The burden of disease and injury attributed to preventable risks to health in Western Australia, 2006

Western Australian Burden of Disease Study

Epidemiology Branch

Delivering a **Healthy WA**

The burden of disease and injury attributed to preventable risks to health in Western Australia, 2006

Epidemiology Branch
Public health Division
Department of Health, Western Australia

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[1] Public Health and Ambulatory Care, North Metropolitan Area Health Service
[2] Epidemiology Department, Department of Health
[3] Centre for International Health, Curtin University of Technology

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1.0 Executive Summary

Introduction
Measuring the impact of risk factors on disease outcomes at a population-level is vital to planning prevention activities that will impact on the health of the population.

This report quantifies the burden of disease and injury in Western Australia (WA) in 2006 that could have been prevented if nine preventable health risk factors were reduced to a level that is considered a theoretical minimum. The risk factors chosen were limited to public health priority areas, namely tobacco, alcohol, physical inactivity, illicit drugs, inadequate fruit and vegetable consumption, unsafe sex, high body mass, high blood pressure and high blood cholesterol.

This report highlights the significant health gains that could be achieved in WA through the reduction of selected risk and provides insight to the changing risk factor impact on population health.

Methods
Attributing burden to each risk factor involved the calculation of a Population Attributable Fraction (PAF), reflecting the proportion of current disease burden attributable to current and past exposure to the particular risk factor. The burden of disease was measured in Disability Adjusted Life Years (DALYs).

Many diseases are caused by multiple risk factors, and individual risk factors may interact in their impact on overall risk of disease. PAFs for individual risk factors often overlap and add up to more than 100 percent. This report provides estimates of individual risk factor contributions as well as the joint effects of multiple risks to health.

Key findings
High body mass ranked as the highest contributor to disease burden, accounting for 8.7% of the total burden of disease and injury in WA in 2006. High body mass contributed 2.2% more to the total burden than the next leading risk factor, tobacco (6.5%). The body mass burden impacted at a significantly younger age than the tobacco burden. The burden attributed to high body mass and tobacco were followed by physical inactivity (6.1%), high blood pressure (6.0%), high blood cholesterol (5.0%), alcohol harm (3.8%), inadequate fruit and vegetable intake (2.3%), illicit drug use (1.6%) and unsafe sex (0.5%).

An estimated 29.5% of the total burden of disease and injury in WA in 2006 was attributed to the joint effect of the nine risk factors (see Table 20 for more information). This highlights the significant burden of preventable risk factors on the health of the WA population and the health gains that could be achieved if exposure to these health risks were reduced.

Risk factors by age and gender

0-14 years: The preventable risk factors covered in this report do not account for the vast majority of the burden experienced by children. However, adult use of illicit drugs, alcohol and tobacco impacted on the health of children. Tobacco contributed to 1.1% of the burden in males and 1.3% of the burden of females, mostly due to the association with maternal smoking and low birth weight.

15-44 years: In males in this age category, over a quarter of the burden was caused by the nine risk factors. Alcohol was the leading cause of burden in young adult males, accounting for approximately 12% of the total burden. More than half of the alcohol burden was due to the injury associated with alcohol. Illicit drugs were the second leading risk factor in young adult males, accounting for 6.3% of the total burden.

The burden attributed to the nine risk factors accounted for 13.8% of the female total, with the burden attributed to alcohol and illicit drug use significantly less than that of males. The leading risk factor burden in females aged 15-44 years was high body mass, which contributed to 5.0% of the total burden.

45-64 years: Males in this age category had the largest burden attributable to the nine risk factors of any age group. The joint effects of these risk factors accounted for 43.1% of the total male burden. The impact of high body mass contributed 15.2% of the total burden. Tobacco was a significant preventable cause of the male burden, contributing 12.7% individually.

About 30% of the total burden in females aged 45-64 years could be attributed to the nine risk factors. The single biggest risk factor in females was high body mass, contributing 14.8% individually.

65 years and older: Approximately 39% of the total burden of disease and injury was experienced by persons in this age group. For both sexes, approximately one third of the total burden (36.2% in males and 33.3% in females) was attributed to the nine risk factors. The biggest single risk factor associated with the burden of disease in this age category was high blood pressure, contributing to 11.7% of the total male burden and 11.3% of the total female burden.

All ages:
A third (33.3%) of the male burden and a quarter (25.3%) of the female burden could be attributed to the nine studied risk factors. In both sexes, high body mass was the leading contributing risk factor.

Risk factors by broad disease group

Cancer: The nine risk factors together explained 30.7% of the total cancer burden. Tobacco was the largest contributor to the cancer burden.

Cardiovascular Disease: The nine risk factors combined accounted for 73.8% of the total cardiovascular burden. Individually, high blood pressure (40.1%), high blood cholesterol (34.2%), high body mass (22.9%) and physical inactivity (23.8%) contributed significantly to the burden.

Mental disorders: Alcohol and illicit drug use contributed to 16.1% of the total mental burden of disease.

Injury: Alcohol was responsible for 17.9% of the total injury burden. Illicit drug use contributed 3.4% to the injury burden. The combined attributable burden of alcohol and illicit drug use was 21% of the total injury burden.

Diabetes: The joint effects of physical inactivity and high body mass accounted for 71% of the total type II diabetes burden. Individually, high body mass contributed to 66% of the total burden of type II diabetes.

Communicable disease: Illicit drug use and unsafe sex accounted for 26.6% of the burden of communicable disease. Individually, illicit drug use contributed 16.8% of the burden through diseases such as Hepatitis C. Unsafe sex contributed almost 11% of the total communicable disease burden.

Key implications

High body mass was the largest contributing risk factor to disease burden in WA in 2006. The findings highlight the urgent need to reverse the increasing prevalence of high BMI to improve the health of the WA population. This study provides evidence of the decreasing burden occurring as a result of effective tobacco control, which needs to be maintained.

The nine risk factors studied were associated with 43.1% of the total burden of disease in males aged 45-64 years. Prevention in this age category will result in significant health gains. The alcohol burden significantly impacted on 15-44 year olds, particularly in males. Preventing alcohol related injury in young males remains a priority for public health interventions. In the 65 and older age category preventable risk factors associated with cardiovascular disease such as high blood pressure and high cholesterol impact significantly. Effective primary health care in this group could impact significantly on the burden of disease. The differing impact on specific age and sex categories reinforces the importance of a life course approach.

Almost three quarters of cardiovascular disease, one third of cancers and more than two thirds of diabetes could be prevented with the elimination of these nine risk factors.

2.0 Introduction

Quantifying the impact that risk factors have on disease outcomes is fundamental to planning prevention activities. However, assessment of risk factors and their impact has been limited by an inability to compare risks and their impact on different diseases. The comparative risk assessment (CRA) framework developed by the Global Burden of Disease study (Ezzati et al 2004a, 2004b) provides a systematic evaluation of the changes in population health which would result from modifying the population distribution of exposure to a group of risk factors. This report quantifies the impact of selected preventable risk factors to health on the burden of disease and injury in Western Australia (WA) in 2006.

Three data components are required for a CRA:

1. A list of diseases that have a known relationship with a particular risk factor;
2. An estimate of the burden from these diseases in the population; and
3. Population Attributable Fraction (PAF), the proportional reduction of disease burden occurring if exposure to a risk factor were reduced to an alternative ideal exposure scenario (e.g. no tobacco use).

The population burden of each disease was estimated in Disability Adjusted Life Years (DALYs), a metric first developed in the 1990s to provide information to support health policy and priority setting at a global level. This approach was subsequently applied to the Australian setting.

Australia's first national burden of disease and injury report, including risk factor analysis, was based on data from the year 1996 (Mathers et al 1999). In WA, a series of technical bulletins on WA's burden of disease were published over 2003-2004, including an analysis of modifiable risk factors (Somerford et al 2004). Since the publication of these reports, techniques to attribute health outcomes to health risk factors have advanced considerably, using CRA. The Australian Burden of Disease (BoD) 2003 project (Begg et al 2007) was the first Australian study to use the CRA methods and assumptions. This report presents the first Western Australian analysis based on the CRA methods and assumptions used in both the Global (Ezatti et al 2004a) and the Australian 2003 (Begg et al 2007) BoD studies.

This analysis quantifies the burden of disease and injury in 2006 that could have been prevented if nine health risk factors were reduced to a level that is considered a theoretical minimum. The risk factors chosen are by no means comprehensive. Where possible, WA prevalence data has been used to derive PAFs to calculate the burden associated with each risk factor. The 2003 burden of disease study included select risks based on the availability of the following:

1. Good evidence of a causal association between the risk factor and the health outcomes
2. Current estimates from reputable epidemiological studies of the relative risk involved
3. Reliable estimates of risk factor prevalence in the Australian population.

The risks were further limited to Public Health Priority areas as listed in Table 1.

Table 1: Nine selected risk factors on health discussed in this report

Lifestyle behaviours	Physiological states
1. Tobacco 2. Alcohol 3. Physical inactivity 4. Illicit drug use 5. Inadequate fruit and vegetable consumption 6. Unsafe sex	7. High body mass 8. High blood pressure 9. High blood cholesterol

This report highlights the significant health gains that could be achieved in WA through selected risk factor reduction and provides insight to the changing risk factor impact on the health of the WA population.

3.0 Methods used to attribute risk

The key advances of the CRA approach over previous attempts to attribute burden to health risk factors are:

1. A consistent theoretical framework that uses a 'hypothetical minimum' distribution as the 'counterfactual' against which burden due to a risk is calculated. For example, with tobacco the hypothetical minimum is zero, or the whole population being non-smokers. For other exposures, such as blood pressure, cholesterol, body mass index, a zero exposure is inappropriate. For these exposures, the hypothetical minimum is based on randomized controlled trial evidence and epidemiological studies. For example, the hypothetical minimum distribution for systolic blood pressure (SBP) has a mean of 115mmHg and a standard deviation of 6mmHg. The risk attributed to high blood pressure is calculated using the proportion of the population with a SBP >115mmHg that is outside this distribution. In the past, risk was attributed to the proportion of the population with blood pressure above a single threshold value (e.g. 140mmHg).
2. Inclusion of continuous risk variables that were previously examined categorically. This takes into account the full range of risk of variables such as high blood pressure, high cholesterol, high BMI and inadequate fruit and vegetable intake, rather than defining thresholds for high blood pressure, high cholesterol and overweight. Previous categorisation of risks into normal and abnormal was likely to underestimate the population attributable burden. The elevation in risk at levels of exposure below abnormal cut off points may be small; however, the large numbers of people at these levels contribute substantially to the total population attributable risk.
3. A more systematic review of the international literature on the impact of risk factors on health outcomes, including estimates of relative risk for a unit increase in continuous risk factors.
4. A theoretical framework and provisional methods for estimating the joint effects of multiple risk factors to health has been developed. Previous

approaches examined each risk factor on its own, without taking into account that many risk factors act through modifying other risk factors. The CRA method allows the burden to be attributed to the nine risk factors combined. For example, physical inactivity can lead to high body mass index, which can then cause high blood pressure and result in cardiovascular disease. The complex causal paths mean that the combined burden attributed to the nine risk factors is not the sum of the risks. Using the 'joint effects' method causal relationships more distal (risk factors that act by modifying other risk factors) in the pathway are modified to produce an estimate of the combined burden. Further information on the joint effects method is available from Begg et al (2007) and Ezzati et al (2004b).

As outlined earlier, the main methods of the CRA involve calculating a PAF. The population attributable fraction (PAF) is a subtype of a more general measure—the 'potential impact fraction' (PIF). The PIF measures the proportional reduction in disease or injury burden experienced by a population that would occur if the population were subjected to an alternative or 'counterfactual' distribution of exposure to a particular health risk. If the alternative exposure scenario is set to a level such that it represents the lowest possible risk in a population (no exposure, for example), the PIF represents the total amount of burden that is attributable to that risk; in this instance it is called the 'population attributable fraction' (Eide & Heuch 2001; Miettinen 1974). For health risks that are measured on a continuous scale, the PIF can be defined thus:

$$PIF = \frac{\int_{x=0}^{m} RR(x)P(x)\,dx - \int_{x=0}^{m} RR(x)P'(x)\,dx}{\int_{x=0}^{m} RR(x)P(x)\,dx}$$

Where RR(x) = relative risk at exposure level, P(x) = population distribution of exposure, P'(x) = counterfactual distribution of exposure, and m = maximum exposure level

(Equation 1)

When a risk is measured on a categorical scale, the discrete version of the PIF formula is (Eide & Heuch 2001; Walter 1980):

$$PIF = \frac{\sum_{c} P_c RR_c - \sum_{c} P_c^{*} RR_c}{\sum_{c} P_c RR_c}$$

Where c = an index for category, P = prevalence, and P* = prevalence after a change, and RR = relative risk

(Equation 2)

The difference between Equation 1 and Equation 2 in practical terms is that the latter can easily be resolved in a spreadsheet environment, whereas the former requires more advanced mathematical techniques. Equation 2 is mathematically the same as the PAF formula for risk factors with multiple categories given by English and colleagues (Equation 3), if the counterfactual is set as the hypothetical minimum distribution (English et al. 1995).

$$PAF = \frac{\sum_c P_c(RR_c - 1)}{\sum_c P_c(RR_c - 1) + 1}$$

(Equation 3)

The relative risk (RR) is the ratio of the chance of a disease developing among members of a population exposed to a risk factor compared with a similar population not exposed. The RR is modified by the duration and intensity of exposure. The current study used the same RRs as the Australian 2003 study (Begg et al 2007). Exposure was calculated from the estimated prevalence of the risk factor in the WA population. Prevalence data for high body mass, tobacco use and fruit and vegetable intake were obtained from the 2006 WA Health & Wellbeing Surveillance System [HWSS] (Wood & Daly 2007), a continuous data collection system conducted as a Computer Assisted Telephone Interview (CATI). Prevalence data for alcohol consumption and physical activity were taken from the WA data in the 2004-2005 National Health Survey (ABS 2005). There are no measured WA prevalence estimates for blood pressure and cholesterol, therefore, national data collected in 2000 as part of the AusDiab study (Dunstan et al 2002a), were used to estimate exposures of these risk factors.

The burden of disease was measured in disability adjusted life years (DALYs). The DALY is a health gap measure providing information on years of life lost due to premature mortality (YLL) and the equivalent healthy years lost due to disability (YLD) for a specific health condition. A DALY is comparable across different risk factors and diseases, and can be disaggregated by disease, sex, age, geography and ethnicity. The equation for the DALY in its simplest form (i.e. without age weighting or discounting) is:

DALY= YLL + YLD (Equation 4)

where YLL = number of deaths × standard life expectancy at age of death and
YLD = disease incidence × duration × severity weight.

The attributable burden of a particular disease due to the risk factor *AB* is then calculated as:

AB= PAF x C (Equation 5)

where C is the total burden of disease from a specific cause.

To estimate the total DALYs due to a risk factor, the attributable burden from each specific cause is added.

Mortality data for WA in 2006 were used to determine the YLL for 2006. YLD were derived by applying WA trend information to the 2003 baseline disease models

developed by the Australian BoD study (please see Appendix 2 for more information on the method).

Example of a calculation of attributable burden in DALYs

In 2006 in the male 20-24 year old age category there were 407 YLL to suicide and self-inflicted injury. The RR for suicide and self-inflicted injury is 1.40 for those with low levels of alcohol intake, 2.32 for hazardous drinkers of alcohol and 2.52 for harmful drinkers of alcohol, as compared to a RR of 1 for abstainers. The prevalence of drinking alcohol in males aged 20-24 is; 27% no alcohol intake, 42% low intake, 13% hazardous intake and 19% harmful intake[1]

The PAF for suicide and self-inflicted injury in males aged 20-24 years is calculated as follows using Equation 3:

$$PAF = \frac{[0.42*(1.4-1)]+[0.13*(2.32-1)]+[0.19*(2.52-1)]}{[0.42*(1.4-1)]+[0.13*(2.32-1)]+[0.19*(2.52-1)]+1}$$

$$PAF = 0.386$$

The attributable burden for YLL is then calculated, using Equation 5 and the PAF calculated above:

$$AB = 0.386*407$$
$$AB = 157 \text{ YLL}$$

Therefore 157 YLL from suicide and self inflicted injuries were attributed to alcohol in males aged 20-24 years. The YLD are calculated in the same manner and added to the YLL to give the total suicide & self-inflicted DALYs attributed to alcohol consumption in males aged 20-24 for WA in 2006. The DALYs from each specific disease attributed to alcohol are then calculated using the same method shown and added together to give the total DALYs attributable to alcohol.

The development of a disease often includes multiple factors at different stages of the causal chain of that disease. Distal factors are risk factors that occur earlier in the causal chain, acting through proximal factors, which are closer in time to the disease outcome. Individual risk factors may interact in their impact on overall risk of disease, with PAFs for individual risk factors often overlapping and adding up to more than 100 percent. Some of the effects of more distal factors (e.g. physical inactivity) are mediated through more proximal factors (e.g. high BMI and high blood pressure). Estimating the joint effects of more distal and proximal factors requires knowledge of independent hazards of the distal ones and the amount of risk mediated through proximal factors. The joint effects calculation gives an estimation of the total combined burden of disease attributed to the nine risk factors.

