The New Zealand Ministry of Transport (2016) estimated that the VSL was $4.06 million in 2015, which was estimated to be $4.19 million in 2016 when accounting for the average growth in AWE. The average person living in New Zealand has 45 years of expected life

[8] The formula is derived from the definition:
VSL = ΣVSLYi/(1+r)^i where i=0,1,2….n
where VSLY is assumed to be constant (i.e. no variation with age).

remaining (Statistics New Zealand, 2015a), so the VLSY was estimated to be **$170,085 in 2016 dollars**.

5.2 Loss of wellbeing from AMD

To estimate the loss of wellbeing from vision loss from AMD, it was necessary to determine an appropriate health weight given the severity of vision loss from AMD. In New Zealand, the current health weights for varying severity of vision loss come from the Ministry of Health's *New Zealand Burden of Diseases, Injuries and Risk Factors Study* (Ministry of Health, 2012). YLDs were estimated using the health states for mild, moderate and severe vision loss multiplied by the number of people with each level of vision loss from AMD as estimated in section 2.2. The health states for each severity of vision loss are as follows:

- mild vision loss from AMD is 0.011;
- moderate vision loss from AMD is 0.060; and
- severe vision loss from AMD is 0.225.

The YLLs are based on the number of deaths due to vision loss from AMD (section 2.4), and the years of expected remaining life at the age of death from standard life tables published in the 2013 global burden of disease study (Forouzanfar et al, 2015). A discount rate of 3% was applied to the value of the loss of wellbeing (a standard rate in discounting life), although no age weighting or discount was applied to the estimates of YLLs or YLDs – consistent with the methodology employed by the global burden of disease study.

Table 5.1 shows the total YLLs, YLDs and DALYs by severity, age and gender. Females have a higher loss of wellbeing compared to males, which is the result of more females being alive in older age groups. As people age, the loss of wellbeing increases in line with prevalence – vision loss from AMD and severity of vision loss both progress with ageing. Overall, people with vision loss from AMD experienced (Table 5.1):

- 1,470 YLDs, or 0.074 YLDs per person with vision loss from AMD;
- 330 YLLs, or around 0.017 YLLs per person with vision loss from AMD; and
- 1,800 DALYs overall, or around 0.091 DALYs per person with vision loss from AMD.

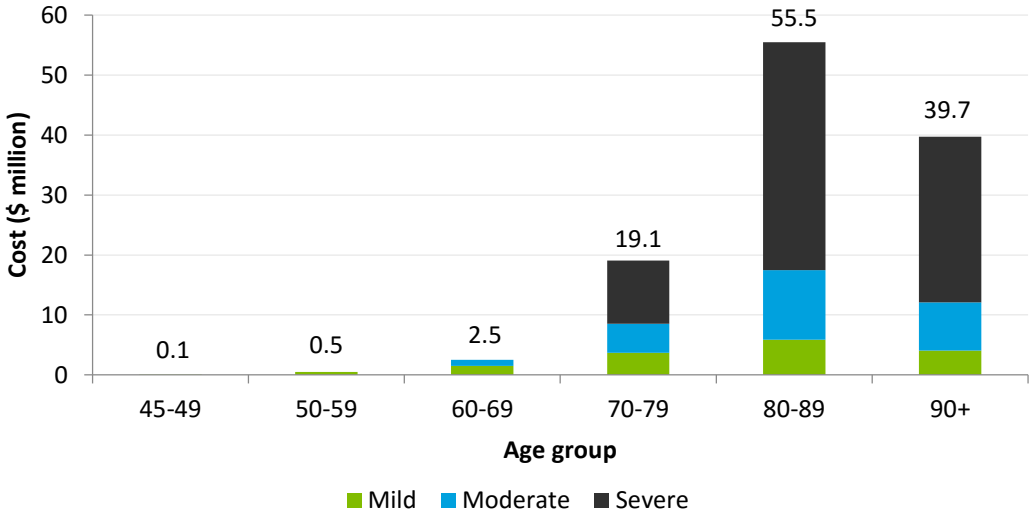
Table 5.1: DALYs due to vision loss from AMD in New Zealand in 2016, by severity, age and gender

Age/ gender	Mild		Moderate		Severe		Overall DALYs	DALYs ($m)
	YLD	*YLL*	*YLD*	*YLL*	*YLD*	*YLL*		
Male								
45-49	0	0	0	0	0	0	0	0.1
50-59	3	0	0	0	0	0	3	0.5
60-69	8	1	6	0	0	0	15	2.5
70-79	16	7	27	2	61	1	114	19.1
80-89	17	20	56	14	211	14	331	55.5
90+	5	20	28	20	137	27	238	39.7
Male total	49	48	117	36	409	42	701	117.3
Female								
45-49	1	0	0	0	0	0	1	0.1
50-59	3	0	0	0	0	0	3	0.5
60-69	9	1	6	0	0	0	15	2.6
70-79	18	5	30	1	67	1	122	20.5
80-89	22	21	77	15	290	15	440	73.9
90+	11	43	61	44	300	57	517	86.5
Female total	63	70	173	60	658	74	1,099	184.1
Persons	**113**	**118**	**290**	**96**	**1,067**	**116**	**1,800**	**301.5**

Source: Deloitte Access Economics calculations. Note: numbers do not multiply out exactly to totals due to discounting applied to the value of YLLs. Components may not sum exactly to totals due to rounding.

