Government of **Western Australia**
Department of **Health**

The cost of excess body mass to the acute hospital system in Western Australia 2011

Delivering a **Healthy WA**

The cost of excess body mass to the acute hospital system in Western Australia 2011.

Epidemiology Branch

Public Health and Clinical Services Division

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Executive Summary

- It is well known that excess body mass is associated with an increased risk of disease. It is not currently known what the cost of excess body mass is to the acute hospital system in Western Australia.
- A cost of illness study was performed using 18 harms that are attributable in part, or wholly, to excess body mass. A population-attributable fraction was calculated for each attributable harm to determine the cost from inpatient separations and emergency department presentations attributable to excess body mass. The term excess body mass was used to mean the body mass above which the risk of disease from the attributable harms are increased.
- There were 62,962 inpatient separations attributed to excess body mass in 2011 representing 6.7 per cent of all separations for the year. This resulted in a cost of $237.4 million or 5.7 per cent of all inpatient costs. The three most costly inpatient conditions attributed to excess body mass were osteoarthritis, ischaemic heart disease and type 2 diabetes (excluding renal dialysis).
- There were 8,655 emergency presentations attributed to excess body mass in 2011 representing 1.0 per cent of all presentations for the year. This resulted in a cost of $3.7 million or 1.2 per cent of all emergency costs. The three most costly emergency presentations attributed to excess body mass were ischaemic heart disease, ischaemic stroke and type 2 diabetes mellitus.
- Males incurred more costs than females with a male to female ratio of 1.46 for inpatient costs and 1.20 for emergency department costs.
- The most costly age group was the 60 to 69 year old age group, owing to the large expenditure on osteoarthritis. If osteoarthritis was removed as an attributable harm, then the most costly age group would be the 45 to 59 year old age group.
- The total acute hospital costs attributed to excess body mass were $241.0 million or 5.4 per cent of all acute hospital expenditure.
- Projections for the year 2021 predict costs of $488.4 million (in constant price dollars) with a 102.6 per cent increase in costs compared to 2011. The predicted 392.9 per cent increase in costs from diabetic renal dialysis resulted in this condition being the most costly in 2021. Osteoarthritis and ischaemic heart disease were predicted to be the second and third most costly conditions in 2021. Diabetes and diabetic renal dialysis accounted for 36.0 per cent of predicted expenditure in 2021.
- This current study details the minimum current costs and future projected costs if excess body mass is not addressed in a prolonged, comprehensive and effective manner. Further it reinforces the importance of sustained investment in preventative health.

Introduction

The increased risk of disease associated with being overweight or obese is well documented. The method most commonly used to assess this risk is based on body mass index (BMI). BMI is calculated by dividing a person's weight in kilograms with their height in metres squared. Body mass index is useful because it is obtained easily and used widely in relevant literature. In conventionally used ranges, a person is defined as overweight if their BMI ranges from 25 kg/m^2 to less than 30 kg/m^2 and deemed obese if their BMI is equal to or greater than 30kg/m^2 (Begg et al., 2007).

In 2008 the World Health Organization (WHO) estimated that worldwide, 1.4 billion adults were overweight or obese (WHO, 2013). In Australia the most recent national health survey states that 62.8 per cent of males and 47.6 per cent of females are overweight or obese (Australian Bureau of Statistics, 2012). The rising rates of overweight and obese people have led to concerns about the potential impact on diseases linked to excess body mass.

Several burden-of-disease studies have analysed the burden from excess body mass. The World Health Organization's *Comparative Quantification of Health Risks Study* included a chapter on the burden of disease attributable to being overweight or obese (James et al., 2004). The WHO study found that 33,415,000 disability-adjusted life years lost were attributable to excess body mass in the year 2000 with the majority of this morbidity being from type 2 diabetes and ischaemic heart disease. Two and a half million deaths were also associated with excess body mass. The WHO study attributed 2.3 per cent of the world's morbidity to excess body mass. The more recent Global Burden of Disease study, which has yet to be published in detail, found 3.8 per cent of global morbidity was attributable to excess body mass in 2010 (Lim et al., 2012).

A similar study undertaken in Australia, *The Burden of Disease and Injury in Australia 2003* (Begg et al., 2007) found that of the 14 factors examined, excess body mass created the third highest burden of disease after tobacco use and hypertension and was responsible for 197,460 disability-adjusted life years. This equated to 7.5 per cent of the total burden of disease and injury.