[1] Note: Prevalences are rounded to the closest integer to simplify the example shown.

4.0 Individual contribution of the nine selected risk factors to health

4.1 High body mass

Methods

Body mass index (BMI) is the most widely accepted population-level indicator of body fat (WHO 2000). BMI is highly correlated with fat mass (NHMRC 2003). BMI is a measure of weight in kilograms over height in metres squared. BMI is usually categorised into under weight (< 18.5), normal weight (18.5-24.9), over-weight (25.0 -<30) and obese (>30) [NHMRC 2003]. In CRA, the health effects of high body mass were calculated against BMI measured on a continuous scale. Analysis of the relationship between BMI and mortality and morbidity suggest that the theoretical optimum population mean is approximately 21kg/m^2, with a standard deviation (SD) of 1 kg/m^2 (Ezzati et al 2004b). The risk associated with high body mass is attributed to all people in the population with a BMI of greater than 21. People in the "normal" weight category (above BMI of 21) have risk attributed to high body mass and contribute to the burden of disease.

The calculation of the PAF attributed to high body mass requires WA age and sex specific prevalence estimates of body mass and estimates of the RR associated with high body mass and diseases.

The prevalence estimates of high body mass were obtained from the 2006 WA HWSS (Wood & Daly 2007). In 2006, 4797 people aged 30 years or over in WA provided a self-reported height and weight. A limitation of self-reported data is that survey respondents have been shown to underestimate their weight and overestimate their height (Hayes et al 2008, Taylor et al 2006). To overcome this limitation, the prevalence data were corrected to account for the self report error using the method documented by Hayes et al (2008, p 545) and shown in Figure 1, enabling a corrected BMI to be calculated.

Figure 1: Corrections used for BMI (cBMI)

$$\text{Male BMIc} = \frac{1.022 * \text{srweight} + 0.07}{(0.00911 * \text{srhieght} + 0.2095)2}$$

$$\text{Female BMIc} = \frac{1.04 * \text{srweight} - 0.067}{(0.00863 * \text{sr height} + 0.2095)2}$$

sr=self-reported

The corrected means and standard deviations used are shown in Table 2.

Table 2: Western Australian population mean BMI and standard deviations by gender and age from the Health and Wellbeing Surveillance System, corrected for self-report error, 2006.

		Age				
Sex		**30-44**	**45-59**	**60-69**	**70-79**	**80+**
Males	Mean	28.0	28.7	28.6	27.4	26.5
	SD	5.3	5.2	6.5	5.1	5.2
Females	Mean	27.4	27.8	28.7	27.2	25.7
	SD	7.3	7.1	7.4	5.8	5.2

In this report, estimates of RR per unit increase of BMI for specific diseases were the same as those used in the Australian study, and are described in Ezzati et al (2004a). The disease outcomes assessed in relation to high body mass index were type II diabetes, ischaemic heart disease (IHD), stroke, hypertension, hypertensive heart disease, osteoarthritis and cancer of the postmenopausal breast, colon and endometrium. Analysis of cohort studies provided estimates of incremental risk associated with each unit increase in BMI above 21 kg/m^2. Conditions that were excluded due to insufficient data or evidence included sleep apnoea, back pain, dermatitis, reactive depression and social isolation, menstrual disorders, infertility and gall bladder disease.

Results

Overall, high body mass was responsible for 8.7% of the total burden of disease and injury in WA in 2006 (Table 3), with the mortality component based on 901 deaths. Type II diabetes accounted for approximately half of the burden (Table 3), followed by IHD. High body mass was the single biggest modifiable risk factor adversely affecting the health of the WA population. In past WA and Australian BoD studies (Mathers et al 1999, Begg et al 2007, Somerford et al 2004), tobacco was the leading risk factor adversely impacting on health.

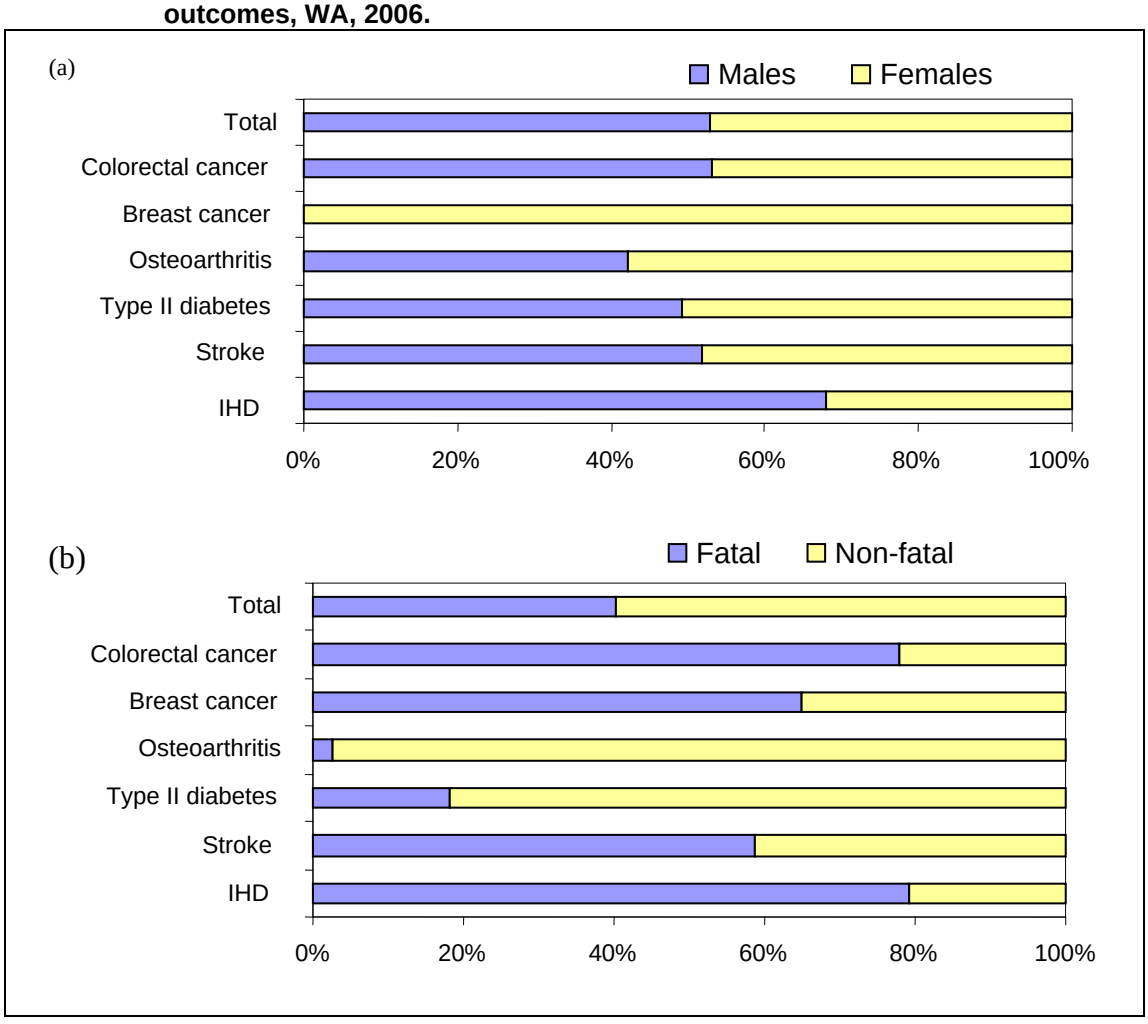
The percentage of burden attributed to obesity was higher than found in the Australian BoD study in 2003 (Begg et al 2007), which attributed 7.5% of the total burden to this risk factor. However, comparisons should be interpreted with caution because of methodological differences in obtaining disease estimates. The higher WA burden is in part due to the higher prevalence estimates of BMI obtained from the HWSS in 2006 compared to the previous estimates used in the 2003 Australian study, which were obtained from the AusDiab study. The AusDiab study used physical measures taken in 2000 to calculate BMI (Dunstan et al 2002), as opposed to corrected self-reported height and weight used in the current study.

Table 3: Deaths and burden (DALYs) attributable to high body mass by specific cause and specific disease cause as proportion of total body mass burden, WA, 2006.

Specific cause	Deaths		DALYs		Percentage of high body mass burden
	Number	Percent of total	Number	Percent of total	
IHD	433	3.8	6,166	2.5	28
Stroke	129	1.1	2,074	0.8	10
Type II diabetes	184	1.6	10,517	4.2	48
Osteoarthritis	4	0.0	850	0.3	4
Breast cancer	35	0.3	745	0.3	3
Colorectal cancer	59	0.5	875	0.4	4
Other	56	0.5	513	0.2	2
Total attributable	**901**	**7.9**	**21,741**	**8.7**	**100%**

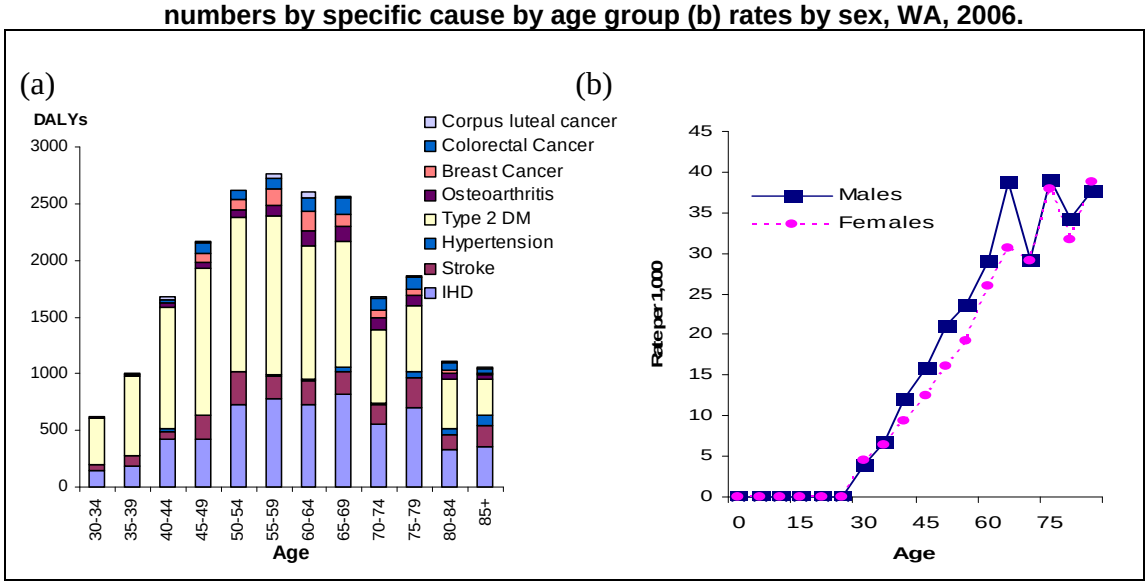
The higher burden of disease attributed to high BMI in males than females is associated with the higher burden of IHD (Figure 2). Over half (56%) of the burden due to high body mass was due to morbidity. This relatively high non-fatal component reflects the 82% of the type II diabetes burden (the highest contributor to this factor) that is non-fatal.

Figure 2: Burden (DALYs) attributable to high body mass expressed as (a) proportions by sex, and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



In terms of absolute burden (the crude number of DALYs per age category), those in the 50-65 year age groups (Figure 3a) experienced the highest burden due to high body mass: this reflects the higher number of people in those age groups, compared to the older age categories. The rates of burden (Figure 3b) attributable to high body mass were negligible until age 30, and then increased, with the highest rates in the older age groups.

Figure 3: Burden (DALYS) attributable to high body mass by age expressed as (a) numbers by specific cause by age group (b) rates by sex, WA, 2006.



Type 2 DM= Type 2 Diabetes Mellitus

4.2 Tobacco

Methods

There is a long lag time between smoking exposure and the development of smoking-related cancers and chronic obstructive pulmonary disease (COPD). Therefore, to calculate a PAF for these diseases, current smoking prevalence is not a reliable method. To overcome this problem, the method developed by Peto et al (1992) was used to calculate a smoking impact ratio from 2006 age and gender specific lung cancer rates in WA.

For diseases other than cancer and COPD, the lag time between exposure to tobacco and the adverse health outcome is shorter. Therefore, 2006 prevalence was used to calculate a PAF, with known RR. The prevalence estimate of tobacco use was obtained from the 2006 WA HWSS (Wood & Daly 2007). The HWSS surveyed 5327 Western Australians about their smoking status. Respondents were classified as smokers if they responded to a question about their smoking status with "I smoke daily." The prevalence estimates for WA in 2006 are shown in Table 4.

The prevalence of maternal smoking in WA was taken from the Midwives' Notification System for the year 2006 (Laws and Hilder 2008). Nearly 1 in 6 (17.5%) women smoked during their pregnancy in WA. This maternal smoking prevalence was also used to calculate PAF attributed to exposure of infants to environmental

tobacco smoke (ETS). The assumption made was that smoking in pregnancy is a reasonable proxy for postnatal smoking.

Estimates of the relative risks used to calculate the PAFs were the same as those used in the Australian BoD study (Begg et al 2007).

Table 4: Prevalence of smoking by age and sex in WA in 2006 from the Health and Wellbeing Surveillance System.

Age group	MALES		FEMALES	
	% smokers	% non-smokers	% smokers	% non-smokers
34 and under	15.1	84.9	13.7	86.3
35-39	22.8	77.2	17.2	82.8
40-44	21.8	78.2	16.2	83.8
45-49	17.0	83.0	17.6	82.4
50-54	17.5	82.5	10.6	89.4
55-59	12.9	87.1	10.2	89.8
60-64	13.1	86.9	7.5	92.5
65-69	6.7	93.3	5.8	94.2
70-74	7.4	92.6	7.8	92.2
75-79	3.1	96.9	3.4	96.6
80+	4.5	95.5	1.1	98.9

Results

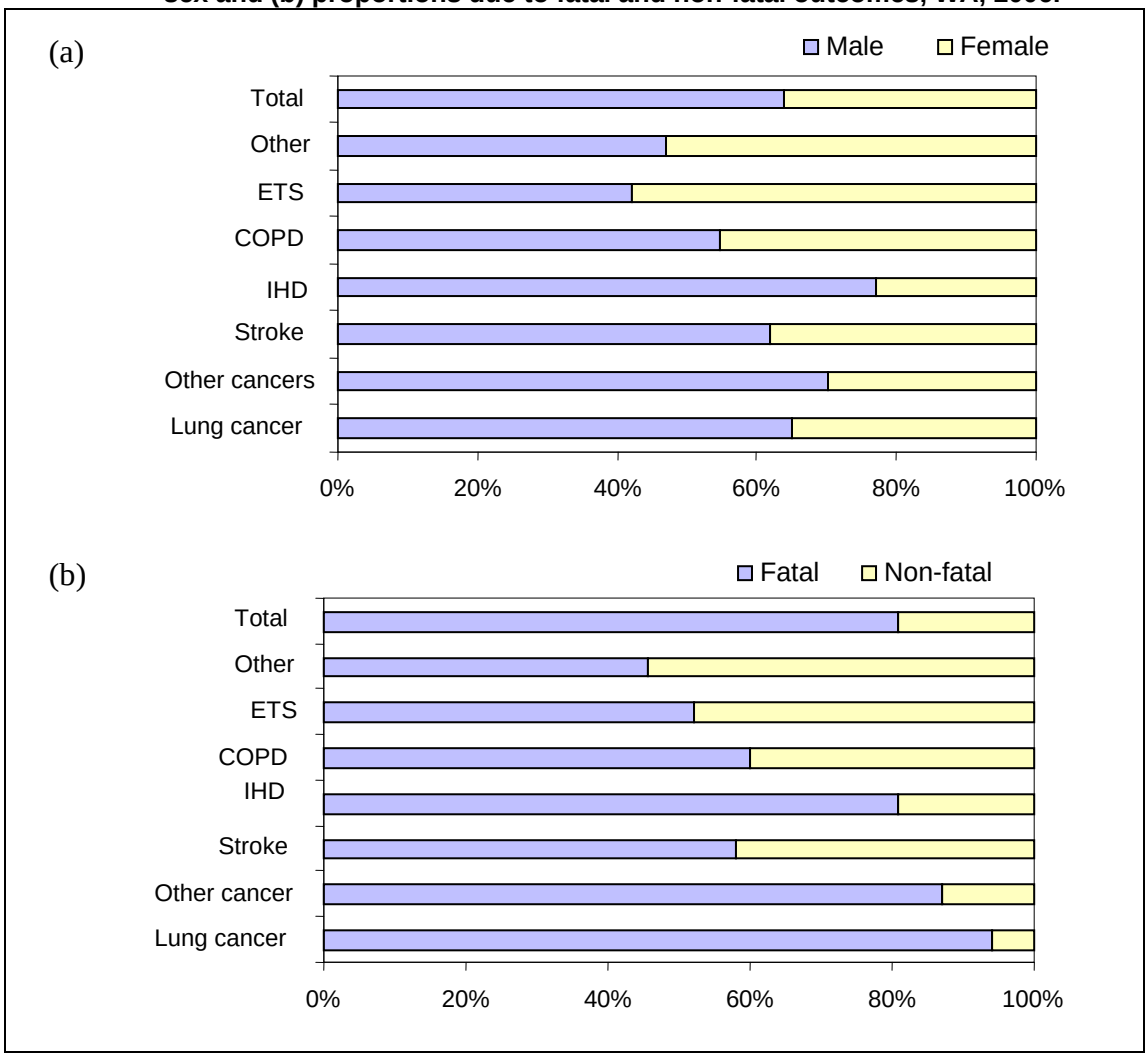
Tobacco is associated with increased risk of a range of conditions including lung and other cancers, cardiovascular disease and COPD. Exposure to ETS is associated with sudden infant death syndrome (SIDS), asthma, passive IHD and passive lung cancer.