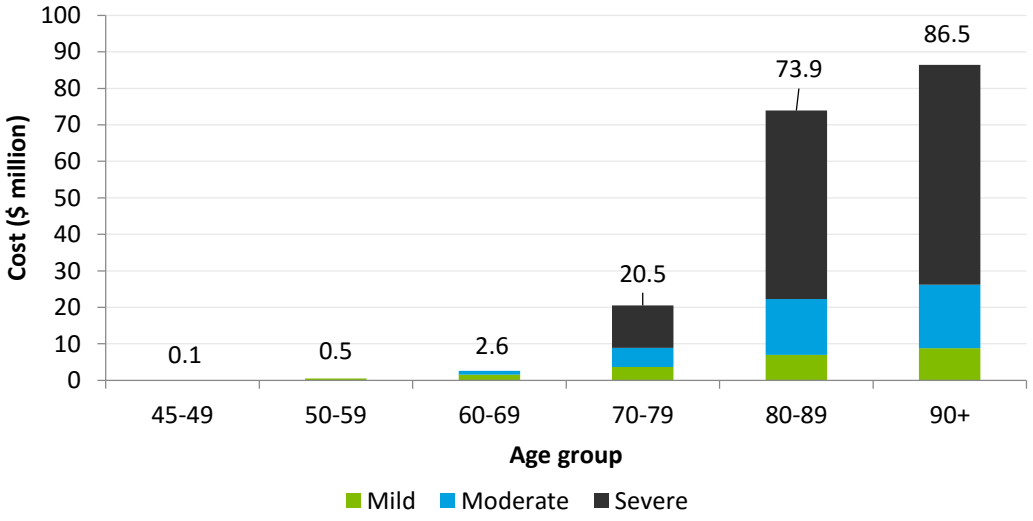
The loss of wellbeing by severity is shown in Chart 5.1 and Chart 5.2 for males and females, respectively. Loss of wellbeing increases with age for both males and females, reflecting both increasing prevalence and severity with age. The loss of wellbeing starts to decline for males in older age groups due to a smaller underlying population.

Chart 5.1: Loss of wellbeing by age and severity, male, $ million



Source: Deloitte Access Economics calculations.

Chart 5.2: Loss of wellbeing by age and severity, female, $ million



Source: Deloitte Access Economics calculations.

Overall, the economic value of lost wellbeing due to vision loss from AMD was estimated to be $301.5 million in 2016 – which was predominately due to YLDs (approximately 82%).

6 Summary of costs of AMD

This chapter summarises the total costs of vision loss due to AMD.

Key findings:

- The total cost of vision loss due to AMD in New Zealand was estimated to be $391.1 million in 2016, comprising $89.6 million in economic (financial) costs and $301.5 million in loss of wellbeing costs. This equates to approximately $19,727 per person in total (both components).

6.1 Total costs of vision loss due to AMD

The total economic costs of vision loss due to AMD were estimated to be $89.6 million in New Zealand in 2016, while including the loss of wellbeing increases that total to $391.1 million. The components of economic costs are:

- health system costs of $56.5 million, or $2,849 per person with vision loss due to AMD. Health system costs were mainly comprised of aged care costs (39%), admitted hospital (29%) and non-admitted hospital (16%) costs;
- productivity losses of $18.5 million, or $931 per person with vision loss due to AMD;
- informal care costs of $0.7 million, or $33 per person with vision loss due to AMD;
- other financial costs of $3.1 million, or $158 per person with vision loss due to AMD;
- efficiency losses of $10.9 million, or $549 per person with vision loss due to AMD; and
- loss of wellbeing of $301.5 million, or $15,207 per person with vision loss due to AMD.

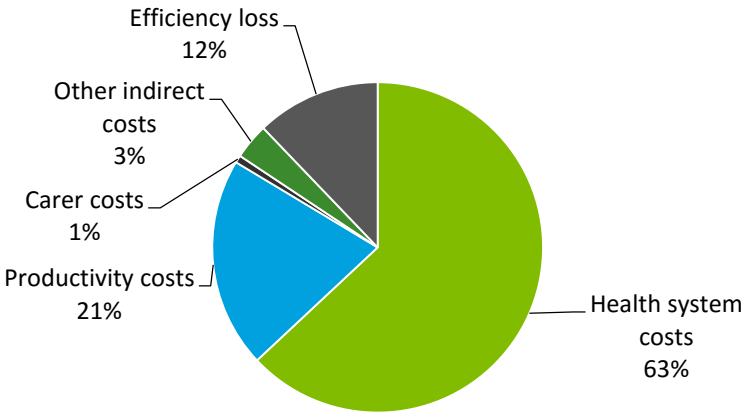
Table 6.1: Total costs of vision loss due to AMD, 2016

Component	Value ($m)	Per person ($)
Health system costs	56.5	2,849
Productivity costs	18.5	931
Carer costs	0.7	33
Other financial costs	3.1	158
Efficiency losses	10.9	549
Total economic costs	*89.6*	*4,521*
Total loss of wellbeing costs	*301.5*	*15,207*
Total costs	**391.1**	**19,727**