A Western Australian-specific study, *The Burden of Disease and Injury Attributed to Preventable Risks to Health in Western Australia, 2006* included a section on overweight and obese people (Hoad, Somerford and Katzenellenbogen, 2010). It found that 21,663 disability-adjusted life years were attributable to excess body mass equating to 8.7 per cent of the total burden of disease and injury. Interestingly, it also found excess body mass to be the leading cause of morbidity in Western Australia, overtaking tobacco use.

These burden-of-disease studies rely on known attributable harms to determine the morbidity associated with excess body mass. They show a temporal trend to an increasing number of attributable harms given the evolving research in this area. It is therefore likely that current research underestimates the number of attributable harms and the total cost attributable to excess body mass.

Burden-of-disease studies are important because they can guide decisions about which diseases or conditions deserve attention and resources. Studies into excess body mass also quantify the burden of disease that can be prevented if programs are implemented to prevent the accumulation of body mass or reduce the rates of excess body mass in a population. Cost-of-illness studies build on burden-of-disease studies by factoring in costs that the treatment of these conditions imposes on health systems. Cost-of-illness studies can therefore provide the financial justifications for preventative interventions to reduce excess body mass.

Multiple international studies have built on these burden-of-disease studies to estimate the costs of excess body mass to health systems. Differing methodologies have been employed in these studies, ranging from small detailed community longitudinal studies that examine individual costs, to large national estimates of cost based on aggregate data.

In 2009 a meta-analysis was undertaken that reviewed cost-of-illness studies for excess body mass covering multiple differing methodologies. Of those studies that used a methodology relying on the use of costing attributable harms and applying population-attributable fractions, the range in cost estimates was between 2.3 per cent and 5.8 per cent of total health expenditure with a bias towards studies from the developed world. Since this meta-analysis, there have been two studies that have followed this general methodology. The first was a Canadian study, which examined data for the year 2006 and used a more extensive list of attributable harms than previous studies, some of which were excluded elsewhere based on the paucity of evidence present (Anis et al., 2010). The final conclusion of the study was that 4.1 per cent of health expenditure was attributable to overweight or obese states. Another study conducted in Brazil from 2008 to 2010 used a similar methodology (Bahia et al., 2012). It concluded that 11 per cent of hospital inpatient expenditure could be attributed to excess body mass. The study was the anomaly and also found greatly increased costs compared to another Brazilian study performed on 2007 data (Sichieri et al., 2007).

Limited research has been undertaken in Australia to calculate the cost of excess body mass. Diabetes Australia commissioned a study to estimate the cost of obesity in Australia for the year 2008 (Access economics, 2008). The study found that the costs to the state and federal governments from obesity were $2 billion with an estimated $147 million in Western Australia. This included Medicare-related costs and used national-level disease-specific costs. It used the same methods to calculate the population-attributable fraction as the *World Health Organization's Comparative Quantification of Health Risks study* (James et al., 2004) and *The Burden of Disease and Injury in Australia 2003* (Begg et al., 2007).

Perhaps the most comprehensive study of hospital expenditure related to excess body mass was performed in South Australia. The South Australian study provided a detailed costing from acute public hospitals emergency presentations, inpatient admissions and outpatient presentations (Larg & Moss, 2011). It attributed 4.6 per cent of the acute public hospital expenditure to excess body mass. Currently no cost-of-illness study of excess body mass in Western Australia has been completed. This study largely replicates the South Australian study with some alterations due to the availability of local data.

The aim of this study is to determine the costs to the acute hospital system that are attributable to excess body mass in Western Australia. Its objectives include to:

- determine the inpatient costs and separations attributable to excess body mass in Western Australia in 2011.
- determine the emergency department costs and presentations attributable to excess body mass in Western Australia in 2011.
- predict the total costs attributable to excess body mass in 2021, based on historical trends in body mass, separations and unit costs.

Methodology

This study uses 18 attributable harms, including obesity itself, to estimate the acute hospital costs of excess body mass in 2011. Population-attributable fractions for each condition have been combined with diagnosis-related group cost weights for each hospital separation to produce the total inpatient costs of excess body mass. Population-attributable fractions have also been combined with emergency department unit costs (by location and triage category) and emergency presentation data to produce the total emergency department costs for excess body mass.