Tobacco was responsible for 6.5% of the total burden of disease in WA in 2006. Tobacco was estimated to have caused 1295 deaths in 2006, or 11.4% of the total in WA. Lung cancer and COPD are the largest contributors to the disease burden attributed to tobacco, accounting for approximately two thirds of the total tobacco burden (Table 5).

Table 5: Deaths and burden (DALYS) attributed to tobacco by specific cause and specific disease burden as proportion of total tobacco burden, WA, 2006

Specific cause	Deaths		DALYs		Percentage of tobacco burden
	Number	Percent of total	Number	Percent of total	
Lung cancer	627	5.5	7,015	2.8	43
Other cancers	223	1.9	2,520	1.0	15
Stroke	32	0.3	737	0.3	5
IHD	110	1.0	1,865	0.7	11
COPD	287	2.5	3,690	1.5	23
ETS	13	0.1	296	0.1	2
Other	4	0.0	167	0.1	1
Total	**1,295**	**11.4**	**16,290**	**6.5**	**100**

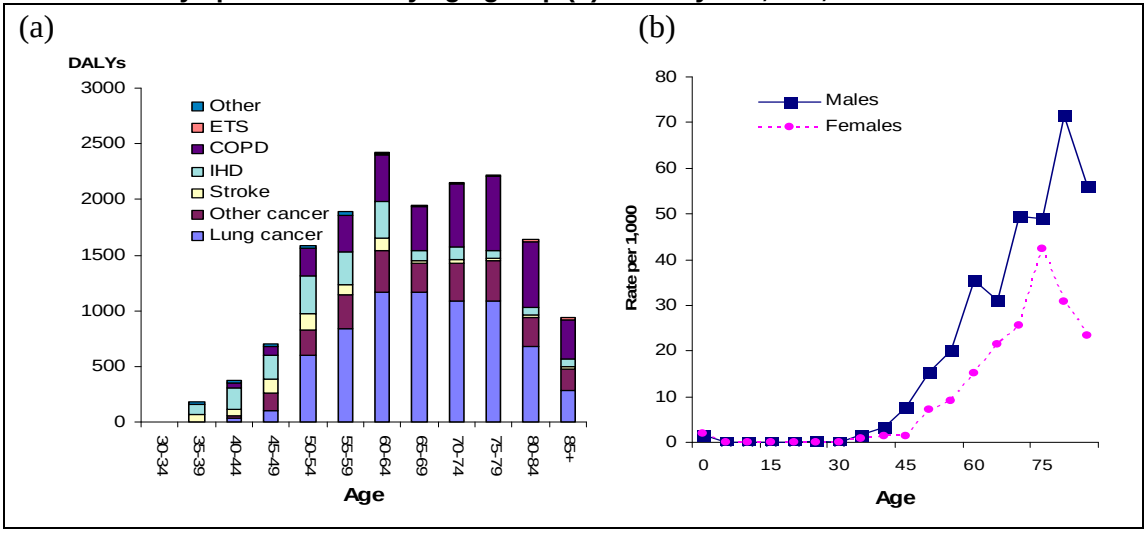
Figure 4: Burden (DALYs) attributable to tobacco expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



Almost two-thirds (64%) of the total burden attributed to tobacco occurred in men (Figure 4a), reflecting the higher current and historical prevalence of tobacco smoking in males. The burden associated with tobacco was predominantly (81%) mortality burden (Figure 4b).

In absolute numbers, the largest burden of DALYs was in the 55 to 75 year old age group. The rates of the tobacco-related burden (Figure 5b) increased steeply after age 35. The highest female rate occurred at age 75. Males have consistently higher rates than females of a similar age, reaching the highest rate at age 80 years.

Figure 5: Burden (DALYS) attributable to tobacco by age expressed as (a) numbers by specific cause by age group (b) rates by sex, WA, 2006.



4.3 Physical Inactivity

Methods

The physical activity guidelines for Australian adults recommend the minimum amount of activity needed to enhance health (Department of Health and Ageing 2005). The definition of the physical activity levels are shown in Table 6. The recommended level remains an important population health target; however, high-level activity offers additional health protective effects above those gained from recommended levels of physical activity. For the purpose of this study, the theoretical minimum exposure used was the entire population participating in high levels of physical activity. The prevalence data was derived from the WA data in the 2004-2005 National Health Survey (NHS) [ABS 2005]. The NHS included physical activity information from 1704 Western Australians who were aged 15 and over. The results of this prevalence data are summarised in Table 7. The majority of Western Australians did not meet the recommended level of physical activity.

Table 6: Definitions of levels of physical activity

High	defined as 3x40 minutes vigorous activity **AND** total energy expenditure of at least 1500 MET[2] mins
Recommended	3x20 minutes vigorous **OR** 5 x 30 minutes moderate **OR** 600 MET mins
Insufficient	some activity but not meeting recommendation
Inactive	No leisure time

[2] MET (metabolic equivalent) is an estimate of energy expenditure and one MET represents the metabolic rate of an individual at rest

Table 7: Western Australians physical activity levels by age and gender from the 2004-2005 National Health Survey.

Sex	Activity Levels	Age in years					
		15-29	30-44	45-59	60-69	70-79	80+
Males	HIGH	13.1	8.9	3.7	2.3	1.5	3.0
	RECOMMENDED	30.3	23.8	25.9	40.7	22.7	15.2
	INSUFFICIENT	31.4	35.5	34.7	31.4	30.3	33.3
	INACTIVE	25.1	31.3	35.6	25.6	45.5	48.5
Females	HIGH	3.0	3.3	3.8	1.2	2.0	0.0
	RECOMMENDED	29.0	23.8	28.1	28.4	12.9	9.4
	INSUFFICIENT	44.0	42.9	41.3	42.0	36.6	29.7
	INACTIVE	23.8	29.6	26.8	28.4	48.5	60.9

The RRs associated with physical inactivity and disease states were the same as those used in the Australian 2003 BoD study (Begg et al 2007) and the Global study (Ezzati et al 2004a). The disease end-points considered for inclusion were IHD, stroke, several site specific cancers (colon, rectal, breast, prostate), type II diabetes, various musculoskeletal conditions (lower back pain, osteoarthritis, osteoporosis), falls and depression. However, only five of these disease end points had adequate evidence of a causal association between physical inactivity, a biologically plausible mechanism to explain the association and sufficient information available to allow quantification of the risk. The diseases included were IHD, stroke, type II diabetes, breast cancer and colon cancer.

Results

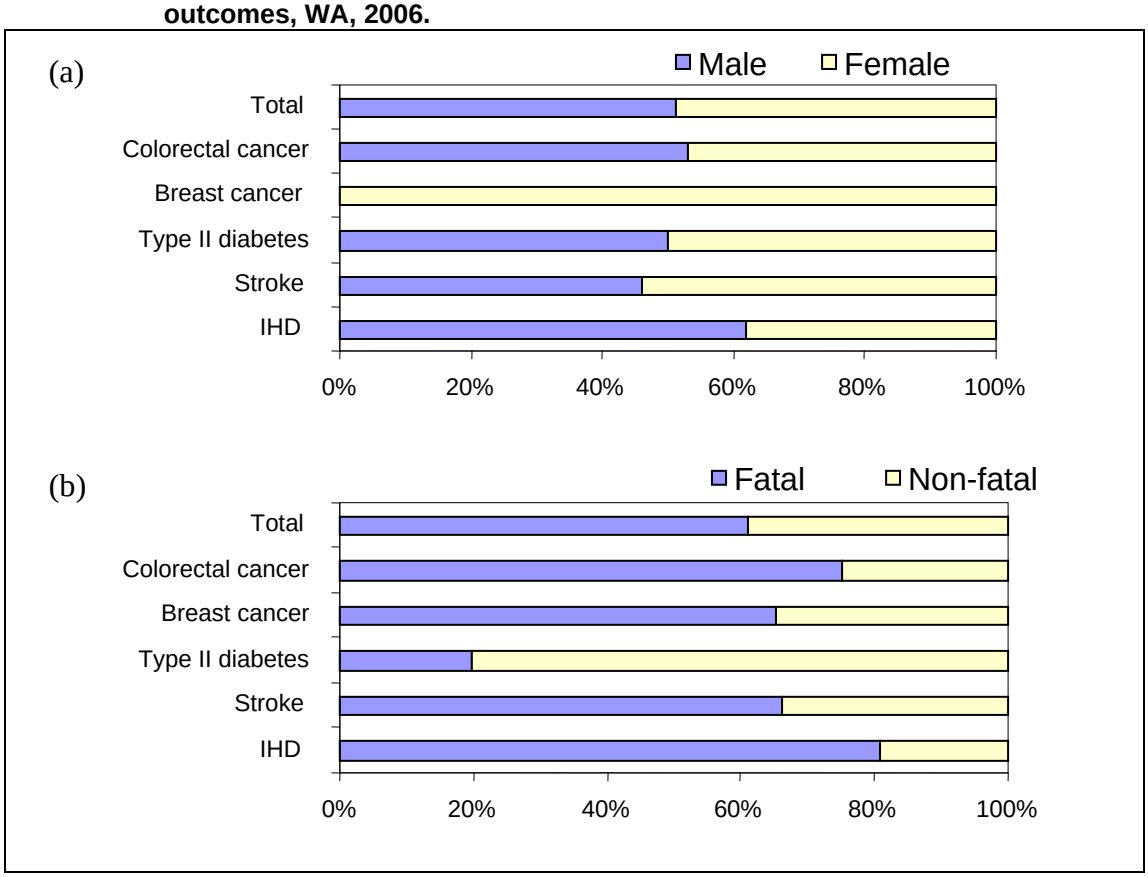
Physical inactivity was responsible for 6.2% of the total burden of disease and injury experienced by the WA population in 2006. The associations between physical inactivity and both cardiovascular disease and type II diabetes were responsible for about 85% of this burden. Breast and colorectal cancer were responsible for the remainder of the burden (Table 8). Physical inactivity was attributed to 1067 Western Australian deaths in 2006.

Table 8: Deaths and burden (DALYS) attributed to physical inactivity by specific cause and specific disease burden as proportion of total physical inactivity burden, WA, 2006.

Specific cause	Deaths		DALYs		Percentage of physical inactivity burden
	Number	Percent of total	Number	Percent of total	
IHD	673	5.9	6,956	2.8	46
Stroke	183	1.6	1,920	0.8	13
Type 2 Diabetes Mellitus	84	0.7	4,034	1.6	26
Breast cancer	50	0.4	1,187	0.5	8
Colorectal cancer	78	0.7	1,146	0.5	8
Total attributable	**1,067**	**9.3**	**15,243**	**6.1**	**100**

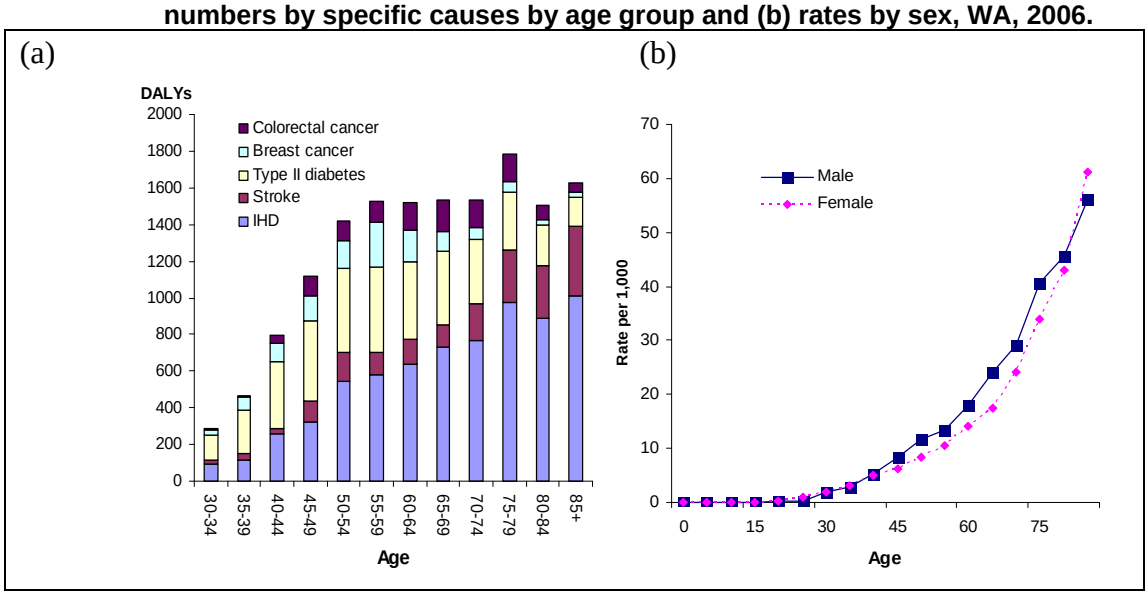
The total burden attributed to physical inactivity was approximately equal amongst males and females. The majority (61%) of the physical inactivity burden manifested as mortality burden (Figure6b). The mortality burden dominated in all diseases associated with physical inactivity, except type II diabetes.

Figure 6: Burden (DALYs) attributable to physical inactivity expressed as (a) proportions by sex, and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



In absolute numbers, the highest burden of disease was in the 75-79 year age group (Figure 7a). The rates in males and females were similar, increasing to a peak rate in old age (Figure 7b).

Figure 7: Burden (DALYs) attributable to physical inactivity expressed as (a) numbers by specific causes by age group and (b) rates by sex, WA, 2006.



4.4 High blood pressure

Methods

High blood pressure is a risk factor in the development of cardiovascular disease. There is evidence of a causal relationship between high blood pressure and stroke, IHD, hypertensive heart disease and other cardiac disease (Ezzati et al 2004a). The relative risks of these diseases were taken from the CRA (Ezzati et al 2004a). There is also evidence for an etiological role for blood pressure in the progression of renal failure (Ezzati et al 2004a). However, a burden of disease study maps diseases to International Classification of Diseases (ICD) codes. There is no specific renal failure category as renal failure causes are distributed to underlying causes such as nephritis and nephrosis and diabetes mellitus. The 'nephritis and nephrosis' category includes a wide range of more diverse renal conditions. Therefore, apart from the 'hypertensive renal disease' incorporated into hypertensive disease, analysis of renal failure as an endpoint could not be included in this study.

The definition for high blood pressure is a systolic blood pressure (SBP) above 140mmHg (National Heart 2008). However, for the purpose of the burden of disease study, the theoretical minimum SBP was estimated to be 115mmHg, with a standard deviation of 6mmHg. This estimate was based on levels where cardiovascular outcomes are observed and consistent with SBPs in populations where no cardiovascular disease occurs. Evidence from clinical trials indicates reductions in stroke incidence after lowering blood pressure by about 10mmHg in those with a mean SBP of 125mmHg (Ezzati et al 2004a). The risk attributed to high blood pressure was, therefore, calculated in persons with a SBP >115mmHg aged 30 years and over, ages at which excess risk of cardiovascular outcomes are known to exist.

There is no recent WA study to estimate distributions of blood pressure by age and sex. The AusDiab study was used to estimate distributions of blood pressure in the WA population. Despite methodological concerns, including only 55.3% of eligible

people attending for a blood pressure measurement (Dunstan et al 2002b), AusDiab remains the only recent study to measure blood pressure in the Australian population.