Source: Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

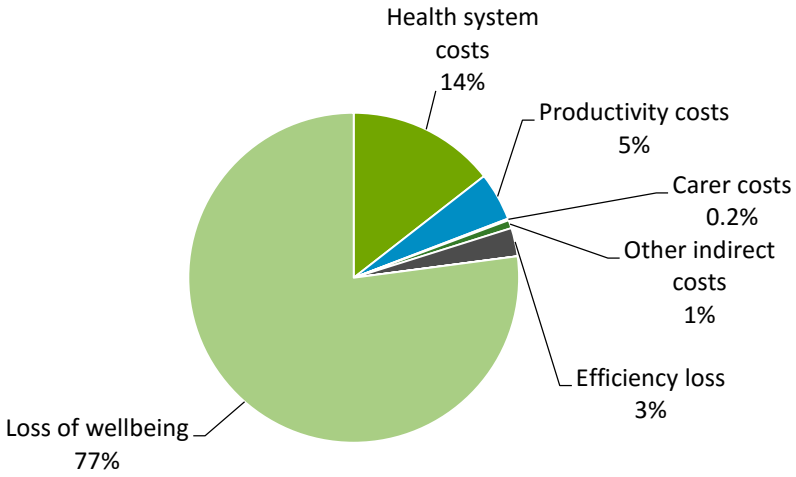
Chart 6.1 illustrates the economic costs associated with vision loss due to AMD in New Zealand for 2016. Overall, the majority of costs were associated with health system expenditure (63%), followed by productivity costs (21%), and deadweight losses (12%). Total costs reflect economic and wellbeing costs, as depicted in Chart 6.2. As a whole, loss of wellbeing accounted for 77% of total costs of vision loss due to AMD in 2016.

Chart 6.1: Economic costs associated with vision loss due to AMD in New Zealand, 2016



Source: Deloitte Access Economics calculations.

Chart 6.2: Total costs associated with vision loss due to AMD in New Zealand, 2016



Source: Deloitte Access Economics calculations.

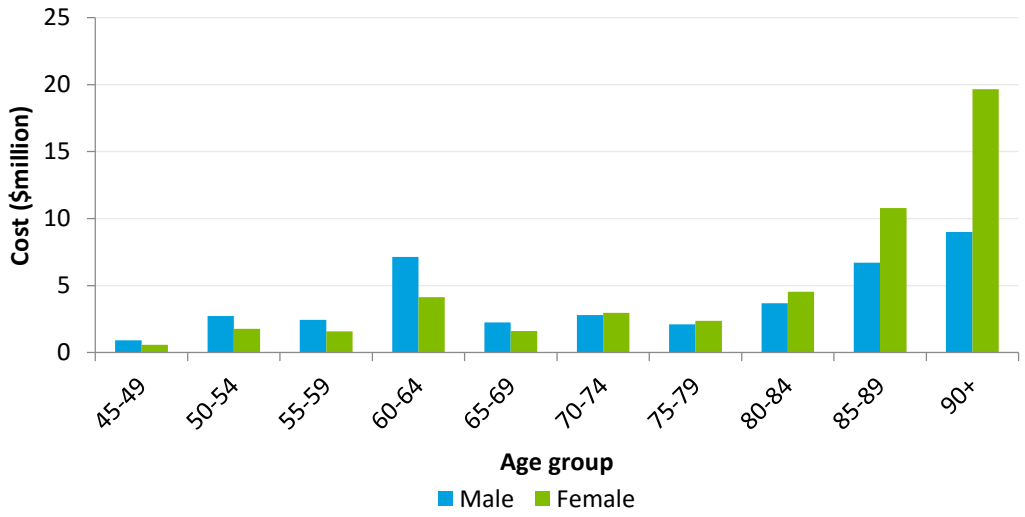
Table 6.2 depicts total economic costs and total costs by age and gender. Economic costs tend to increase with age – owing to greater aged care requirements and the increased underlying prevalence in older age groups. The same trend is apparent for burden of disease costs, which is primarily driven by increased severity and increased mortality in older age groups. These trends are illustrated in Chart 6.3 and Chart 6.4.

Table 6.2: Total costs associated with vision loss due to AMD by age and gender, $ million

Age/ gender	Economic cost ($m)	Loss of wellbeing ($m)	Total cost ($m)
Male			
45-49	0.9	0.1	1.0
50-59	5.1	0.5	5.6
60-69	9.4	2.5	11.9
70-79	4.9	19.1	24.0
80-89	10.4	55.5	65.8
90+	9.0	39.7	48.7
Male total	39.7	117.3	157.0
Female			
45-49	0.6	0.1	0.7
50-59	3.3	0.5	3.9
60-69	5.7	2.6	8.3
70-79	5.3	20.5	25.9
80-89	15.3	73.9	89.3
90+	19.7	86.5	106.1
Female total	49.9	184.1	234.1
Persons	**89.6**	**301.5**	**391.1**

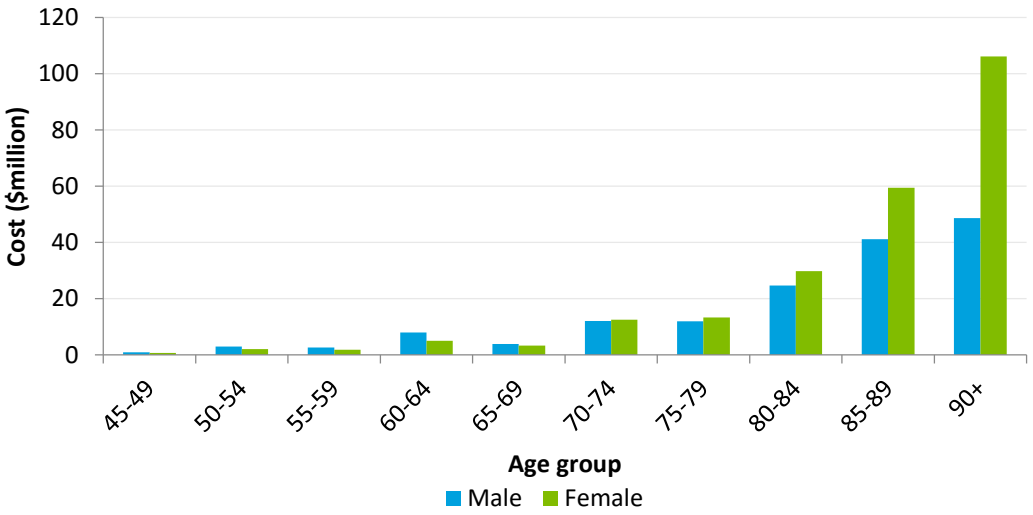
Source: Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