This study is similar to other cost-of-illness studies, most notably a South Australian study by Larg and Moss (2011). The major difference between this study and the Larg and Moss (2011) study is that this study, due to data limitations, does not assess outpatient hospital costs. This study is strengthened by its use of the Western Australia Health and Wellbeing Surveillance System to more accurately estimate population body mass index distribution (Epidemiology Branch, 2013a). Most hospitals within the metropolitan region of Perth assign an ICD10 code for each emergency presentation so it was possible in this study to use a similar methodology for the inpatient and emergency data. This differs from the Larg and Moss (2011) study that used a continuous estimation of risk from excess body mass for each attributable harm concerning inpatient data, but categorical data for self-reported emergency presentations linked to body mass from the National Health Survey, without considering the costs for each attributable harm.

Attributable harms

Attributable harms were chosen where a condition was partially or wholly attributed to excess body mass. Attributable harms were sourced from the South Australian costing study (Larg and Moss, 2011). The following attributable harms have therefore been included:

- ischaemic heart disease
- ischaemic stroke
- hypertensive disease
- hypertensive heart disease
- type 2 diabetes
- type 2 diabetic renal dialysis
- osteoarthritis
- colon and rectum cancers
- breast cancer (females and postmenopausal only)
- endometrial cancer
- kidney cancer
- gall bladder disease
- asthma
- pancreatic cancer
- oesophageal adenocarcinoma
- ovarian cancer
- congestive heart failure

A search of the relevant literature failed to find additional meta-analyses in this area and therefore no additional attributable harms are included compared to the South Australian study.

A further attributable harm of ‘obesity’ has been added, as per the South Australian study, to include those separations and presentations whose primary diagnosis was directly attributed to excess body mass. The partly published global study (Lim et al., 2012) did include additional attributable harms, and modified others, but the associated relative risks were not yet published and therefore could not be included in this study. Table 1 summarises the major burden of disease studies.

Table 1. Attributable harms used in Australian and global burden of disease and cost of illness studies.

Area studied Reference	Australia Mathers et al., 1999	World James et al., 2004	World WHO, 2009	Australia Begg et al., 2007	WA Hoad et al., 2010	SA Larg et al., 2011	World Lim et al., 2012
Study year	1996	2000	2004	2003	2006	2007/8	2010
Ischaemic heart disease	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ischaemic stroke	Yes	Yes[1]	Yes[1]	Yes	Yes[1]	Yes	Yes
Hypertension	Yes	Yes				Yes	
Hypertensive heart disease			Yes	Yes	Yes	Yes	Yes
Type 2 diabetes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Osteoarthritis	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Colorectal cancers	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Breast cancer (post menopausal)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cancer of the uterus	Yes[2]	Yes	Yes	Yes	Yes[2]	Yes[2]	Yes
Gall bladder disease	Yes				[3]	Yes	Yes[4]
Back problems	Yes				[3]	[3]	Yes
Kidney cancer	Yes				Yes	Yes	Yes[5]
Congestive heart failure						Yes	
Asthma						Yes	
Pancreatic cancer						Yes	Yes
Oesophageal adenocarcinoma						Yes	Yes
Ovarian cancer						Yes	
Cardiomyopathy/ myocarditis/ endocarditis							Yes
Atrial fibrillation and atrial flutter							Yes
Peripheral vascular disease							Yes
Chronic kidney disease							Yes

1 Cerebrovascular disease in general.
2 Endometrial specifically.
3 Excluded due to lack of data
4 Included gall bladder and biliary tract cancers.
5 Included tumours of the urinary tract also.

Determination of the population-attributable fraction

The population-attributable fraction was calculated using the following formula. Each component of the formula is discussed in turn in the sections following.

$$\text{PAF} = \frac{\int_{x=0}^{m} RR(x)P(x) - \int_{x=0}^{m} RR(x)P'(x)}{\int_{x=0}^{m} RR(x)P(x)}$$

RR(x) is the relative risk at BMI=x
P(x) is the actual population prevalence of BMI=x
P'(x) is the theoretical minimum risk population prevalence of BMI=x
m is the maximum BMI in the actual population

Relative risks

Relative risks were sourced from *The Burden of Disease and Injury in Australia 2003* study (Begg et al., 2007). As per the South Australian study, the relative risks of attributable harms not included in this study were sourced from a meta-analysis from Guh (2009) and Renehan (2008). When available, relative risks were used by age, gender and body mass index. For many attributable harms, age-specific relative risks were not available but were instead applied equally across all age groupings.