Table 9: Age and sex prevalence estimates of blood pressure (mmHg) in Australia (AusDiab)

		Age				
		30-44	45-59	60-69	70-79	80+
Males	**mean**	124	131	140	148	154
	SD	11	16	17	19	19
Females	**mean**	115	126	138	146	150
	SD	12	17	19	22	21

Results

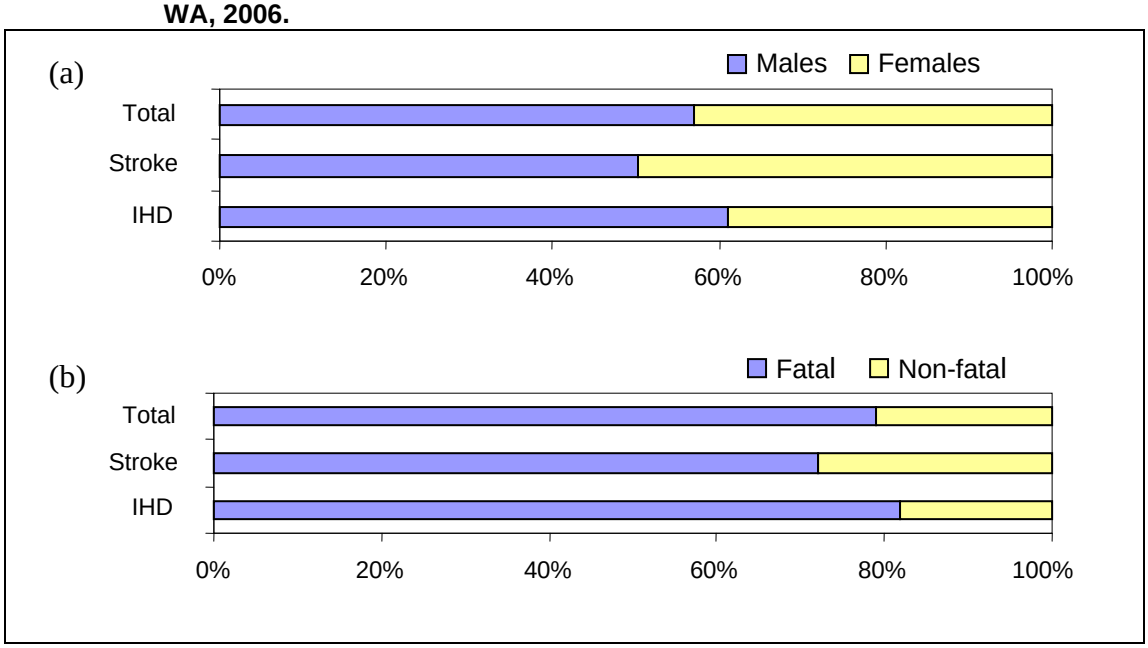
High blood pressure was responsible for 6.0% of the total burden of disease and injury in WA in 2006, of which IHD and stroke accounted for 93%. Approximately 1644 deaths (14.3% of total) were attributed to high blood pressure, accounting for more deaths in WA than any other risk factor studied and reflected in mortality contributing to a high percentage of the total burden.

Table 10: Deaths and burden (DALYs) attributable to high blood pressure by specific cause and specific disease as proportion of total BP burden, WA, 2006.

	Deaths		DALYs		
Specific cause	**Number**	**Percent of total**	**Number**	**Percent of total**	**Percentage of total high BP burden**
IHD	1,045	9.1	9,404	3.8	63
Stroke	468	4.1	4,479	1.8	30
Hypertensive Heart Disease	100	0.9	551	0.2	4
Other CVD	30	0.3	543	0.2	4
Total attributable	**1,644**	**14.3**	**14,978**	**6.0**	**100**

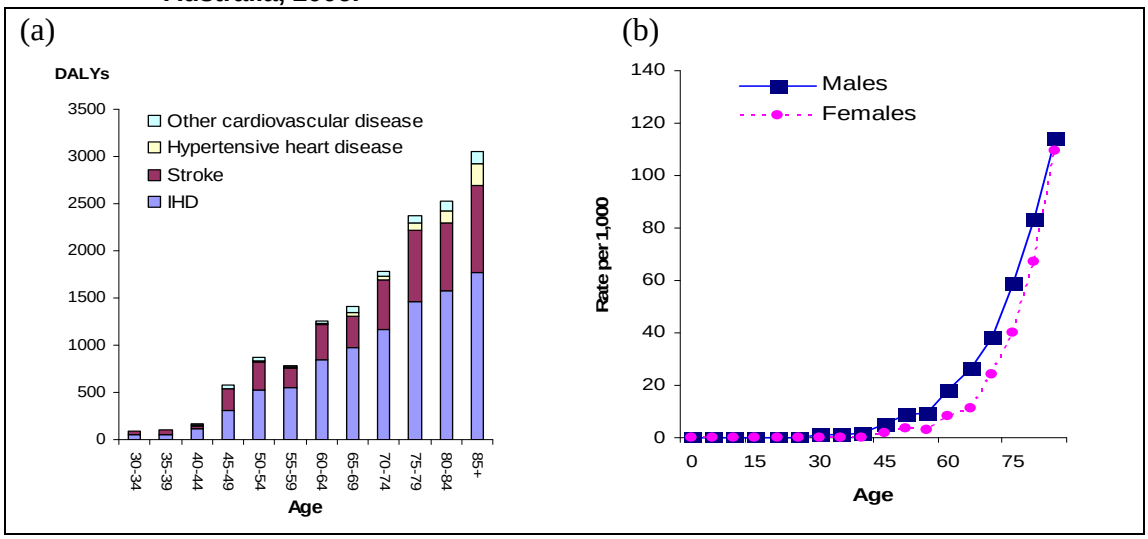
Males accounted for 57% of the total burden due to high blood pressure; this was associated with the larger IHD burden in men (Figure 8a). The high mortality burden of high blood pressure attributed to the large number of years of life lost due to IHD**.**

Figure 8: Burden (DALYs) attributable to high blood pressure expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



The DALYs contributed by high blood pressure commenced at age 30 years. The absolute burden from high blood pressure peaked in old age (Figure 9a), reflecting the cardiovascular burden that occurs in this age group. After age 60 years, the rates rose dramatically to reach the highest rate in the 85 years plus age group. The rates of DALYs attributed to high blood pressure were slightly higher in the male population (Figure 9b).

Figure 9: Burden (DALYs) attributable to high blood pressure by age expressed as (a) numbers by specific cause by age group and (b) rates by sex, Western Australia, 2006.



4.5 High cholesterol

Methods

Cholesterol is a lipid (fat-like) molecule produced by the body to fulfill a number of important functions; increased blood cholesterol levels are associated with IHD and ischaemic stroke. While there are different types of cholesterol and different associations with disease, the majority of descriptive and epidemiological data are available only for total cholesterol levels (Ezzati et al 2004a). Therefore, cholesterol was analysed as total cholesterol.

The RRs used in this study were obtained from the CRA project (Ezzati et al 2004a). The theoretical minimum risk distribution of cholesterol was taken as a mean of 3.8mmol/l, with a standard deviation of 0.5mmol/l. The main basis for this estimate was:

1. The level of cholesterol down to which epidemiological relationships with cardiovascular disease outcomes are documented.
2. Clinical trials showing benefits from cholesterol lowering among those with below-average cholesterol levels.
3. Consistency with cholesterol levels in populations with little cardiovascular disease.

As with high blood pressure, no recent WA study has been conducted to estimate distributions of blood pressure by age and sex. Therefore, the AusDiab study (Dunstan et al 2002a) was used to estimate distributions of blood pressure in the WA population (Table 11).

Table 11: Age and sex prevalence estimates for total cholesterol levels (mmol/L) used in calculations (AusDiab)

		Age				
		30-44	**45-59**	**60-69**	**70-79**	**80+**
Males	**mean**	5.5	5.8	5.6	5.6	5.3
	SD	0.7	0.7	0.6	0.6	0.6
Females	**mean**	5.2	5.8	6.0	6.1	5.9
	SD	0.6	0.7	0.6	0.6	0.6

Results

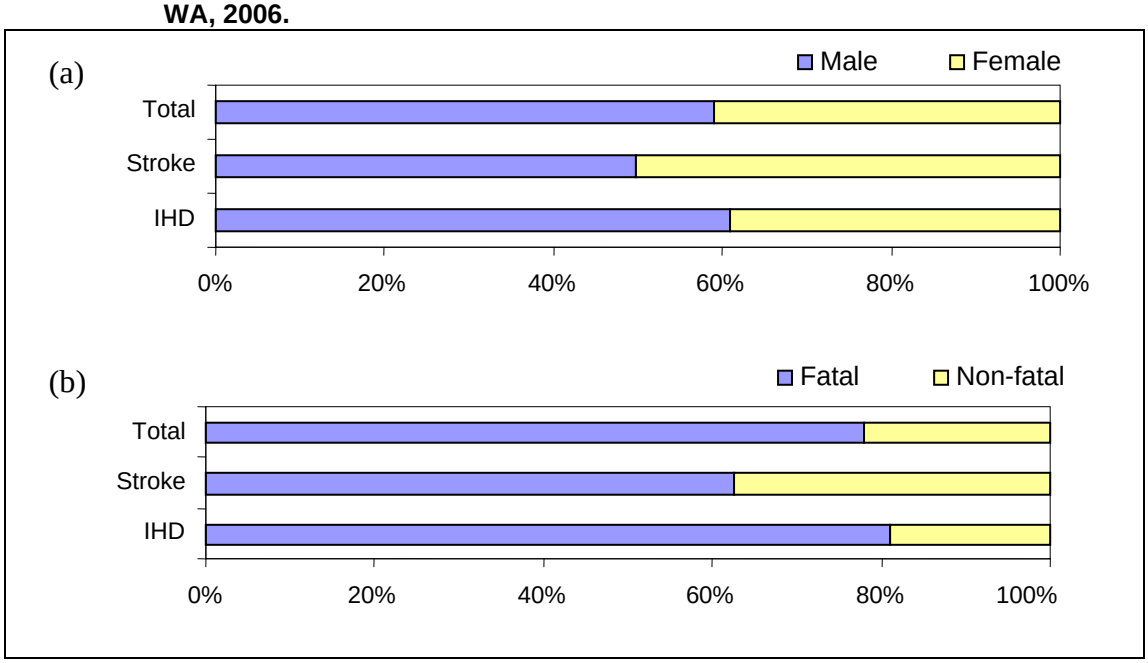
High blood cholesterol was responsible for 5.0% of the total burden of disease and injury in 2006. The higher mortality burden associated with IHD and stroke resulted in 10 percent of all deaths (1151 deaths) being attributed to high cholesterol. The vast majority (84%) of the burden due to high cholesterol is due to IHD (Table 12).

Table 12: Deaths and burden (DALYs) attributable to high cholesterol by specific cause and specific disease as proportion of total cholesterol burden, WA, 2006.

Specific cause	Deaths		DALYs		Percentage of total high cholesterol burden
	Number	Percent of total	Number	Percent of total	
IHD	1,009	8.8	10,773	4.3	84
Stroke	142	1.2	1,999	0.8	16
Total	**1,151**	**10**	**12,772**	**5.1**	**100**

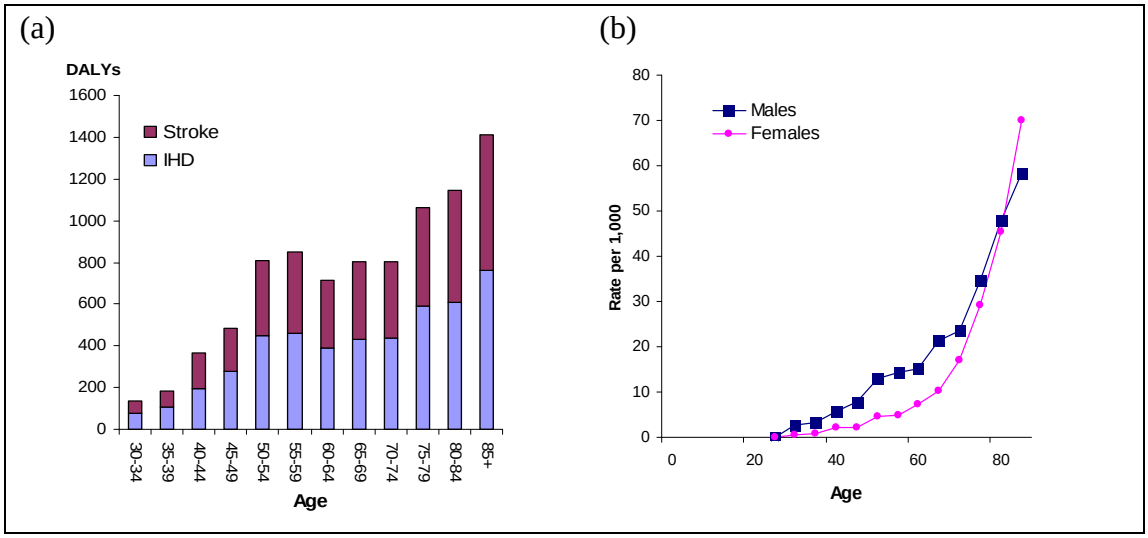
Compared to females, males had a higher (59%) burden of disease attributable to high blood cholesterol (Figure 10a), associated with the higher IHD burden. The higher fatal burden attributed to high blood cholesterol (Figure 10b) was associated with the fatal component of IHD and stroke.

Figure 10: Burden (DALYs) attributable to high blood cholesterol expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



In terms of absolute numbers, the bulk of the burden was between ages 50 to 80 years, with the peak number occurring in the 75 to 80 year old age group (Figure 11a). Males had a higher rate of burden attributable to high cholesterol than females in WA in all ages except those aged 85 plus (Figure 11b).

Figure 11: Burden (DALYS) attributable to high blood cholesterol by age expressed as (a) numbers by specific cause by age groups and (b) rates by sex, WA, 2006.



4.6 Alcohol

Methods

The prevalence of alcohol consumption in the WA population was estimated from the WA data in the 2004-2005 National Health Survey (NHS) [ABS 2005]. The NHS provided average daily alcohol consumption over the previous week in millilitres, which was used to calculate an average daily consumption. This was then converted into a proportion consuming a number of standard drinks per day or proportion classified into the prevalence categories used in the Australian BoD study (abstinence, low, medium and high). These prevalence categories were based on the revoked 2001 National Health and Medical Research Council (NHMRC) Australian guidelines (NHMRC 2001).

The burden of disease attributed to alcohol in 2006 presented challenges in the methods to attribute risk. The 2003 Australian BoD study was completed prior to revision of the Australian guidelines to reduce health risks from drinking alcohol (NHMRC 2009). The NHMRC 2009 guidelines emphasise the lifetime risk from alcohol increases with the amount consumed and recommends no more than two standard drinks on any day for both men and women. These guidelines are based on calculations that provide RRs of disease by standard drinks per day ranging from abstinence to the risk of disease associated with 10 plus drinks per day for age and gender categories. The injury risk was calculated using age and sex specific PAFs derived from the literature. The RRs and the PAFs used in the calculations of the guidelines also provide alternative values with which to calculate the burden of disease and injury in the WA population, using prevalence per standard drink per day. The Australian BoD study and the 2009 NHMRC guidelines were based on different RRs and PAFs for some diseases, resulting in differing results. In the current study, burden of disease was calculated using the RRs and PAFs from both studies to allow comparison of results.

Both studies found evidence of causation by alcohol consumption on diseases which include cancers (mouth, esophagus, pharynx, larynx, liver and breast), cardiovascular disease (IHD, stroke, hypertension), injury (road traffic accidents, falls, fire injuries, scalds, drowning, assault, other injuries) and suicide and self-inflicted injuries.

In many cases, the RRs and PAFs used in the 2003 Australian study were the same as the Australian NHMRC guidelines (NHMRC 2009) for a particular disease, resulting in the same estimates of DALYs attributed to alcohol. For example, road traffic accidents used the same PAFs in both studies and resulted in the same number of DALYs attributed to alcohol. However, for some disease and injury categories RRs and PAFs differed. Additionally, the 2009 NHMRC guidelines did not take into account any health benefit alcohol may have, assigning a minimum RR of 1, whereas the Australian BoD study estimated an almost 1% health benefit because of the protective effect of alcohol on IHD and stroke at older ages. When the benefit was not taken into account, the total DALYs attributed to alcohol did not differ remarkably between methods. There was, however, variation in the cancer and injury burden. This was attributed to several factors:

- NHMRC 2009 guidelines utilised RR of cancer that were generally lower than BoD RR, which resulted in decreased PAFs for cancer. The 2009 NHMRC guidelines are based on a 1999 meta-analysis (Corrao et al 1999), whereas the BoD RRs are based on two Australian studies (English et al 1995; Ridolfo and Stevenson 2001). It is beyond the scope of this report to assess the evidence for the use of the differing RRs.
- With the injury burden, the BoD revised some estimates with the addition of more recent studies. The fire injury PAF used in calculating the 2009 NHMRC guidelines was 44%. This PAF was updated when used in the BoD study with more recent studies. The drowning PAF of 34% used by NHMRC (2009) was also updated by BoD using estimates from Driscoll et al (2004), who found that 17% of unintentional drowning was due to alcohol.
- In the BoD study, where the RR applied to only a proportion of the Australian BoD category, the PAF were adjusted to suit. For example, the BoD study did not apply the PAF to all poisonings, only those associated with alcohol. This resulted in the 2009 NHMRC methods attributing higher DALYs to injury such as poisoning, as the PAF was applied to the whole AusBod category when applying the methods.

In the current study, the main results presented are based on the RR and PAFs used in the Australian 2003 study (Begg et al 2007). To be consistent with the 2009 NHMRC Australian alcohol guidelines, alcohol consumption data are presented per standard drink (Table 13) and categorised to fit the burden of disease format (Table 14). Approximately one third of males aged 15-59 in WA in 2004 drank more than the current recommended guidelines a day, whereas only 10% of females in the same age group drank more than the recommended guidelines.