Chart 6.3: Total economic costs associated with vision loss due to AMD by age and gender, 2016



Source: Deloitte Access Economics calculations.

Chart 6.4: Total cost associated with vision loss due to AMD by age and gender, 2016



Source: Deloitte Access Economics calculations.

7 Cost of blindness due to AMD

This chapter summarises the total costs of blindness due to AMD. The estimates presented in this chapter follow the same methodology as those presented throughout each of the previous chapters.

Key findings:

- The total cost of blindness due to AMD in New Zealand was estimated to be $216.6 million in 2016, comprising $28.2 million in economic costs and $188.4 million in loss of wellbeing costs. This equates to approximately $45,677 per person with severe vision loss from AMD in both financial and wellbeing costs.

7.1 Methodology

The following steps outline the methodology used to attribute costs to blindness.

- **Health system costs** were apportioned using the estimated number of people who are blind due to AMD relative to the total prevalence of vision loss and blindness due to AMD. For aged care, this was slightly different as the calculation used the share of blindness relative to the combined prevalence of moderate and severe vision loss.
- **Productivity losses** for individuals were not included as there were no estimated cases of blindness due to AMD in the working age population. In reality, there may be a small number of cases, and for these individuals, the impact would be profound. However, this would have minimal impact on the costs presented here.
- **Informal care** costs were estimated in the same way as in section 4.2, although the proportion of those receiving care was applied only to severe cases.
- **Aids, equipment and modification** costs were estimated in the same way as in section 4.3, although the proportion of those requiring these items was applied only to severe cases.
- **Deadweight losses** were recalculated using the same approach as in section 4.5. The rate of efficiency loss was only applied to health system costs and lost tax revenue attributed to blindness.
- **Loss of wellbeing** estimates are as per chapter 5 for severe vision loss (blindness).

7.2 Costs of blindness due to AMD

The total economic costs of blindness due to AMD were estimated to be $28.2 million in New Zealand in 2016, or approximately one-third of all economic costs associated with vision loss due to AMD. Including loss of wellbeing, the total cost of blindness due to AMD was estimated to be $216.6 million, more than half of all costs due to vision loss from AMD. The components of economic costs associated with blindness are:

- health system costs of $22.5 million, or $4,742 per person with blindness due to AMD;
- informal care costs of $0.2 million, or $38 per person with blindness due to AMD;
- other financial costs of $1.8 million, or $377 per person with blindness due to AMD;
- efficiency losses of $3.8 million, or $792 per person with blindness due to AMD; and

- loss of wellbeing of $188.4 million, or $39,729 per person with blindness due to AMD.

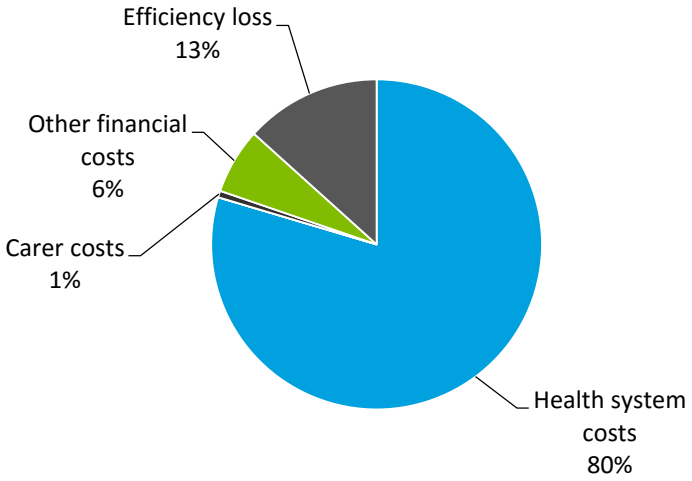
Table 7.1: Total costs of blindness due to AMD, 2016

Component	Value ($m)	Per person ($)
Health system costs	22.5	4,742
Productivity costs	0.0	0
Carer costs	0.2	38
Other financial costs	1.8	377
Efficiency losses	3.8	792
Total economic costs	*28.2*	*5,949*
Total loss of wellbeing costs	*188.4*	*39,729*
Total costs	**216.6**	**45,677**