Relative risks from *The Burden of Disease and Injury in Australia 2003* study were available only for those aged over 30 years (Begg et al., 2007). This study, therefore, included only those aged over 30 years.

For those attributable harms included in *The Burden of Disease and Injury in Australia 2003* study relative risk, based on a continuous function with small increases in relative risk from the BMI of 21.5 kg/m^2 were used (Begg et al., 2007).

For some attributable harms data were available only for the categories of overweight and obese, as compared to those with a normal body mass index. In the South Australian study this was addressed through presuming that the relationship between obese and normal body mass is linear and that there is a difference of 10 units between the mean of these two categories. This produced a per unit increase and allowed the calculation of relative risks for the continuous function used in the population-attributable fraction calculation. For this study a similar method has been used but three points used for calculation. The per unit increase in relative risk has been calculated between normal body mass and overweight body mass by presuming a five unit difference between the mean of these two populations and a linear relationship. This was then applied to the body mass index levels of 25 through to 29.5 kg/m^2. Similarly a per unit increase in relative risk has been calculated between overweight and obese body mass by presuming a five-unit difference between the mean of these two populations and a linear relationship. This has then been applied to the body mass index levels above 30kg/m^2. This extra step was added to avoid overestimating the risk of the large numbers of people in the overweight category whose risk could potentially be overestimated if the two points from normal and obese categories were used alone.

Estimate of Western Australian BMI distribution

The BMI was estimated using the WA Health and Wellbeing Surveillance System (Epidemiology Branch, 2011). This system continually samples randomly selected participants from Western Australia. In 2011 the raw response rate was 74.7 per cent with an adjusted response rate (for those who answered their telephone) of 82.1 per cent in a sample of 9277 telephone number participants (Epidemiology Branch, 2013a). This system continually surveys weight and height for all participants (or their parent) aged five years and above (Epidemiology Branch, 2011). This report does have some limitations, however, including that an estimated 10.7 per cent of dwellings in Western Australia do not have a landline telephone, 1.8 to 6.7 per cent are disabled in a way that precludes them from answering a telephone and that some Aboriginal people may find it culturally inappropriate to answer a telephone survey (Epidemiology Branch, 2011).

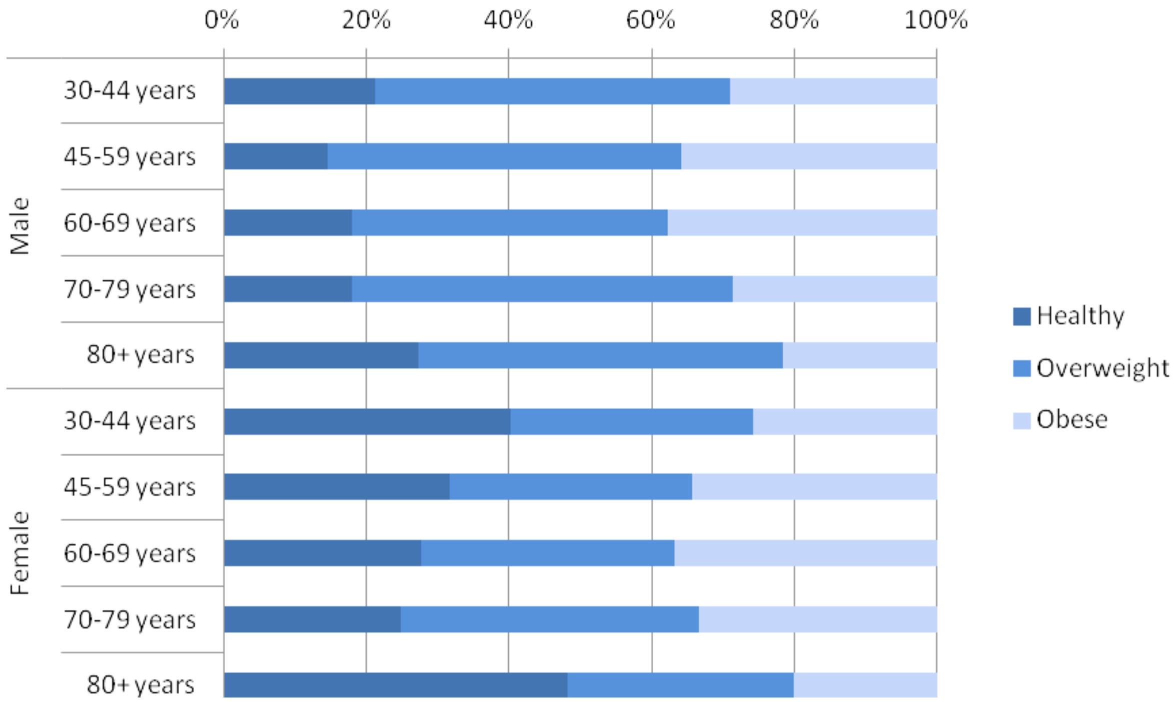
A further limitation of all self-reported surveys is that there is a trend to misreport height and weight (Hayes et al., 2008). To counter this, a widely used algorithm was applied to the data to produce a more valid measure of body mass index from Hayes' (et al., 2008) study. This algorithm is shown below.