Table 13: Proportion consuming number of standard drinks per day, Western Australian in 2004-2005, National Health Survey[3]

	15-59 years		60-69 years		70+ years	
Number of standard drinks per day	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
0	41	60	35	72	60	80
1	13	19	24	15	14	8
2	13	11	12	2	8	4
3	9	3	6	7	4	4
4	5	4	3	1	8	5
5	4	2	2	1	2	2
6	3	1	2	1	0	0
7	2	0	5	0	1	0
8	1	0	3	0	0	0
9	0	0	3	0	1	0
10	2	0	1	0	1	0
10+	5	0	2	0	1	0

Table 14: Classification and prevalence of alcohol intake levels per day used in this report by Western Australians, 2004-2005, National Health Survey[3]

	Age category														
Male	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80+**	**ALL**
Abstainer	80	27	23	39	29	35	31	29	17	33	21	41	56	67	51
Low	17	42	61	39	51	46	35	51	57	50	55	41	36	33	34
Hazardous	1	13	7	8	11	8	8	9	13	2	5	10	4	0	6
Harmful	1	19	9	14	10	11	26	11	13	15	18	7	4	0	9
Female															
Abstainer	81	52	45	54	56	41	41	53	54	62	68	79	69	52	64
Low	16	29	31	26	36	40	40	35	31	24	23	13	22	27	25
Hazardous	0	16	18	14	5	11	12	10	11	15	4	6	7	5	8
Harmful	3	4	6	6	3	9	7	2	4	0	4	2	2	2	4

Results

Alcohol has both harmful and protective effects on health, but these effects have different age and sex distributions. Overall, alcohol was responsible for 2.85% of the total attributable burden of disease and injury in WA in 2006. When the benefit was not taken into account, alcohol caused 3.85% of the total attributable burden of

[3] Note: Prevalences may not add up to exactly 100% due to rounding

disease and injury. The harmful effects of alcohol greatly outweigh the beneficial effects in all age categories, except the elderly.

Alcohol dependence and abuse attributed the most harm, with road traffic accidents and suicide and self-inflicted injury together contributing approximately two thirds of the total alcohol harm burden. IHD contributed three quarters of the alcohol benefit (Table 15).

Table 15: Deaths and burden (DALYs) attributable to alcohol by specific cause and specific disease as proportion of total alcohol burden, Western Australia, 2006.

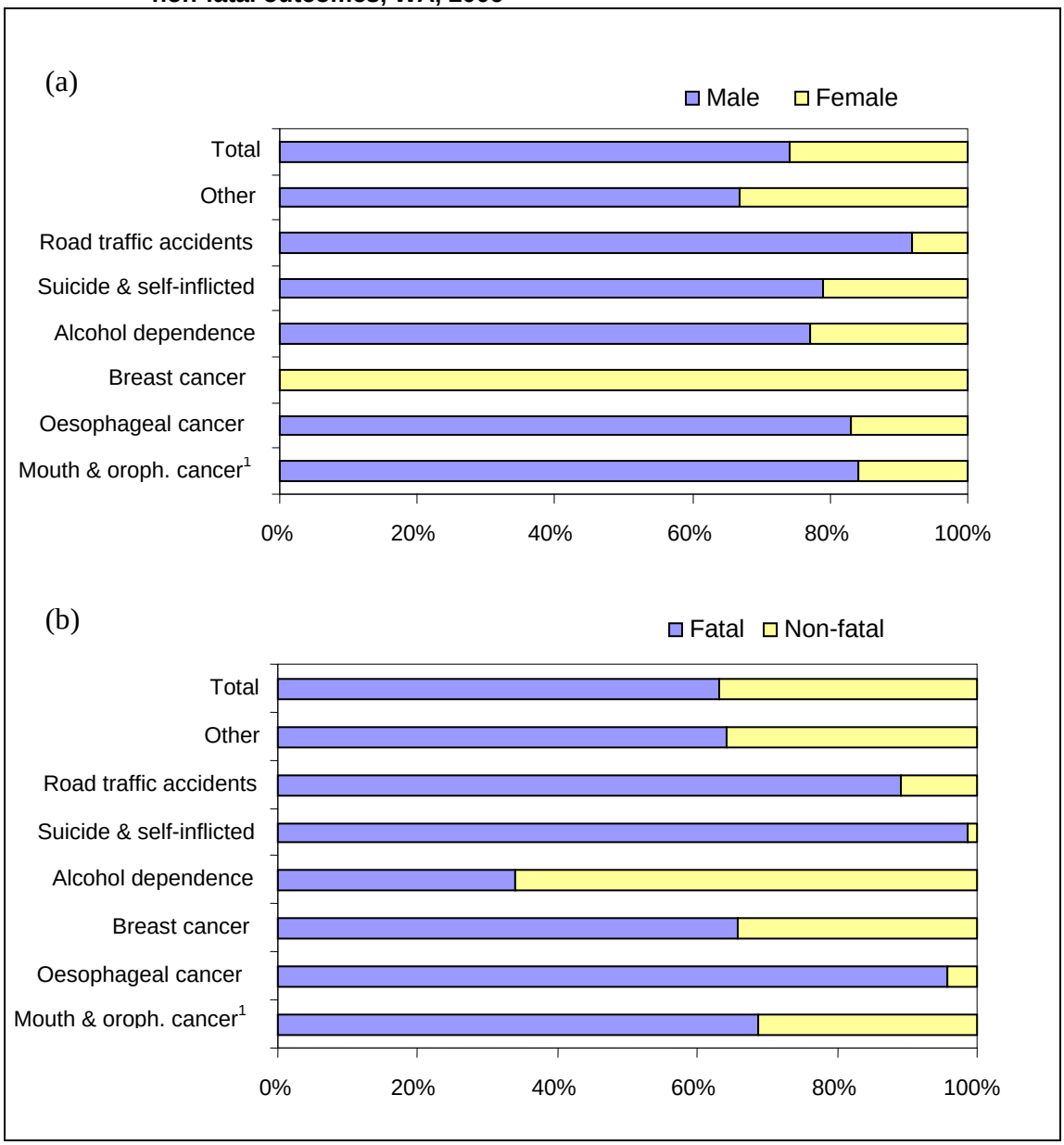
Specific cause	Deaths		DALYs		Percentage of total alcohol burden
	Number	Percent of total	Number	Percent of total	
Harm					
Mouth and oropharynx cancers	26	0.2	484	0.2	5
Oesophageal cancer	50	0.4	687	0.3	7
Breast cancer	21	0.2	511	0.2	5
Alcohol dependence & harmful use	77	0.7	3,594	1.4	38
Suicide and self-inflicted injuries	62	0.5	1,356	0.5	14
Road traffic accidents	44	0.4	1,216	0.5	13
Other	89	0.8	1,712	0.7	18
Total attributable harm	**368**	**3.2**	**9,559**	**3.8**	**100**
Benefit					
IHD	-164	-1.4	-1,837	-0.7	75
Stroke	-79	-0.7	-597	-0.2	24
Other	-2	-0.0	-27	-0.0	1
Total attributable benefit	**-245**	**-2.1**	**-2,461**	**-1.0**	**100**

Alcohol harm

Alcohol has an overwhelmingly detrimental effect on health in the younger and middle age categories. Almost three quarters of the alcohol burden was in males (Figure 12). Males dominated the alcohol burden in all diseases categories, the exception being breast cancer. Males suffered 92% of burden from road traffic accidents.

The proportion of burden that is fatal and non-fatal is dependant on the disease. The burden from the condition contributing most to alcohol harm, namely alcohol dependence and abuse, was predominantly non-fatal in nature. In all other categories, the fatal burden dominated.

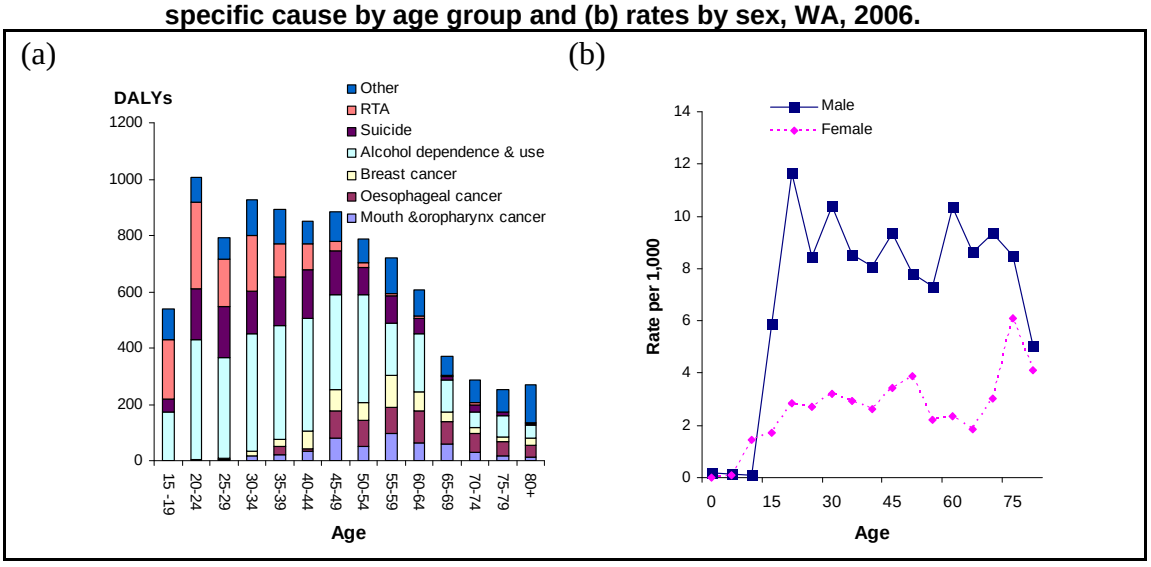
Figure 12: Burden (DALYs) attributed to alcohol (alcohol harm) by specific cause expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006



1= Mouth and oropharnyx cancer

In terms of absolute numbers, the burden was highest in the 20-24 year old age group. In the younger age groups alcohol dependence and use, suicide and self-inflicted injury and road traffic accidents dominated. Alcohol is the single biggest attributable risk factor in males aged 15-44 years. In the older population, cancers were responsible for a significant proportion of the alcohol burden. The rate of DALYs lost per 1,000 denominator was highest in 20-24 year old males. In males the rate of burden was sustained at high levels, declining only after the age of 80. Male rates were between 3.1 and 4.4 times higher than females in all age categories, except those aged over 75 years, where the rates were similar.

Figure 13: Burden (DALYs) attributable to alcohol harm expressed as (a) numbers by specific cause by age group and (b) rates by sex, WA, 2006.



Alcohol benefit

There is no benefit from consuming alcohol in younger ages when harm is the highest due to the high prevalence of harmful levels of drinking (Figure 15). The benefits of alcohol consumption only outweigh the detrimental effects in males aged over 80 years and females aged over 75 years. It should be noted that the benefits of alcohol can be achieved at very low levels of alcohol consumption, for example, a drink every second day (NHMRC 2009). The benefit seen in older ages was associated with the low prevalence of harmful drinking in older ages and the high burden of IHD and stroke at older ages.

Figure 14: Burden (DALYs) prevented due to alcohol (alcohol benefit) by specific cause expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.

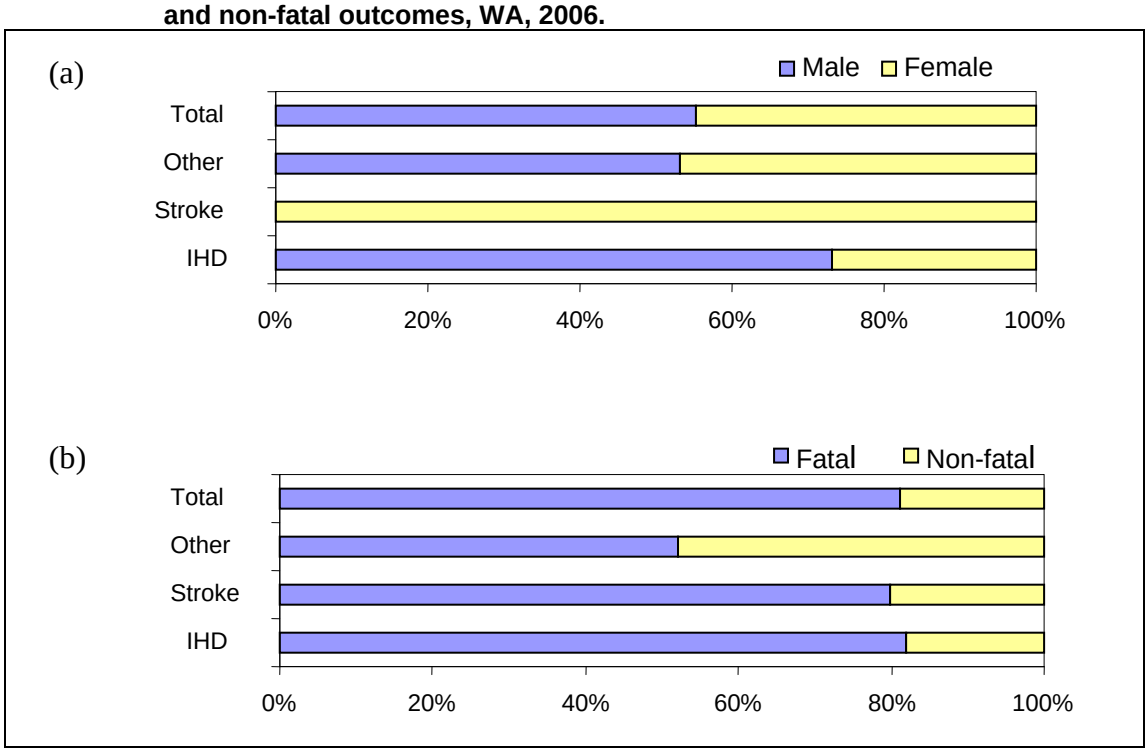
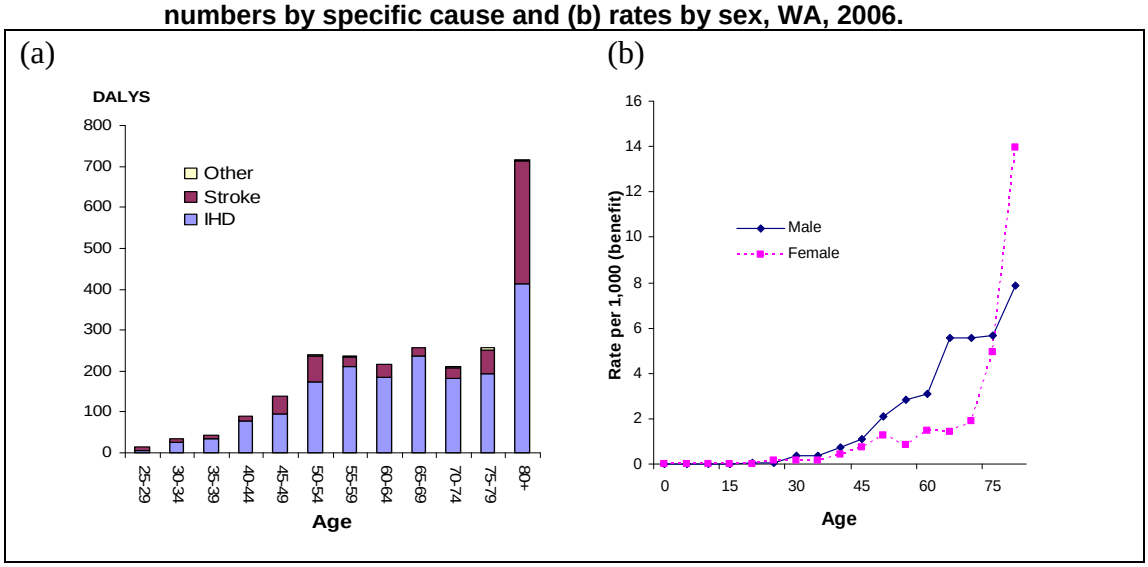


Figure 15: Burden (DALYs) prevented due to alcohol (alcohol benefit) expressed as (a) numbers by specific cause and (b) rates by sex, WA, 2006.



4.7 Inadequate fruit and vegetable intake

Methods

The Australian dietary guidelines (NHMRC 2005) recommend at least five serves of vegetables and at least two serves of fruit a day to maintain health. For the purpose of burden of disease studies, the CRA defines fruit and vegetable intake in grams per day. The Australian Bureau of Statistics defines one serve of fruit as 150 grams, or 50 grams of dried fruit. One serve of vegetables is defined as 75 grams (ABS 2009). To be consistent with the Australian dietary guidelines, the theoretical minimum risk distribution for fruit and vegetable intake was estimated to be 675 grams (equivalent to 2 fruits and 5 vegetables) a day, with a standard deviation of 50 grams per day. Estimates of fruit and vegetable intake for the WA population were taken from the 2006 WA HWSS (Wood & Daly 2007). A sample of 5604 people aged 16 years and over was surveyed. The means and standard deviations of this sample are shown in Table 16.