Source: Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

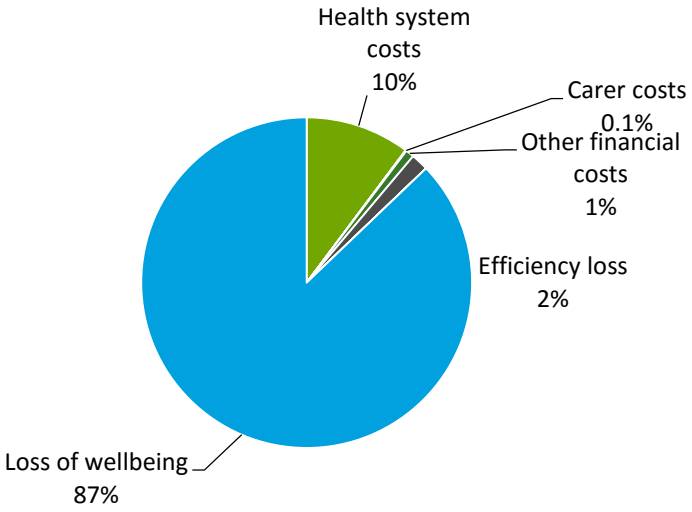
Chart 7.1 illustrates the economic costs associated with blindness due to AMD in New Zealand for 2016. Overall, the majority of costs were associated with health system costs (80%), followed by deadweight losses (13%) and aids, equipment and modifications (6%). Total costs reflect economic and wellbeing costs, as depicted in Chart 7.2. As a whole, loss of wellbeing accounted for 87% of total costs of blindness due to AMD in 2016.

Chart 7.1: Economic costs associated with blindness due to AMD in New Zealand, 2016



Source: Deloitte Access Economics calculations.

Chart 7.2: Total costs associated with blindness due to AMD in New Zealand, 2016



Source: Deloitte Access Economics calculations.

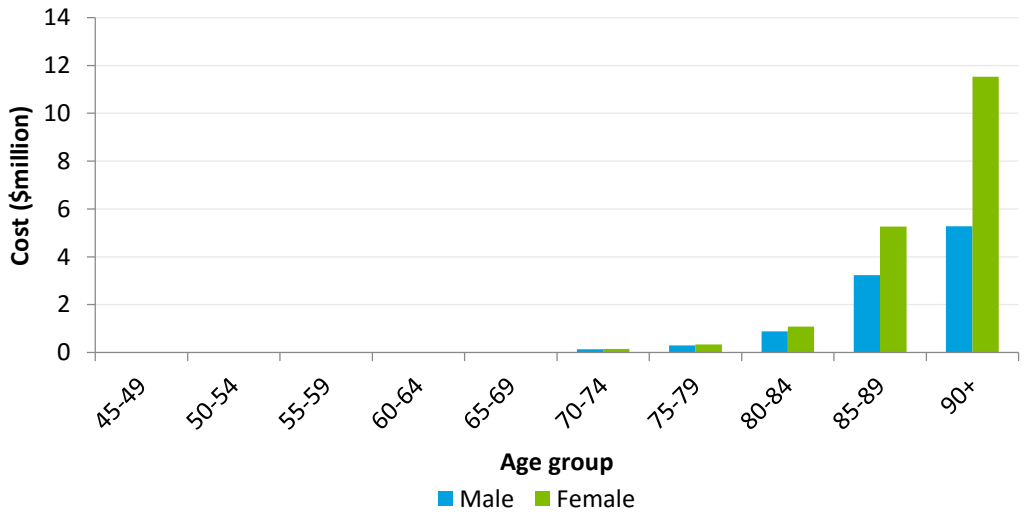
Table 7.2 depicts total economic costs and total costs by age and gender. Economic costs tend to increase with age – owing to greater aged care requirements and the increased underlying prevalence in older age groups, as with all vision loss due to AMD. The same trend is apparent for burden of disease costs, which is primarily driven by increased severity and increased mortality in older age groups. These trends are illustrated in Chart 7.3 and Chart 7.4.

Table 7.2: Total costs associated with blindness due to AMD by age and gender, $ million

Age/ gender	Economic cost ($m)	Loss of wellbeing ($m)	Total cost ($m)
Male			
45-49	0.0	0.0	0.0
50-59	0.0	0.0	0.0
60-69	0.0	0.0	0.0
70-79	0.4	10.4	10.9
80-89	4.1	36.5	40.6
90+	5.3	25.1	30.4
Male total	9.8	72.0	81.8
Female			
45-49	0.0	0.0	0.0
50-59	0.0	0.0	0.0
60-69	0.0	0.0	0.0
70-79	0.5	11.5	12.0
80-89	6.4	50.1	56.4
90+	11.5	54.8	66.4
Female total	18.4	116.4	134.8
Persons	**28.2**	**188.4**	**216.6**

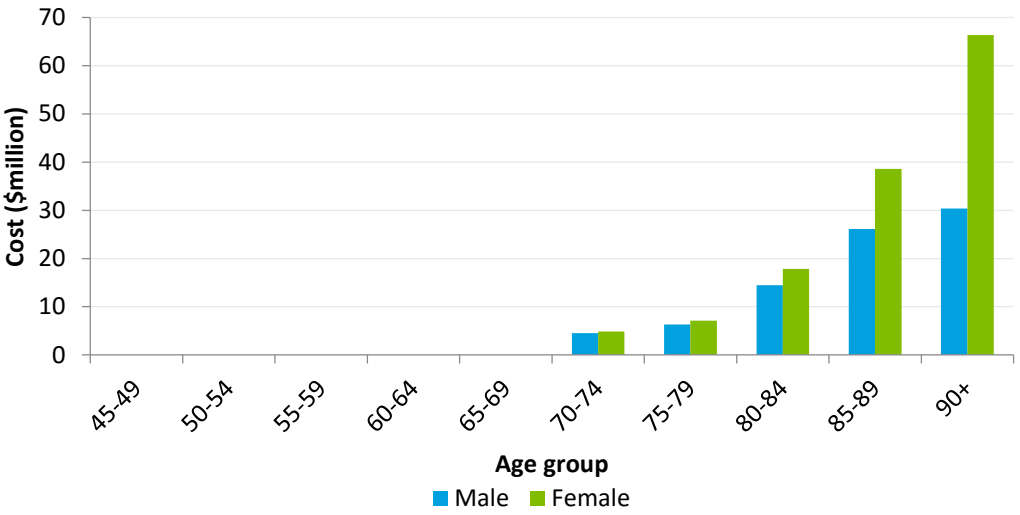
Source: Deloitte Access Economics calculations.
Note: components may not sum exactly to totals due to rounding.