$$\text{Men } BMI_c = \frac{(1.022*srweight+0.07)}{(0.00911*srheight+0.1375)^2}$$

$$\text{Women } BMI_c = \frac{(1.022*srweight-0.067)}{(0.00863*srheight+0.2095)^2}$$

The weighted results from the WA Health and Wellbeing Surveillance System are shown in Figure 1 (Epidemiology Branch, 2013a).

Figure 1. Body mass index distribution, by age group, estimated for the WA population, 2011.



Theoretical minimum risk BMI distribution (Counterfactual)

The theoretical minimum risk BMI distribution is the distribution in a population that would be associated with the lowest risk to health from excess body mass. The World Health Organization has developed such a distribution based on an optimal balance between the diseases associated with excess body mass and the health hazards associated with being underweight (James et al., 2004). A population with a mean BMI of 21 kg/m^2 and a standard deviation of one has been predicted to result in a population with the lowest health risk from both excess body mass as well as being underweight. This was also found to be in keeping with studies of real-world populations and their risk of disease.

As in multiple previous studies, this BMI distribution was used as the counterfactual given that it is a more realistic scenario than a scenario in which no person has a BMI that places them at increased risk (Larg & Moss, 2011; Begg et al., 2007; James et al., 2004). The estimated distribution of BMI in Western Australia was then compared against this hypothetical population distribution by mapping each BMI, by age and gender group, against its corresponding value in the alternative population using z-scores. Prior to this comparison occurring, as in previous studies, the data was presumed to be positively skewed and transformed using a 1/square root transformation (Larg and Moss, 2011; Begg et al., 2007).

Attributable harms that were assessed differently

An extra attributable harm, called obesity, was added for a principal diagnosis that was directly related to excess body mass. Conditions related directly to obesity were considered to have a population-attributable fraction of 100 per cent.

The proportion of renal dialysis related to type 2 diabetes was determined by using the Western Australian subset of the ANZDATA dialysis register for 2011. Rates of dialysis for hospital-based services were determined by age and gender groups. The general diabetes population-attributable fraction was then applied to this reduced figure.

There is no ICD10 code that differentiates oesophageal cancer by morphology, so for oesophageal adenocarcinoma, morphology codes from the Western Australian Cancer registry were used to further differentiate these separations by morphology type. For emergency presentations these data were not available. For emergency presentation data the rate of adenocarcinoma, compared to the total of all oesophageal cancer separations from the inpatient data, was applied to emergency presentations to estimate the likely proportion from this subtype.

Disease-specific costs

Inpatient separations and costs

The numbers of inpatient separations, for each attributable harm, were obtained through their associated ICD10 codes (Appendices A to C). For each separation the Diagnostic Related Group (DRG) code was used to assign a monetary value. This monetary value was sourced from the national public sector cost weights and average Australian Refined-DRG cost weights (DoHA, 2013). This document provides the national estimates for the 2009 to 2010 financial year. To obtain the estimate for the financial year 2010 to 2011 an escalation factor of 4.6 per cent has been used. This figure was obtained from the business and financial modelling system of the Western Australia Department of Health. These estimates use the 'Whole health cost model' that projects Western Australia's recurrent health expenditure, using the major inputs of current costs and expected changes in prices and wages. Using this same process, a further increase of 4.79 per cent has been obtained for the financial year 2011 to 2012 (Department of Health WA, 2013).