Table 16: Prevalence estimates of Western Australian fruit and vegetable intake, grams per day, 2006, Health and Wellbeing Surveillance System.

Sex		Age					
		16-29	30-44	45-59	60-69	70-79	80+
Males	mean	406	419	462	500	514	445
	SD	253	271	270	281	238	219
Females	mean	447	455	519	588	551	495
	SD	338	255	285	274	268	236

The relative risks of inadequate fruit and vegetable intake were the same used in the Global BoD study (Ezzati et al 2004a).

Results

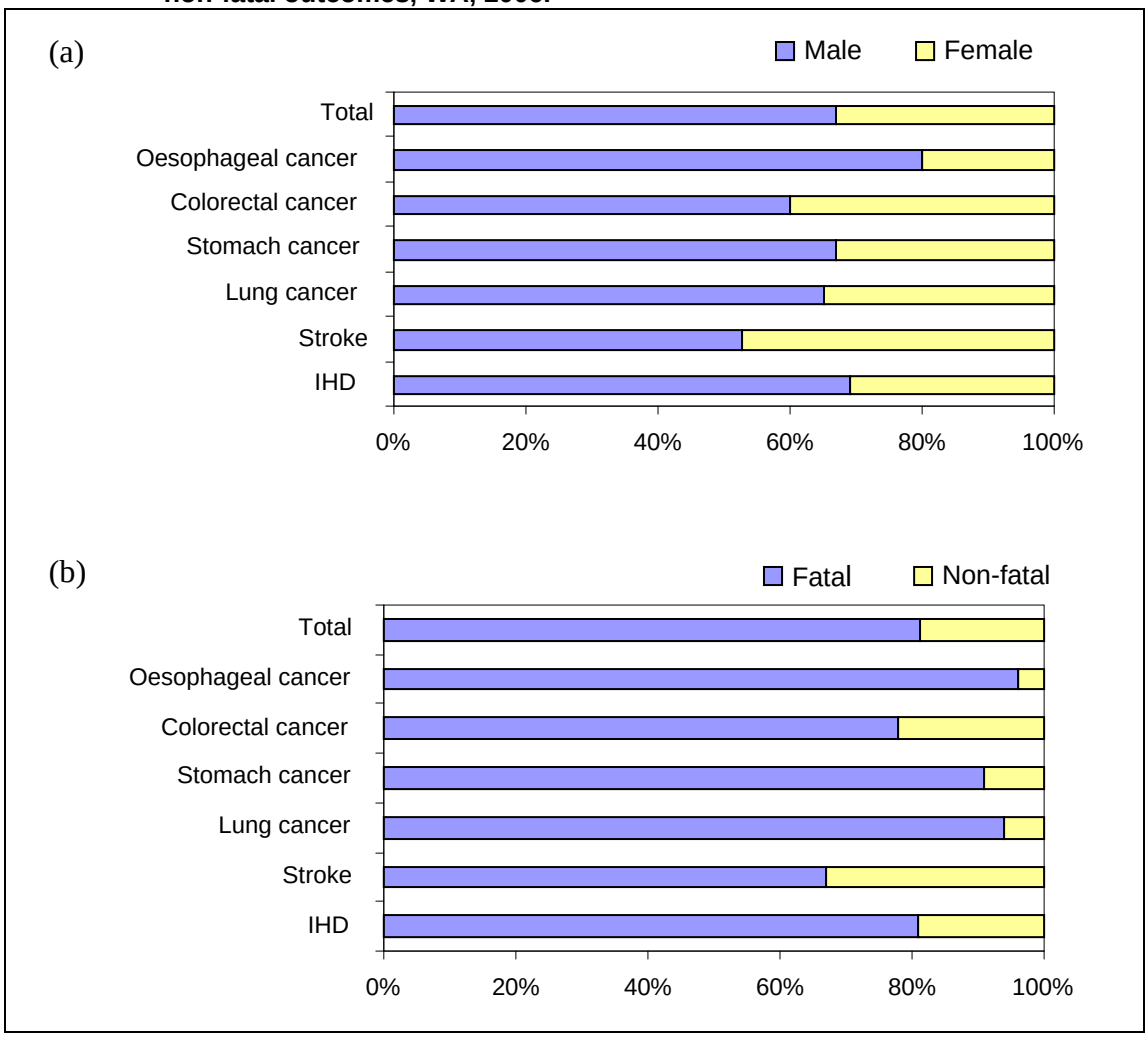
Inadequate fruit and vegetable intake contributed to 2.3% of the total burden of disease and injury in WA in 2006. If the WA population ate the recommended servings of fruit and vegetables 12.1% of cardiovascular disease and 2.6% of cancers could be prevented. IHD accounted for almost two-thirds of burden resulting from inadequate fruit and vegetable intake.

Table 17: Deaths and burden (DALYs) attributable to inadequate fruit and vegetable intake by specific cause and specific disease as proportion of total fruit and vegetable burden, WA, 2006.

Specific cause	Deaths		DALYs		Percentage total burden of inadequate F & V intake
	Number	Percent of total	Number	Percent of total	
IHD	319	2.8	3,694	1.5	64
Stroke	60	0.5	834	0.3	15
Lung cancer	58	0.5	729	0.3	13
Stomach cancer	13	0.1	174	0.1	3
Colorectal cancer	4	0.0	74	0.0	1
Oesophagus cancer	17	0.1	233	0.1	4
Total attributable	**471**	**4.1**	**5,737**	**2.3**	**100**

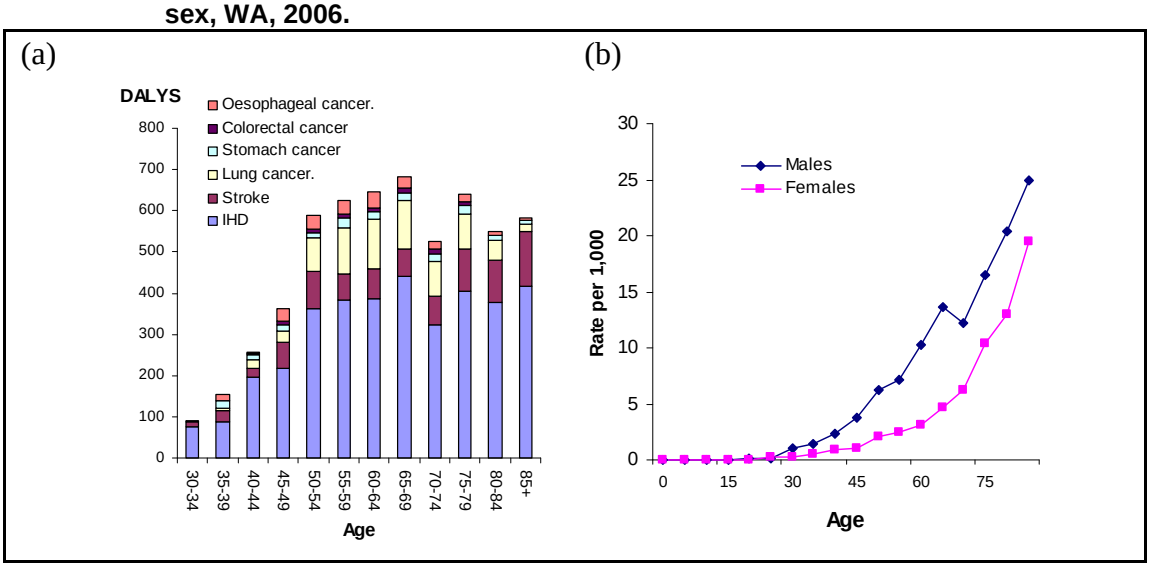
Males experienced two-thirds of the burden associated with inadequate fruit and vegetable intake (Figure 16a). Fatal burden (based on 471 deaths) comprised 81% of the burden from inadequate fruit and vegetable intake (Figure 16b), reflecting the high mortality associated with IHD and cancers.

Figure 16: Burden (DALYs) attributable to inadequate fruit and vegetable intake expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



The absolute burden from inadequate fruit and vegetable intake was highest in the 50-80 year age groups (Figure 17a). The rates of the burden due to inadequate fruit and vegetable rose with age and peaked in old age (Figure 17b). These high rates in later life were mainly due to the high burden contributed by IHD at older ages.

Figure 17: Burden (DALYs) attributable to inadequate fruit and vegetable intake by age expressed as (a) numbers by specific cause by age group and (b) rates by sex, WA, 2006.



4.8 Illicit drug use

Methods

Illicit drug use includes the non-medical use of a variety of drugs that are prohibited by law including amphetamines, cannabis, heroin and other opioids, cocaine and ecstasy (MDMA). Illicit drug use can be a direct cause of death and disability. For example, all illicit drug harmful use and dependence can be attributed to illicit drug use. Illicit drug use is also a risk factor for conditions such as HIV/AIDS, hepatitis, road traffic accidents, maternal hemorrhage, low birth weight, inflammatory heart disease and schizophrenia.

A 2005 systematic review and meta analysis provides evidence in the literature of an association between cannabis use and schizophrenia (Semple et al 2005). The odds ratio used in the calculation of the PAF comes from a meta analysis by Semple et al. The prevalence of daily cannabis use was obtained from the WA data from the 2004 National Drug Strategy Household Survey (AIHW 2004).

The PAFs for injecting drug use in HIV were based on newly diagnosed HIV cases from WA over a three year period from 2005-2007 (due to the small numbers in one year), available from the Australian HIV Public Access Database (National Centre in HIV 2008a). The database provides the exposure category and the proportion due to injecting drug use. AIDS cases and deaths attributable to injecting drug use were sourced from the Australian AIDS Public Access Database (National Centre in HIV 2008b). National data for 2006 (National Centre 2006) was used for Hepatitis B because WA does not provide Hepatitis B surveillance. For Hepatitis C, WA enhanced surveillance provided the proportion due to illicit drug use (Department of Health 2007). All other PAFs were the same as those provided in the Australian 2003 BoD study (Begg et al 2007).

Results

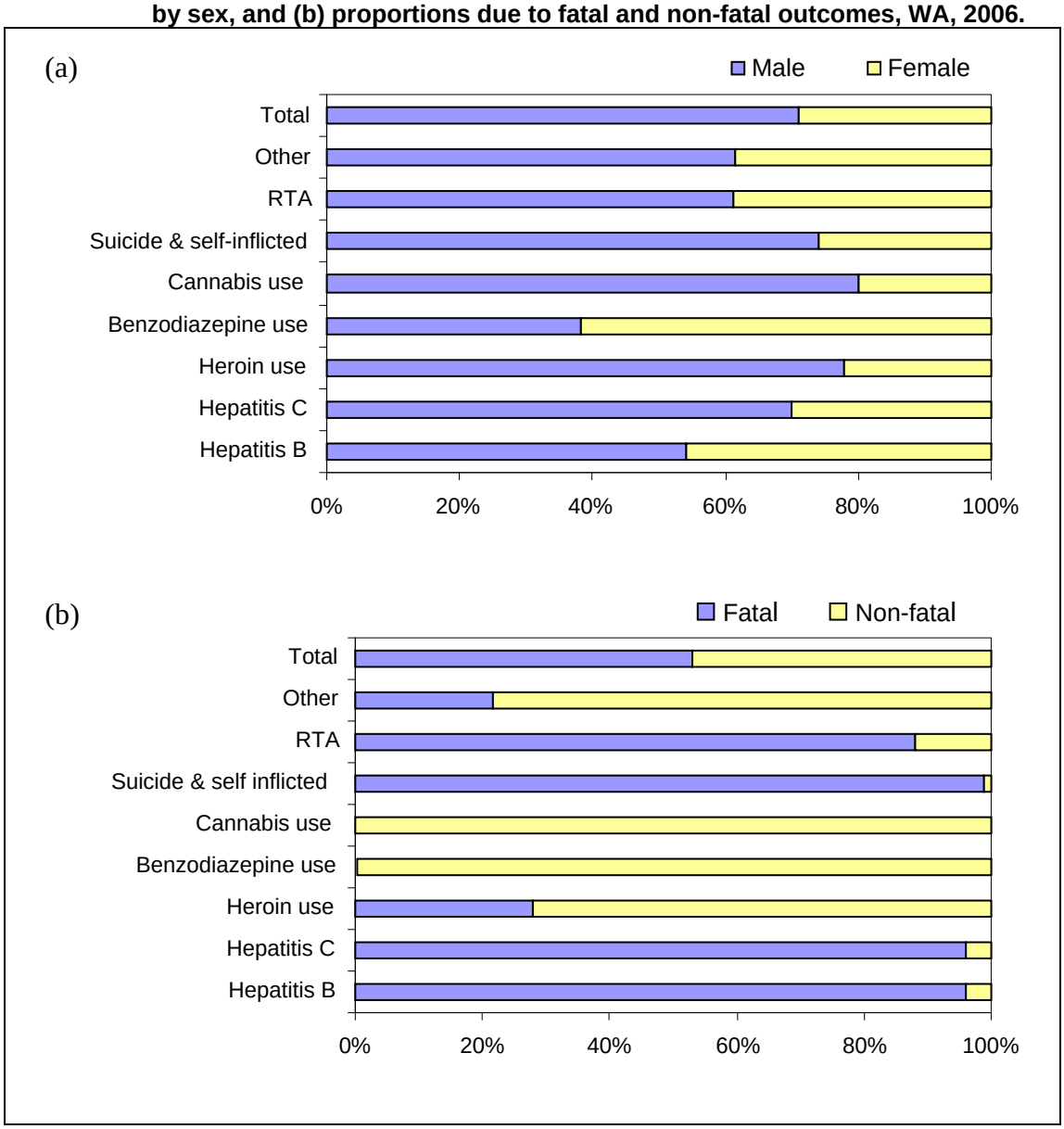
Illicit drug use was responsible for 1.6% of the total burden of disease and injury in WA in 2006, with the majority of the illicit drug use burden being attributed to direct effects of drugs, such as, deaths secondary to a fatal overdose. Hepatitis also made a substantial contribution to burden from illicit drug use (Table 18).

Table 18: Deaths and burden (DALYS) attributable to illicit drug use by specific cause as proportion of total and specific disease proportion contributing to illicit drug use, WA, 2006.

Specific cause	Deaths		DALYs		Percentage contributing to total illicit drug burden
	Number	Percent of total	Number	Percent of total	
Hepatitis B	22	0.2	255	0.1	6
Hepatitis C	59	0.5	891	0.4	23
Heroin use	13	0.1	1,096	0.4	28
Benzodiazepine use	0	0.0	206	0.1	5
Cannabis use	0	0.0	523	0.2	13
Suicide & self inflicted	19	0.2	413	0.2	10
RTA	10	0.1	239	0.1	6
Other	3	0.0	336	0.1	8
Total	**125**	**1.1**	**3,957**	**1.6**	**100**

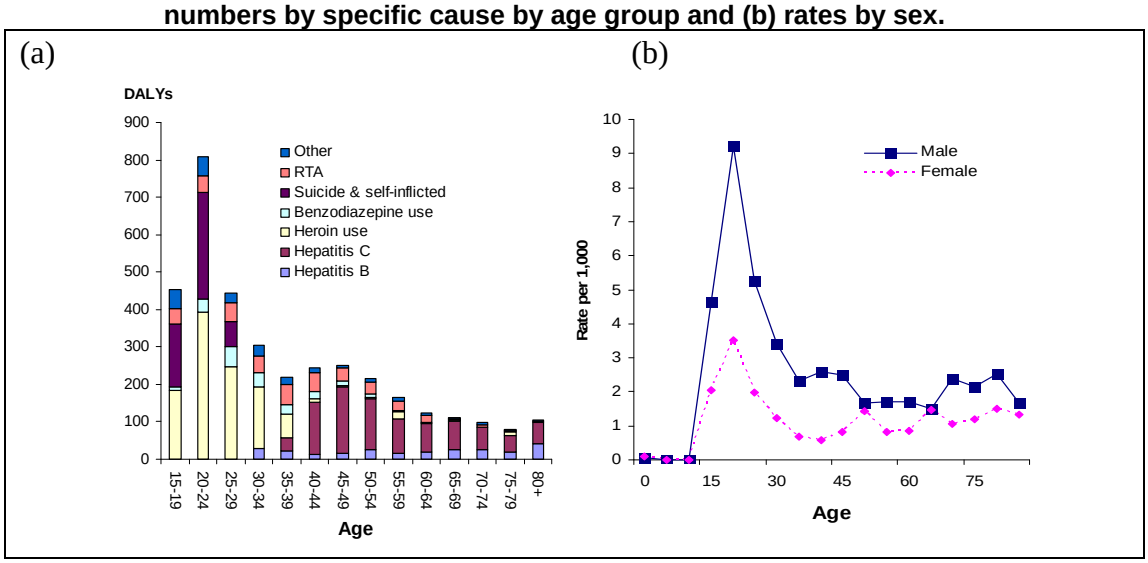
Males (Figure 18a) contributed over 70% of the burden of disease and injury attributed to illicit drug use, accounting for the majority of the burden in all causes except benzodiazepine use. Overall, the burden attributed to illicit drug use was approximately equally distributed across fatal and non-fatal outcomes, varying for different underlying cause (Figure 18b). The drug dependence and use burden was predominately non-fatal, whereas the hepatitis burden was predominately fatal.