Chart 7.3: Total economic costs associated with blindness due to AMD by age and gender, 2016



Source: Deloitte Access Economics calculations.

Chart 7.4: Total cost associated with blindness due to AMD by age and gender, 2016



Source: Deloitte Access Economics calculations.

8 Cost effectiveness measures

This chapter provides an understanding of the cost effectiveness of anti-VEGF treatment for AMD, and raising awareness of AMD with earlier recognition and its associated prevention of progression to AMD.

8.1 Background

The MARINA study performed a comparison of ranibizumab and PDT with verteporfin in the treatment of classic neovascular AMD. Overall, the study reported an improvement in mean visual acuity of 6.5 letters in the 0.3-mg group and 7.2 letters in the 0.5-mg group. Conversely, there was a decrease of 10.4 letters in the sham-injection group. Combining these results together, the average benefit associated with the use of ranibizumab is 17.6 letters over one year of treatment (Rosenfeld et al, 2006).

Anti-VEGF treatment may also prevent the decline of visual acuity. Of the 716 participants enrolled in the MARINA study, 94.5% of the group given 0.3 mg of ranibizumab and 94.6% of those given 0.5 mg ranibizumab lost fewer than 15 letters at 12 months, as compared with 62.2% of patients receiving sham injections. That is, the MARINA study showed that not only did ranibizumab prevent vision loss, it was also associated with a mean improvement in vision at one year.

For this analysis, we do not make a distinction between type of anti-VEGF treatment (bevacizumab, ranibizumab and aflibercept) as they have been shown to have comparable levels of effectiveness (CATT Research Group, 2011; Heier et al, 2012).

A line is considered to be read if more than half of the characters are identified correctly (International Council of Ophthalmology, 1984). Early Treatment Diabetic Retinopathy Study charts typically have five letters per line, meaning that an improvement of 17.6 letters is equivalent to an improvement of three lines.

Additionally, a one line gain on the visual acuity chart is reflective of a 0.1 unit decrease on the logMAR scale. Assuming a change of 0.3logMAR (three units) over a -0.3logMAR to 1.3logMAR scale (17 units), a reduction of the visual severity classification can occur in individuals with neovascular AMD.

8.2 Cost effectiveness of anti-VEGF treatment

To estimate the cost effectiveness of anti-VEGF treatment, it is necessary to know how effective each available treatment is (e.g. in reducing the burden of vision loss from AMD), and the costs of those treatments.

8.2.1 Costs of anti-VEGF treatment

The total cost of anti-VEGF treatment was estimated using the number and cost of injections in 2016, as per section 3.6. For all age groups, total cost of anti-VEGF injections was estimated to be $3.3 million.

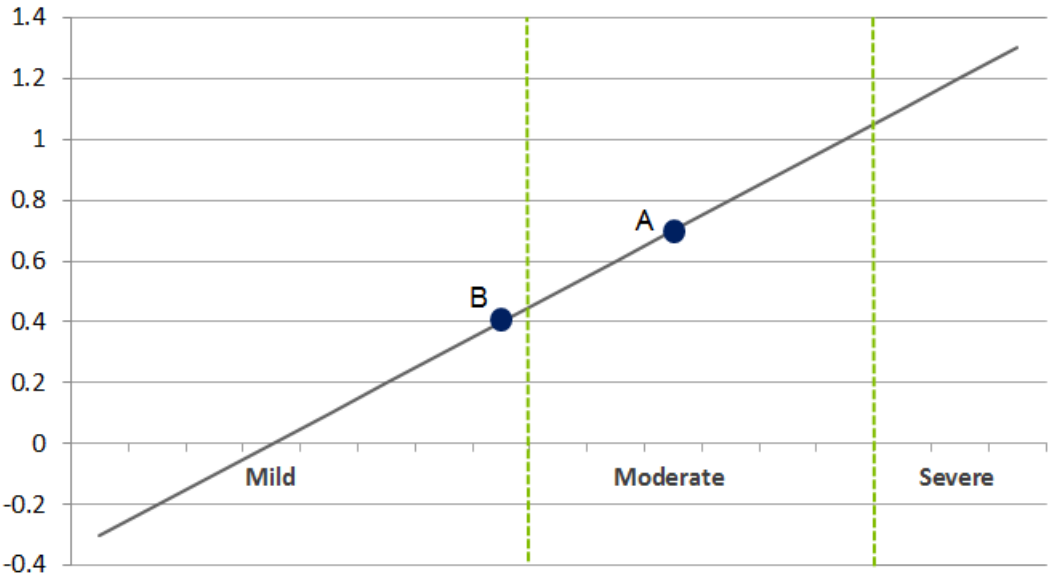
This was based on data from the National Health Committee (2015), which showed that 90% of anti-VEGF treatments in New Zealand use bevacizumab, with the remaining 10% of anti-VEGF treatments being second-line treatments – primarily ranibizumab (Lucentis).