The potential total costs influenced by excess body mass related comorbidities were also included. This was found by including the cost and separations for each separation that included one or more attributable harms as a secondary diagnosis. This was performed to estimate the total costs and separations for which excess body mass may influence, if only partially and of an indeterminate level. These figures are reported as a total only and not by attributable harm because many separations have numerous harms and produce an inflated figure when all harms are totalled.

Emergency Presentations and costs

In Western Australia all metropolitan hospitals, except for one, provide ICD10 coding for emergency presentations. All non-metropolitan hospitals provide only major diagnostic category information except for one which provides ICD10 codes.

For metropolitan hospitals with ICD10 coding, the inpatient data and emergency data were linked. The two data sets were linked anonymously based on a complete match between month and year of birth, gender, hospital, suburb of residence, date of admission and time of admission (to the precise minute). For emergency presentations that had a linked inpatient record, the ICD10 code given at discharge from the inpatient setting was used as the diagnosis for the emergency presentation.

For the single metropolitan hospital that does not provide ICD10 codes, presentations for each attributable harm were estimated based on the rates in other metropolitan hospitals by combined age and triage groups. For non-metropolitan hospitals without ICD10 codes, rates of presentations for each attributable harm were applied from metropolitan hospitals. This was performed based on age group, triage category and major diagnostic category with a rate for each of these groups from the metropolitan data being applied to the rural non-metropolitan data. To determine the validity of this technique it was applied to the one non-metropolitan hospital that currently uses ICD10 coding. A Z test was performed on the aggregate results by triage category between predicted presentations and actual presentations with no significant differences found between the proportions of each category. There was a general trend to underestimating the number of presentations (Table 2).

Once the number of presentations was determined by location and triage category, costs were estimated. The business and financial modelling system of the Western Australian Department of Health provided emergency department costing for metropolitan hospitals for the 2009 to 2010 financial year. These data included the number of presentations for each triage category and hospital type along with the total costs for each triage group by hospital type. The costs for metropolitan hospitals were based on mean actual costs for the 2009 to 2010 financial year with escalation factors for later years calculated as per the inpatient costs (Department of Health WA, 2013). Extra costs associated with delivery of health care to the various rural and remote areas within Western Australia were included by applying escalation factors for rural and remote hospitals (Department of Health WA, 2013b).

Table 2. Triage category, absolute difference between predicted and actual result for a regional hospital.

Triage category	Percentage difference	95 % Confidence interval
Triage 1	0.6	-1.7 to 0.4
Triage 2	3.2	-0.8 to 7.2
Triage 3	3.5	-7.7 to 0.7
Triage 4	1.0	-2.0 to 4.0
Triage 5	0.05	-0.8 to 0.7