Figure 18: Burden (DALYs) attributable to illicit drug use expressed as (a) proportions by sex, and (b) proportions due to fatal and non-fatal outcomes, WA, 2006.



In the younger ages, the burden predominately consisted of the short-term consequences of illicit drug use, drug dependence and use. In the older age groups, the longer-term health consequences of illicit drug use dominated, such as the consequences of Hepatitis. Males had higher rates of burden attributed to illicit drug use (Figure 19b). The peak rate of burden attributed to illicit drug use occurred in the 20-24 year age group. The male to female rate ratios were highest in the younger age groups.

Figure 19: Burden (DALYs) attributable to illicit drug use by age expressed as (a) numbers by specific cause by age group and (b) rates by sex.



4.9 Unsafe sex

Methods

Unsafe sex as a risk factor was defined in this study as sex between a susceptible person and a partner who has a sexually transmitted infection (STI), without taking measures to prevent infection (Ezzati et al 2004b, p1181). All sexually transmitted diseases were attributed to unsafe sex; therefore, all YLL and YLD attributed to syphilis, chlamydia and gonorrhea were given a PAF of one. All cervical cancer was attributed to sexual transmission of the human papilloma virus (HPV), which was also given a PAF of one (Begg et al 2007). The PAFs of HIV/AIDS, Hepatitis C and Hepatitis B were derived as described in the section on illicit drugs.

Results

Unsafe sex was associated with 0.5% of the total burden of disease and injury in WA in 2006, with 52 deaths contributing to the fatal burden. Cancer of the cervix was the single biggest contributor to the burden of disease attributed to unsafe sex, followed by HIV/AIDS (Table 19).

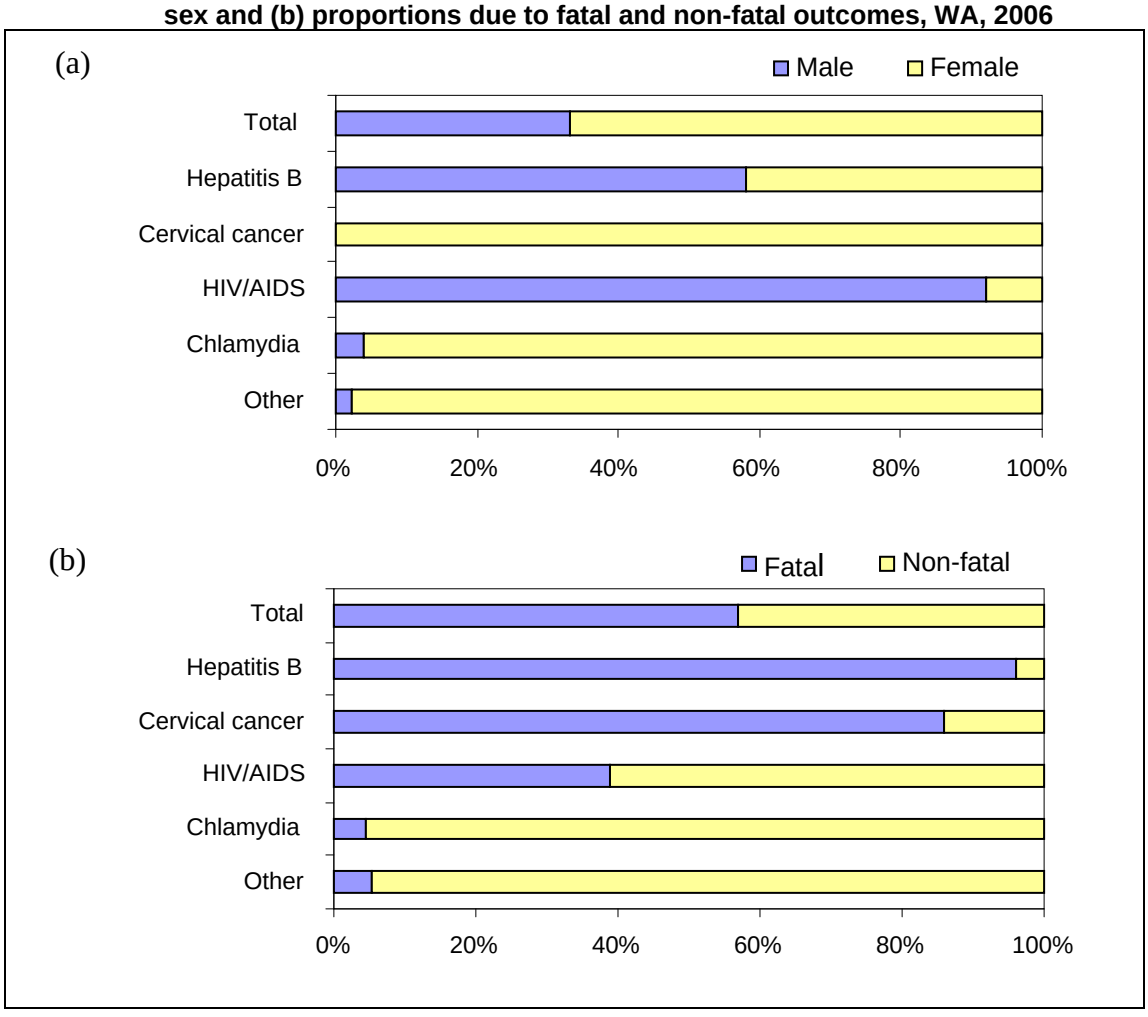
Table 19: Deaths and burden (DALYs) attributable to unsafe sex by specific cause and specific disease as proportion of total of unsafe sex burden

Specific cause	Deaths		DALYs		Percentage of total unsafe sex burden
	Number	Percent of total	Number	Percent of total	
Other	1	0.0	93	0.0	7
Chlamydia	1	0.0	151	0.1	11
HIV/AIDS	6	0.1	421	0.2	32
Cervix cancer	38	0.3	576	0.2	43
Hepatitis B	7	0.1	84	0.0	6
Total	**52**	**0.5**	**1,325**	**0.5**	**100**

Females had the highest burden attributed to unsafe sex, comprising approximately two-thirds of this burden (Figure 20a). The high female burden was associated with cervical cancer. The HPV vaccine (NHMRC 2008) has the potential to impact on the burden of unsafe sex, but will take many years before making an impact, because of long lag time between HPV exposure and the development of cervical cancer. Males suffered 92% of the unsafe sex burden associated with HIV/AIDS, attributed to increased transmission of the HIV virus that occurs with male to male sex practices (Figure 20a).

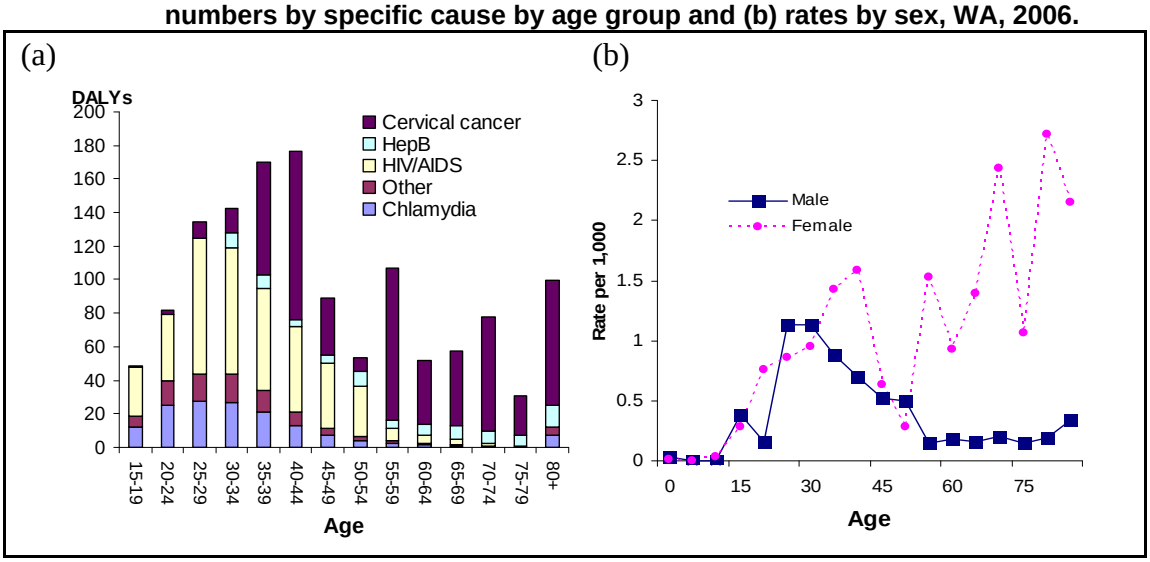
The burden attributed to unsafe sex was a mixture of fatal and non-fatal burden (Figure 20b). The burden of unsafe sex associated with Hepatitis B and cervical cancer was predominately fatal, whereas the burden associated with HIV/AIDS, chlamydia and other STIs was predominately non-fatal.

Figure 20: Burden (DALYs) attributable to unsafe sex expressed as (a) proportions by sex and (b) proportions due to fatal and non-fatal outcomes, WA, 2006



The rate of burden of males and females in the younger age groups were similar, (Figure 21b) but associated with different causes. The male burden was attributed largely to HIV/AIDS, whereas the female burden was attributed to chlamydia, other STIs and cervical cancer. With increasing age, the rate of burden among females overtook the rate among males, due to the increasing burden of cervical cancer occurring in older females (Figure 21b).

Figure 21: Burden (DALYs) attributable to unsafe sex by age expressed as (a) numbers by specific cause by age group and (b) rates by sex, WA, 2006.



5.0. Comparative risk assessment and joint effects

Table 20 provides an overview of the contribution of each of the nine selected risk factors to disease burden, and the combined effect of these risk factors. High body mass ranked highest as a contributor to disease burden, being associated with 8.7% of the total burden of disease and injury in WA in 2006. Tobacco was responsible for 6.5% of the total burden. The burden attributed to high body mass and tobacco were followed by physical inactivity (6.1%), high blood pressure (6.0%), high blood cholesterol (5.0%), Alcohol harm (3.8%), inadequate fruit and vegetable intake (2.3%), illicit drug use (1.6%) and unsafe sex (0.5%).

The fact that high body mass has overtaken tobacco as the largest single contributing risk factor is of significance to both WA and Australia as a whole. This increase in the burden of high body mass can be partly explained by several factors. First, there has been a substantial increase in the prevalence of persons with a higher than ideal body mass index. Second, this study examined BMI as a continuous variable with attributable risk commencing at BMI 21, whereas previous WA BoD analyses were undertaken prior to the CRA methodology using categorisation into normal (BMI less than 25) and abnormal (overweight and obese). The effect of this methodological change was to decrease the threshold where BMI risk was attributed. Although the elevation in risk of persons with BMIs from 21- 25 is small, the large numbers of people with BMIs in-between 21-25 would contribute significantly to the total burden attributed to high body mass. Third, the increase in high BMI has been coupled with a decrease in tobacco use and subsequent decreasing tobacco-related burden.

An estimated 29.5% of the total burden of disease and injury in WA in 2006 was attributed to the joint effect of the nine risk factors. This highlights the potential to reduce the burden of disease attributed to these risk factors and the significant health gains that could be achieved in WA, if exposure to these health risks could be reduced.

Table 20: Individual and joint burden (DALYs) attributable to nine selected risk factors by broad cause group, Western Australia, 2006.

	Broad cause group							
	Cancer	**CVD**	**Mental**	**Injury**	**Diabetes**	**Com. Dis[4]**	**Other**	**All causes**
Total burden (number)	46,136	37,311	34,117	19,261	15,927	6,841	89,407	249,000
Attributable Burden (%)[(a)]								
High body mass	4.0	22.9	-	-	66.0	-	1.0	8.7
Tobacco	20.7	7.7	-	0.4	-	1.0	-	6.5
Physical Inactivity	5.1	23.8	-	-	25.3	-	-	6.1
High blood pressure	-	40.1	-	-	-	-	-	6.0
High blood cholesterol	-	34.2	-	-	-	-	-	5.0
Alcohol								
Harmful effects	4.3	1.3	10.5	17.9	-	-	<0.01	3.8
Beneficial effects	-	-6.5	-	-	-	-	<-0.01	-1.0
Net effects	4.3	-5.2	10.5	-	-	-	<0.01	2.9
Inadequate fruit and veg. intake	2.6	12.1	-	-	-	-		2.3
Illicit drug use	-	0.02	6.2	3.4	-	16.8	0.01	1.6
Unsafe sex	1.2	-	-	-	-	10.9		0.5
Joint effect[(b)]	**30.7**	**73.8**	**16.1**	**21.0**	**71.0**	**26.6**	**1.0**	**29.5**
Joint effect with alcohol benefit removed[(b)]	**30.7**	**75.1**	**16.1**	**21.0**	**71.0**	**26.6**	**1.0**	**30.2**

(a) Attributable burden within each column is expressed as a percentage of total burden for that column

(b) Figures for joint effects are not column totals

5.1 Risk factors by disease group

Estimates of burden are typically attributed to a comprehensive set of disease and injury entities using categorical attribution. For example, an event such as death is attributed to a single cause (e.g. stroke, HIV), according to the International Classification of Disease system (ICD). Each entity is mutually exclusive and belongs to a number of broad cause groups of the ICD. For example, stroke is classified under CVD and HIV is classified under communicable diseases. The broad cause groups have been modified and used as sub-headings to illustrate how the studied risk factors impact on disease outcomes. For some disease entities there was only a minimal proportion attributable to the nine risk factors. The disease entities with minimal attributable risk to the nine studied risk factors are grouped under 'other'.

Cancer: Cancer was the disease group responsible for the largest burden in the WA population in 2006. The nine risk factors together explained 30.7% of the total cancer burden, with tobacco being the largest contributor to the cancer burden.

[4] Com. Dis= Communicable Disease

Cardiovascular Disease: The nine risk factors combined accounted for 73.8% of the total cardiovascular burden in WA in 2006. High body mass (22.9%) and physical inactivity (23.8%) were distal risk factors responsible for a large proportion of the cardiovascular burden. High blood pressure (40.1%) and high blood cholesterol (34.2%) were proximal risk factors that were responsible for a large proportion of the cardiovascular burden.

Mental disorders: Alcohol and illicit drug use contributed to 16.1% of the total mental burden experienced by Western Australians in 2006.

Injury: Of the nine risk factors examined, alcohol was responsible for 17.9% of the total injury burden in WA in 2006. Illicit drug use contributed 3.4% to the injury burden.

Diabetes: Individually, high body mass contributed to 66% of the total burden of type II diabetes. The joint effects of physical inactivity and high body mass accounted for 71% of the total type II diabetes burden.

Communicable disease: Illicit drug use and unsafe sex accounted for 26.6% of the burden of communicable disease. Individually, illicit drug use contributed 16.8% of the burden through diseases such as Hepatitis C. Unsafe sex contributed almost 11% of the total communicable disease burden.

5.2 Risk factors by sex and age

The burden of disease and injury attributed to the nine risk factors differs by age and sex (Table 21).

Table 21: Individual and joint burden (DALYS) attributable to nine selected risk factors by sex and age group, Western Australia, 2006.

	Males					Females				
	0-14	**15-44**	**45-64**	**65+**	**All ages**	**0-14**	**15-44**	**45-64**	**65+**	**All ages**
Total burden	11,405	32,798	37,341	47,642	129,186	9,663	30,886	30,156	49,109	119,814
Attributable Burden[(a)]										
High body mass	0.0	5.4	15.2	8.3	8.8	0.0	5.0	14.8	8.8	8.6
Tobacco	1.1	1.3	12.7	10.8	8.1	1.3	0.5	6.2	7.5	4.9
Physical Inactivity	0.0	2.5	8.6	7.9	6.1	0.0	2.8	9.9	7.3	6.2
High blood pressure	0.0	1.0	6.8	11.7	6.6	0.0	0.1	3.1	11.3	5.4
High blood cholesterol	0.0	2.7	8.6	7.2	5.8	0.0	0.9	3.8	7.8	4.4
Alcohol										
Harmful effects	0.3	12.2	6.0	1.9	5.6	0.1	3.4	2.9	0.9	2.0
Beneficial effects	0.0	-0.4	-1.5	-1.4	-1.1	0.0	-0.2	-0.9	-1.6	-0.9
Net effects	0.3	11.9	4.5	0.5	4.5	0.1	3.2	2.0	-0.7	1.1
Inadequate fruit and veg. intake	0.0	1.2	4.6	3.6	3.0	0.0	0.5	1.7	2.5	1.6
Illicit drug use	0.0	6.3	1.4	0.5	2.2	0.1	2.3	0.8	0.3	1.0
Unsafe sex	0.0	1.0	0.3	0.0	0.3	0.0	1.4	0.7	0.5	0.7
Joint effect[(b)]	**1.3**	**27.3**	**43.1**	**36.2**	**33.3**	**1.6**	**13.8**	**29.8**	**33.3**	**25.3**

(a) Attributable burden within each column is expressed as a percentage of total burden for that column

(b) Figures for joint effects are not column totals

0-14 years: The preventable risk factors in this report do not account for the vast majority of the burden experienced by children aged 0-14 years. However, adult use of illicit drugs, alcohol and tobacco impacted on the health of younger children. Tobacco contributed to 1.1% of the burden in males of this age group and 1.3% of the burden of females in this age group, mostly due to the association with maternal smoking and low birth weight.