8.2.2 Benefits of anti-VEGF treatment

The following methodology is based on current treatment patterns including the current cost and number of injections outlined in section 3.6 and is based on the methodology used by Deloitte Access Economics (2011) to establish cost savings and life years gained.

To estimate the number of people who improve their visual severity classification, a uniform distribution was assumed across all classifications. Therefore, logMAR is presented on a linear scale, as per Figure 8.1. Here, a 0.3logMAR change will result in approximately half of individuals classified with moderate visual impairment (number of individuals with vision loss due to AMD at point A) to transition into the mild visual impairment classification (point B). This is based on a moderate severity range of 0.6logMAR.

Figure 8.1: LogMAR scale classification



Source: Deloitte Access Economics.

To estimate the potential savings associated with anti-VEGF treatments, the number of people who improve their visual severity classification are multiplied by the cost difference between each classification.

With respect to visual severity classification, the cost of neovascular AMD per person is estimated using the relationship between the previously calculated total cost of AMD per person ($19,727) and the weighted prevalence in each severity group, based on Deloitte Access Economics (2011). That is:

Mild weight (x) + Moderate weight (y) + Severe weight (z) = weighted cost per person

0.24 (x) + 0.34 (y) + 0.42 (z) = $19,727

Where, for neovascular AMD:
x = cost per person with mild visual impairment
y = cost per person with moderate visual impairment
z = cost per person with severe visual impairment

Based on Deloitte Access Economics (2011) and the prevalence estimates in chapter 2, it was estimated that 24%, 34% and 42% of people who have neovascular AMD would have mild, moderate and severe vision loss, respectively. The cost relativities by severity are proxied using the disability weights for AMD, listed in Table 8.1.

Table 8.1: Disability weights for AMD, by severity

	EDS	Mild	Moderate	Severe
AMD	0.011	0.011	0.060	0.225
Relative to the next lowest severity	0.962	1.000	5.455	3.750

Source: Deloitte Access Economics (2011); Ministry of Health (2012a); Deloitte Access Economics Calculations.
EDS (Early Disease Stage) of AMD is mapped to normal visual acuity.

8.2.3 Cost effectiveness of anti-VEGF treatment

Based on Table 8.1, the cost relativities between each visual severity group are demonstrated below:

5.46 (x) = y ; 20.46 (x) = z ; 20.46/5.46 (y) = z

Solving for x, y and z, the cost savings per person was estimated as:

- $1,843 for mild visual impairment;
- $10,050 for moderate visual impairment; and
- $37,688 for severe visual impairment.

The total benefits by severity were calculated by multiplying the mild, moderate and severe prevalence that transition to the lower severity – e.g. for moderate severity, 50% were assumed to transition to mild based on the uniform logMAR scale. This was then multiplied by the cost differential between each severity stage to determine the overall benefits. Using this approach, the total number of cases averted from anti-VEGF treatment was estimated as follows (based on the full cost of a case):

- 87 cases for mild vision loss;
- 1,343 cases for moderate vision loss; and
- 2,970 cases for severe vision loss.

By multiplying the cases averted by the cost of AMD by severity, the total benefit of using anti-VEGF treatment if all neovascular AMD was treated was estimated to be $125.6 million, or 569 DALYs averted.

The cost effectiveness of using anti-VEGF treatments was estimated to be $5,803 per DALY averted, which is considered very cost effective based on World Health Organization benchmarks.

These estimates are substantially lower than that calculated in Deloitte Access Economics (2011) as the per person cost of bevacizumab is significantly lower than ranibizumab and aflibercept (see Table 3.4).

8.2.4 Cost effectiveness of timely and adequate anti-VEGF treatment

Early detection and treatment of AMD is crucial to ensure that patients achieve the best treatment outcome possible (Sanjay et al, 2014). Research has observed that regular timely treatment can substantially reduce both the time required for lesions to become inactive (i.e. prevent vision from degrading further) and the number of injections required (Gillies et al, 2015). Gillies et al (2015) observed that for patients who receive injections at intervals no longer than 5.3 weeks require 3 injections (median) to inactive lesions, while 6 injections (median) are required for patients with treatment intervals longer than 5.3 weeks.

To estimate the benefits of timely and adequate anti-VEGF treatment, it was necessary to make the following assumptions:

- both treatment interval regimes were assumed to inactivate all lesions, and thus prevent further degradation of visual acuity;
- the treatment interval regimes were assumed to be the same regardless of the anti-VEGF agent used; and
- benefits were assumed to occur before one year, and therefore were not adjusted for the total duration of the treatment regime.

Using a similar methodology to section 8.2.3, the total benefit and cost effectiveness of timely and adequate treatment was calculated. Table 8.2 highlights that the provision of timely and adequate treatments (i.e. at intervals less than 5.3 weeks) is a more optimal treatment regime to prevent progression of the condition.

Table 8.2: Comparison of anti-VEGF treatment regimes

Regime	Benefit ($m)	Costs ($m)	DALYs averted	$/DALY
<5.3 weeks (timely and adequate)	75.1	2.8	340	8,210
>5.3 weeks	75.1	5.6	340	16,421

Source: Deloitte Access Economics' calculations based on Gillies et al (2015).

The total benefit of timely and adequate anti-VEGF treatment (intervals less than 5.3 weeks) was estimated to be $75.1 million, or 340 DALYs averted. The cost effectiveness of this regime was estimated to be $8,210 per DALY averted – substantially better than the treatment regime with intervals greater than 5.3 weeks. Both regimes are considered to be highly cost effective given World Health Organization benchmarks.