Cost predictions

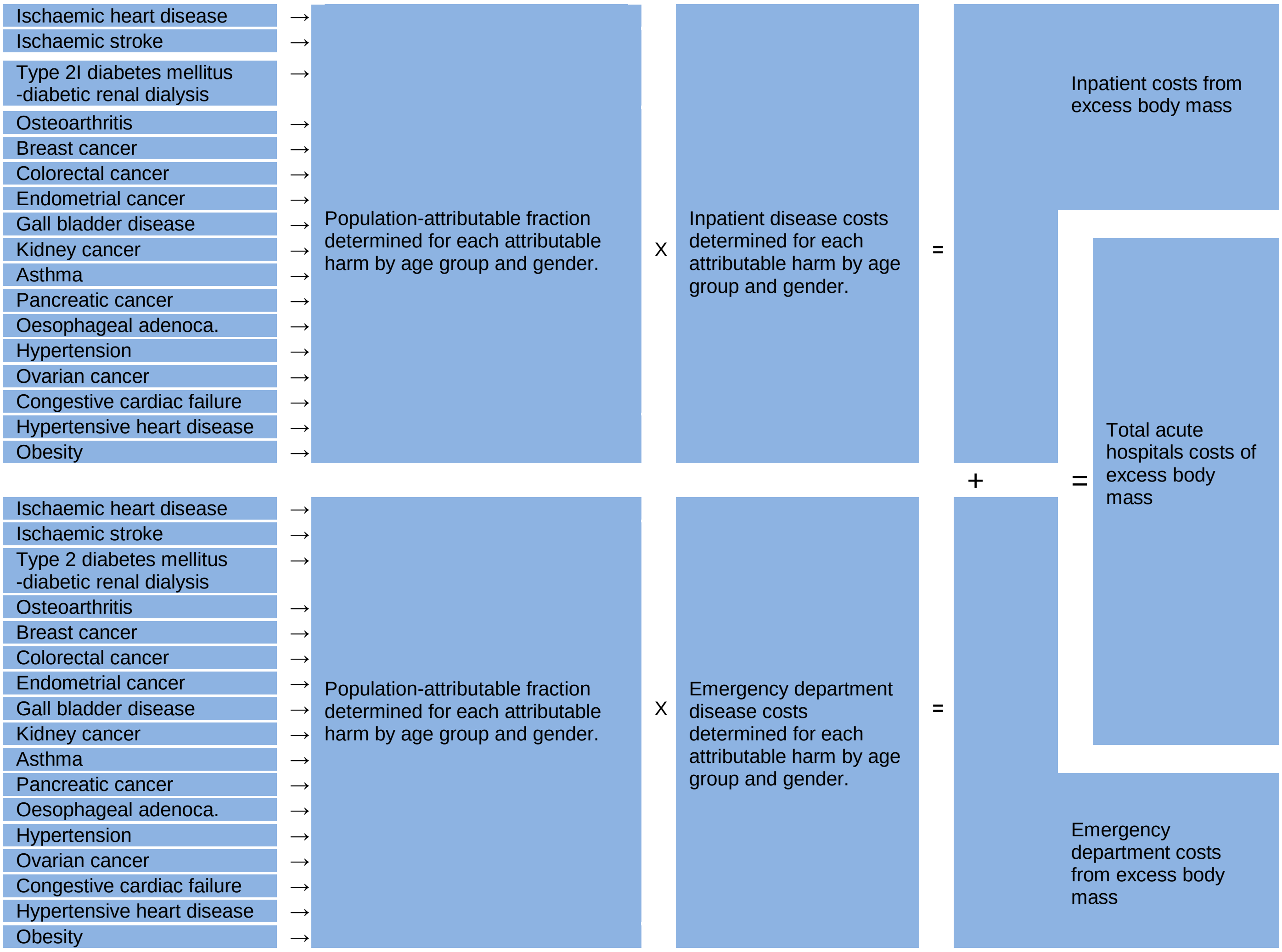
Predicted future costs attributed to excess body mass were estimated for the year 2021. As 10 years of inpatient data were available prior to, and inclusive of, the study year, costs were predicted for the year 2021, 10 years after the study year. Three factors were used to estimate future costs: predicted increased cost per separation, predicted increased separations and increases in the population-attributable fractions based on predicted increases in body mass.

The predicted increase in cost per separation for each condition was estimated using multiple regression with an incremental increase in cost estimated per year by each attributable harm, gender and age group. The predicted increase, or decrease, in separations was estimated using the exponential weighted moving average based on the separations recorded for the 10 years prior for each condition by age and gender groups with adjustments made for predicted future changes in the age and gender distribution in Western Australia. Lastly for the period from 2002, data from the Western Australian Health and Wellbeing Surveillance system was used to predict future body mass trends (Epidemiology Branch, 2011). Linear regression was used to predict increases in the mean body mass index for each gender and age group, the standard deviation for the 2021 prediction was presumed to be constant to the 2011 value because a consistent trend was not detected on examination of the data.

As 10 years of historic data were not available for the emergency presentations, it was presumed that presentations for each condition increased at the same rate as the inpatient separations for each condition.

The methods for calculating total acute hospital costs attributable to excess body mass are summarised in Figure 2.

Figure 2. Summary of methods used to determine total acute hospital costs, 2011.



Results

Cost estimates for inpatient admissions

In 2011 there were a total of 946,253 hospital separations incurring an estimated cost of $4,202.5 million. Of these separations 62,962, or 6.7 per cent of all separations, were attributed to excess body mass. This resulted in a cost of $237.4 million or 5.7 per cent of all inpatient costs. A further 124,874 separations had one or more comorbidities attributed to excess body mass. This resulted in a cost of $814.9 million to the hospital system (Table 3). The fraction of this amount that would be attributable to excess body mass remains unknown but emphasises how much larger the true cost could be if other factors, such as excess body mass complicating other diagnoses, could be calculated.