15-44 years: Over a quarter (27.3%) of the burden of males 15-44 years was caused by the nine risk factors. Alcohol was the leading cause of burden in young adult males, accounting for approximately 12% of the total burden. More than half of the alcohol burden was due to the injury associated with alcohol. Illicit drugs were the second leading risk factor in young adult males, accounting for 6.3% of the total burden. The majority of this burden was due to dependence and the harmful use of heroin and cannabis.

The burden attributed to these risk factors accounted for 13.8% of the female total. The burden attributed to alcohol and illicit drug use was significantly less than that of males. The risk factor attributed the highest burden in females aged 15-44 years was high body mass, which contributed to 5.0% of the total burden. This was largely a result of the association between high body mass and type II diabetes.

45-64 years: Males in this demographic group had the largest burden attributable to the nine risk factors. The joint effects of these risk factors accounted for 43.1% of the total. The impact of high body mass was the most significant single risk factor, contributing 15.2% of the total burden. Tobacco was a significant preventable cause of the male burden, contributing 12.7, largely as a result of lung cancer.

Approximately 30% of the total burden in females aged 45-64 years could be attributed to the nine risk factors. The single biggest risk factor in females was high body mass, contributing 14.8% individually. In this demographic group, significant contributions to disease burden were also made by physical inactivity (9.9%) and tobacco (6.2%)

65 years and older: For both sexes aged 65 years and older, approximately one third of the total burden (36.2% in males and 33.3% in females) was attributed to the nine risk factors. Approximately 39% of the total burden of disease and injury in WA was to persons aged 65 years and older. The biggest single risk factor associated with the burden of disease in this age category was high blood pressure, contributing to 11.7% of the total male burden and 11.3% of the total female burden. In this demographic group, tobacco (10.8% of the male burden, 7.5% of the female burden) and high body mass (8.3% of the male burden, 8.8% of the female burden) contributed significantly to the burden.

All ages: Over all ages combined, a third (33.3%) of the male burden and a quarter (25.3%) of the female burden can be attributed to the nine studied risk factors. In both sexes, high body mass was the leading contributing risk factor. Unsafe sex is the only risk factor studied for which females had a higher burden of disease than males.

6.0 Discussion and conclusions

This report quantifies the impact that preventable health risks factors had on the burden of disease in the Western Australian population in 2006. It provides an estimate of the impact of each risk factor individually and the joint effects of the risk factors combined.

Individually, tobacco has been overtaken by high body mass as the single biggest measured risk factor to the health of Western Australians in 2006. The decreasing burden associated with tobacco has resulted from the continued decreasing prevalence of people who smoke in WA, as a result of effective tobacco control. The decreasing smoking prevalence needs to be maintained, to further limit the negative impact of tobacco on health. High body mass impacts negatively on the health of Western Australians in all the age and gender categories aged over 15 years. Evidence based interventions targeting high body mass index should be implemented as a priority. Further research is needed to determine interventions that are effective in targeting high body mass.

The burden of disease associated with tobacco, alcohol, illicit drug use and inadequate fruit and vegetable intake was considerably higher in males. Unsafe sex is the only risk factor where females had a higher burden of disease. The largest disparity in burden between males and females in any age group is the alcohol related burden in the 15-44 year age category. Illicit drug use also remains an important public health problem in males in young to middle age. Effective risk reduction interventions targeting alcohol and illicit drugs in young to middle aged males would result in significant health gains in the WA population. Male health inequity is an under-acknowledged aspect of health in WA. Policy should reflect the higher burden associated with preventable risk factors experienced by males in WA.

In the 65 years plus age category the preventable risk factors associated with cardiovascular disease such as high blood pressure, high blood cholesterol and tobacco greatly contribute to the burden of disease. High blood pressure and high blood cholesterol have shorter lag times on the impact of cardiovascular disease. Effective primary health care and treatment of these conditions in the elderly could impact considerably on the burden of disease in this group.

The quantification of “joint effects” is important as many of the risk factors studied are interrelated and exert effects through modifying other risk factors. Many of the risk factors occur in clusters. Almost three quarters of cardiovascular disease, one third of cancers and more than two thirds of diabetes could be prevented with the elimination of the joint effects of the nine risk factors. Determining the “joint effects” of risk factors clarifies the need for public health programs to be comprehensive and target risk factors in clusters, as they occur in the population.

This study is dependent on accurate prevalence estimates of risk factors. Several factors may have affected the accuracy of the risk factor prevalence. WA specific data was used to estimate prevalence for tobacco, alcohol, high body mass, fruit and vegetable intake and physical activity. The survey sample size introduces uncertainty in the measures. The WA specific risk factors relied on self-reported data, rather than measurement. For risk factors other than BMI, self-reported data is not known to significantly affect the validity of the prevalence data. For BMI in particular, self-

reporting is known consistently to result in a lower than actual BMI. This was overcome by correcting for self-reporting using the method developed by Hayes et al (2008).

AusDiab data was used to calculate the prevalence of cholesterol and blood pressure in WA. Total Australian data from AusDiab (a sample size of 11,247) was used, as opposed to the WA data (a sample size of 1561), on the basis of the limited number of WA clusters used, potentially affecting the representativeness of the sample. AusDiab estimates have the advantage of being based on actual measures, rather than self-report, although more up-to-date estimates are required to ensure that prevalence data are current.

This report highlights the lack of measured data on prevalence estimates of the risk factors studied. Knowing the true prevalence of a risk factor is important, not only to reduce uncertainty of the results of this study, but to quantify the number of Western Australians that are likely to need services and treatment in the future and to initiate public health interventions early as risk factors change and emerge.

This study is reliant on accurate RRs as published in the literature. The majority of RRs used were obtained from the Global BoD Study. This was published in 2004 and involved an extensive review of the literature. However, updated estimates subsequent to this date have not been included. Many risk factor and disease associations are likely to exist that have not been included because of insufficient evidence, rather than a lack of an association. This potential limitation would cause an underestimate of the burden of disease attributed to risk factors.

This study is dependent on the precision of the estimates of the DALYs attributed to each disease end point in 2006. More information on the precision of these estimates can be found in the Australian BoD study report (Begg et al 2007). The calculation of fatal burden (YLL) is dependent on mortality data, which are considered to be accurate and complete. The calculation of the YLD is associated with greater levels of uncertainty. Providing WA-specific updated estimates for this study (as described in Appendix 2) introduced other sources of error. The uncertainty associated with the calculation of the DALYs for type II diabetes mellitus is of importance to this report. As documented by Begg et al (2007), the type II diabetes DALYs calculated for WA was limited to information obtained in one cross-sectional survey and assumptions dependent on incidence and case-fatality projections. Any miscalculation of the burden of type II diabetes would impact on estimates of the burden attributed to high body mass.

This study does not provide any information on the effectiveness and cost-effectiveness of interventions aimed at targeting the prevalence of risk factors. Any public health program aiming to modify risk factors must take into account the burden of disease and injury as well as the effectiveness of the intervention. Research demonstrates that significant cost savings from the avoidable disease burden can be made if there were feasible reductions in select risk factors. Cadilhac et al (2009) demonstrated savings of between 2,334 million to 3,057 million dollars over the lifetime of the 2008 Australian population if feasible reductions in high BMI, tobacco, alcohol consumption, physical inactivity, intimate partner violence and inadequate fruit and vegetable consumption were achieved. In addition to the significant health

benefits demonstrated in this report, there are proven economic and financial benefits in risk factor reduction. The current health care cost in treating the outcomes of these risk factors could then be spent elsewhere in the health system.

The burden of disease and injury in WA does not allow analysis at sub-group levels of the population. There are populations in WA such as Aboriginal people, ethnic minorities, persons who suffer a mental illness and low socioeconomic groups that would have a higher proportion of the burden of disease and injury attributed to risk factors. The burden attributed to these sub-groups in the population cannot be extracted from the analysis that reflects WA as a whole.

The mortality and morbidity from disease and injury within a population is a result of a complex interaction of many known and unknown factors. The methodology of this analysis enables a measure of the burden of disease on the WA population to be attributed to known modifiable risk factors. Presenting burden of disease data attributed to risk factors provides a measure of the health gains that can be achieved in the WA population through the reduction of these risk factors. The burden of these risk factors identifies known potential health gains that can be achieved. In addition to providing the burden of disease attributable to each risk factor, the burden of disease of each risk factor was broken down by age, gender and disease categories. Calculating the differing impact of risk factors on the burden of disease and injury on different age and gender groups enables public health interventions to be targeted for maximum impact.

Appendix one: Definitions, theoretical minima, health outcomes and data sources for nine selected risk factors

Health risk	Exposure variable	Theoretical minimum	Outcomes	Source for exposure estimates	Sample size	Sources for RR (hazard estimates) *the majority sourced from Begg et al 2007
High body mass	Body mass index (weight over height squared)	21 (SD 1) kg/m^2	IHD, stroke, hypertensive heart disease, diabetes, osteoarthritis, endometrial cancer, kidney cancer, colon cancer, post-menopausal breast cancer	Western Australian Health and Well-being Surveillance System (HWSS), corrected for self-reported error	4797	Meta-analysis of 33 cohorts with 310,000 participants of cardiovascular disease risks, 27 cohorts for cancer risks and systematic review of cohort studies for diabetes risk
Tobacco	Past smoking	No smoking	COPD, cancers of mouth, oesophagus, lung, pancreas, kidney, stomach and uterus	Peto-Lopez method	-	Systemic reviews by English and colleagues (1995) and Ridolfo and Stevenson (2001)
	Current daily smokers	No smoking	IHD, stroke, peripheral vascular disease, Parkinson's disease, pneumonia (adults)	Western Australian HWSS (Wood & Daly 2007)	4797	Systemic reviews by English and colleagues (1995) and Ridolfo and Stevenson (2001)
	Passive smoking	No smoking	IHD, stroke	Western Australian HWSS	4797	Systemic reviews by English and colleagues (1995) and Ridolfo and Stevenson (2001); US Surgeon General's Report on Involuntary exposure to tobacco smoke (US Department of Health and Human Services 2006); systematic review by Anderson and Cook (1997)
	Maternal smoking while pregnant	No smoking	Asthma, pneumonia (children), sudden infant death syndrome, otitis media, low birth weight	Australia's mothers and babies 2002, WA data (Laws & Hilder 2008)		
Physical inactivity	Four categories: inactive, insufficient, recommended and highly active	All in highly active group	IHD, stroke, breast cancer, colon cancer, diabetes	National Health Survey 2004-2005 WA data (ABS 2005)	1704 aged 15 plus	Systematic review of published literature and new meta-analysis of cohort studies

Appendix one continued.

Health risk	Exposure variable	Theoretical minimum	Outcomes	Source for exposure estimates	Sample size	Sources for RR (hazard estimates)
High blood pressure	Level of usual systolic blood pressure	115 (SD 6) mmHg	IHD, stroke, hypertensive heart disease	AusDiab study (Dunstan et al 2002)	11247 (Australian sample)	Meta-analysis of 61 cohort studies with 1,000,000 North American and European participants (Prospective Studies Collaboration (Ezzati et al 2004a)
High cholesterol	Level of usual total blood cholesterol	3.8 (SD 0.5) mmol/L	IHD, stroke	AusDiab study (Dunstan et al 2002)	11247 (Australian sample)	Meta-analysis of 10 cohorts with 490,000 North American and European participants and 29 cohorts with 350,000 thousand participants from the Asia-Pacific region
Alcohol	Average number of standard drinks per day	Low level of drinking	Cancers of mouth and oropharynx, oesophagus, liver, larynx and breast; inflammatory heart disease, hypertensive heart disease, IHD, stroke, alcohol dependence and harmful use, gallbladder and bile duct disease, pancreatitis, road traffic accidents, falls, fire/burns/scalds, drowning, machinery accidents, suffocation and foreign bodies, suicide and self-inflicted injuries, homicide and violence, occupational injuries	WA data from National Health Survey 2004-2005	1704 aged 15 plus	Systemic reviews by English and colleagues (1995) and Ridolfo & Stevenson (2001) the National Coroners Information System (Driscoll et al 2004) for alcohol-related drowning and occupational YLL; fire injuries and fatalities pooled results from published studies: scalds and burns from Levy and colleagues (2004).
Low fruit and vegetable consumption	Fruit and vegetable intake per day	600 (SD 50) gram intake per day for adults	IHD, stroke, colorectal cancer, gastric cancer, lung cancer, oesphageal cancer	WA HWSS	4797 aged 30 and over	Systemic review and new meta-analysis of published cohort studies

Appendix one continued

Health risk	Exposure variable	Theoretical minimum	Outcomes	Source for exposure estimates	Sample size	Sources for RR (hazard estimates)
Illicit drugs	Use of illicit drugs	Abstinence	Heroin or polydrug, benzodiazepine, cannabis, and other drug dependence and harmful use	AusBoD drug use and dependence models (Begg et al 2007)		PAF=1 by definition
	Use of illicit drugs	Abstinence	HIV/AIDS, hepatitis B, hepatitis C, inflammatory heart disease, suicide and self inflicted injuries, road traffic accidents	Population attributable fraction direct from the literature		Incorporated findings from a multi-centre case-control study on 3,398 fatally injured drivers in Australia; viral hepatitis and sexually transmitted infections from Australian AIDS and HIV public access dataset ((http://web.med.unsw.edu.au/nchecr) and from the WA Communicable Disease Control Directorate (2007); and systematic literature reviews by English and colleagues (1995) and Ridolfo and Stevenson (2001)
	Daily cannabis use	No cannabis use, or less often than daily	Schizophrenia	National Drug Household Survey 2004, WA data only	2857 persons aged 15 years and older	Meta-analysis of 7 published case-control or cohort studies (examining link between psychosis and cannabis use).
Unsafe sex	Unprotected sex	Abstinence/ protected sex	Sexually transmitted diseases, abortion, cervical cancer, HIV/AIDS, hepatitis B and C	AusBoD sexually transmitted diseases, abortion and cervical cancer models; PAF direct from literature		PAF=1 (STIs, abortion, cervical cancer); HIV/AIDS proportion from WA data (3 year period as small numbers) from the Australian HIV and AIDS Public Access Datasets (National Centre in HIV Epidemiology and Clinical Research 2008a and 2008b); Hepatitis B fraction from National Centre in HIV Epidemiology and Clinical Research 2006; Hepatitis C from WA Communicable Disease Control Directorate (2007)

Appendix 2: Method for estimating WA Burden of Disease

State estimates

Estimates for WA derived by the Australian Burden of Disease Study for 2003 were the basis of the Western Australian 2006 burden of disease estimates. While mortality data for WA in 2006 were used to determine the Years of Life Lost (YLL) for 2006, Years of Healthy Life Lost to Disability (YLD) were derived by applying more recent WA data to the 2003 baseline disease models for WA developed by the Australian Burden of Disease Study.

Mortality data from 2004 to 2006 were appended to data for WA from 1997 to 2003 to allow estimation of the trends in mortality of specific conditions. Mortality trends were used to reflect changes in incidence of most fatal conditions for inclusion in the disease modelling process. While for most fatal conditions case fatality was held constant, evidence of a decrease in cardiovascular deaths due to decreasing incidence and case fatality required an adjustment for each parameter. All-cause mortality projections by year, age and sex were also generated from the mortality data for use in the disease modelling process.

To update YLDs estimates from the 2003 to 2006, hospitalisation data were used to determine the rate of change from 2003 to 2006 for many non-fatal conditions, such as, maternal and neonatal conditions, cataracts, digestive disorders, slipped discs and some genitourinary conditions. The rate of change in hospitalisation was used to reflect changes in incidence. Although hospitalisation data may not be ideal for estimating changes in incidence, it provides a workable indication of changes in disease occurrence.

Projections of incidence and assumptions of case fatality for type II diabetes as applied in the Australian study were used to derive WA estimates of YLDs for type II diabetes.

For other mainly non-fatal conditions such as mental disorders, musculoskeletal conditions and some neurological conditions there was either no evidence of trends or only a single source from which trends could not be derived. For these conditions no trends in incidence were assumed.

The estimated changes in incidence derived from mortality data, hospitalisation data and diabetes considerations were combined with case fatality and remission rates from the Australian Burden of Disease study as input into the disease modelling process to derive prevalence and disease duration. These parameters were then used to determine the YLDs and PYLDs for WA in 2006. The total burden measured by DALYs for WA was derived from combining the YLLs and YLDs.

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