8.3 Cost effectiveness of raising awareness with earlier recognition

The cost effectiveness of raising awareness with earlier recognition is estimated by evaluating individuals who have late AMD and are 'at risk' of visual acuity degradation in 2016. Benefits of increased awareness stem from earlier treatment and the associated reduction in progression from mild or moderate vision loss from AMD to moderate or severe vision loss from AMD.

This analysis is therefore based on the potential benefit of raising awareness with respect to reducing the progression of vision loss due to AMD.

8.3.1 Costs of awareness campaigns

There are currently no nation-wide AMD awareness or screening programs in New Zealand (National Health Committee, 2015a). Therefore, total costs were derived from Macular Degeneration New Zealand annual reports, the national charity for Macular Degeneration with the purpose of raising awareness of AMD. The costs of raising awareness included: variable costs such as awareness campaign funding, education, printing and design; pro-bono and sponsored work including digital signage in malls, design and postage; trustee time and lobbying; volunteers; and a fixed proportion of wages and contracting that could be attributed to raising awareness campaigns.

The total costs of awareness raising were estimated to be $1.23 million over the two years from 2015 to 2016. This timeframe aligns with the total expenditure on awareness for the timing of the two Galaxy polls (conducted in 2014 and 2016) – the benefits data. It is important to note that this funding included substantial amounts of pro-bono support and sponsorship (approximately 44% of the total).

8.3.2 Benefits of awareness campaigns

To estimate the potential savings associated with raising awareness with earlier recognition, the average cost of AMD per person is divided by the prevalence weight of those 'at risk' of progressing in severity from either mild to moderate vision loss, or from moderate to severe vision loss. Benefits of earlier awareness are associated with a reduction in progression to more advanced stages of AMD (e.g. see Cheng et al, 2015). The benefits of reducing progression through awareness and education were calculated by multiplying the benefit of reducing the progression of AMD by the disability weight relationship between the severity classifications (as per Table 8.1).

Based on the results of the Galaxy survey, an 11% change in awareness of AMD was noted in individuals aged 50 years and older between 2014 and 2016[9]. For the purposes of this analysis, an 11% increase in awareness was assumed to translate to an 11% increase in early treatment, and thus an 11% decrease in progression from mild to moderate vision loss from AMD and from moderate to severe vision loss from AMD. No literature was identified that allowed for a more specific estimate of the translation between increased awareness and the decrease in progression. The cost savings were calculated in a similar way as for the anti-VEGF cost effectiveness, comparing the cost differential between mild and moderate vision loss from AMD and moderate and severe vision loss from AMD.

In other words, at the end of 2016, 11% of people with mild or moderate vision loss would have progressed to the next severity of vision loss, had they not received earlier treatment. Multiplying these rates by the prevalence of mild and moderate vision loss from neovascular AMD, and the expected progression (100% for mild to moderate, and 50% for moderate to severe as outlined previously, it was estimated that 252 and 181 cases of moderate and severe vision loss could be averted through earlier treatment, respectively.

8.3.3 Cost effectiveness of current awareness raising campaigns

Awareness raising campaigns may increase the number of people in New Zealand receiving timely treatment for AMD, and can be successful at reducing the progression of AMD. Using similar methodology as for anti-VEGF treatments, awareness campaigns were found to be cost effective based on World Health Organization benchmarks.

> The total benefit of awareness-raising campaigns was estimated to be $6.5 million, or 29 DALYS averted. Cost-effectiveness of awareness-raising campaigns was estimated to be $42,062 per DALY averted. This is considered to be highly cost effective given World Health Organization benchmarks.

8.3.4 Benefits and cost savings of increasing AMD awareness in New Zealand to Australian levels

Increased awareness has the propensity to increase education levels of AMD, encouraging individuals to go and have an eye test. This may lead to earlier detection of conditions, meaning that treatment would be more effective (Gillies et al, 2015). The Galaxy survey (Personal communication, 2016) highlighted key differences in awareness levels between Australia and New Zealand. Australia has significantly higher awareness of AMD compared to New Zealand, as indicated below.

- AMD awareness in Australia in 2016: 82%.
- AMD awareness in New Zealand in 2016: 59%.

The awareness difference is approximately 23% between the two countries.

[9] In 2014 and 2016 respectively, 48% and 59% of adults aged over 50 years of age knew which part of the body is affected by macular degeneration (Personal communication, Macular Degeneration NZ, 2016).

Using similar methodology to above, the total benefit of increasing awareness of AMD in New Zealand to Australian standards was estimated to be $13.5 million, or 61 DALYs averted.

It is expected that awareness and education campaigns would experience diminishing marginal returns over time. This means that a 1% increase in awareness when awareness levels are already 80% would be more costly than a 1% increase in awareness when the awareness levels are 59%. MDNZ estimates that it will cost approximately $4.9 million to reach the targeted awareness levels (Personal communication, MDNZ).

An investment of $4.9 million in awareness raising campaigns has the potential to reap $13.5 million worth of benefits, a net gain of $8.5 million in 2016.

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Contact us

Deloitte Access Economics
ACN: 149 633 116

8 Brindabella Circuit
Brindabella Business Park
Canberra Airport ACT 2609

Tel: +61 2 6263 7000
Fax: +61 2 6263 7004

www.deloitteaccesseconomics.com.au

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To reduce the incidence and impact of
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Macular Degeneration New Zealand
PO Box 137070, Parnell, Auckland 1151
Helpline: 0800 622 852
www.mdnz.org.nz