Osteoarthritis produced the greatest costs of a harm attributed to excess body mass, accounting for 2.0 per cent of all inpatient costs. Ischaemic heart disease and type 2 diabetes also contributed large costs with 1.2 per cent and 1.1 per cent of all inpatient costs respectively (Table 3).

The greatest costs were accrued in the 60 to 69 year old age group with $69.9 million. This cost distribution was distorted largely by the one condition of osteoarthritis and if it were removed the most costly age group would be the 45 to 59 year old group (Appendices E to G).

Males accounted for more costs than females with respective costs of $141.0 million and $96.4 million, producing a male to female rate ratio of 1.46. For the three most costly conditions, males incurred greater costs than females. The less costly asthma, gall bladder disease, hypertension and obesity were the conditions, other than those with an inherent gender bias, in which females incurred greater costs (Appendices E to G).

When gender and age group were analysed concurrently there were greater costs for females aged 30 to 44 years as compared to males of the same age. In all other age groups males incurred greater costs than females in the same age group. The most costly age grouping for females was 45 to 59 years whereas for males it was 60 to 69 years (Appendix G).

Table 3. Estimated inpatient costs of each disease that is attributable to excess body mass, 2011.

Condition	Total		Attributable Fraction	Attributed to excess body mass		% of total costs
	Separations	Costs		Separations	Costs	
Osteoarthritis	11,406	$180,679,395	46.8%	5,320	$84,535,963	2.0%
Ischaemic heart disease	14,661	$121,640,084	40.2%	5,792	$48,952,634	1.2%
Type 2 diabetes mellitus	2,195	$22,503,228	70.4%	1,564	$15,840,654	0.4%
-diabetic dialysis	59,816	$39,184,025	72.4%	43,266	$28,380,689	0.7%
Gall bladder disease	6,225	$45,091,085	28.9%	1,827	$13,021,734	0.3%
Obesity	1,082	$10,743,499	100.0%	1,082	$10,743,499	0.3%
Ischaemic stroke	2,743	$22,673,674	36.4%	999	$8,244,744	0.2%
Congestive cardiac failure	4,370	$35,803,628	23.9%	1,032	$8,569,574	0.2%
Colorectal cancer	2,593	$34,749,264	21.5%	559	$7,476,476	0.2%
Breast cancer	2,149	$16,201,765	18.9%	410	$3,059,981	0.07%
Kidney cancer	570	$7,331,059	34.2%	196	$2,504,575	0.06%
Endometrial cancer	271	$2,503,813	61.0%	165	$1,527,454	0.04%
Asthma	1,158	$5,305,436	23.0%	270	$1,221,354	0.03%
Pancreatic cancer	505	$4,818,353	29.6%	148	$1,424,801	0.03%
Hypertension	573	$2,026,340	33.3%	193	$674,564	0.02%
Oesophageal adenocarcinoma	212	$1,584,340	33.8%	72	$535,022	0.01%
Hypertensive heart disease	49	$380,687	57.6%	29	$219,200	0.01%
Ovarian cancer	307	$3,402,361	12.6%	39	$427,471	0.01%
Total inpatient	946,253	$4,202,522,704		62,962	$237,360,389	5.65%
Excess body mass related comorbidities*	124,874	$814,912,587	-	-	-	19.4%

*Includes all other inpatient separations which recorded comorbid diagnoses (secondary diagnoses) of an attributable harm but which was not included above.

Cost estimates for emergency presentations

In 2011 there were a total of 902,873 presentations to emergency departments with an estimated cost of $302.3 million. Of these presentations 8,655, or 1.0 per cent, were attributed to excess body mass. This resulted in a cost of $3.7 million or 1.2 per cent of emergency department costs being attributed to excess body mass (Table 4).

The most costly attributable harm in emergency departments was ischaemic heart disease accounting for 0.5 per cent of all emergency costs. Ischaemic stroke and type 2 diabetes were the second and third most costly attributable harms accounting for 0.2 per cent and 0.1 per cent of all emergency costs respectively (Table 4).

In contrast to the inpatient data, where the most costly age group was the 60 to 69 year old group, the most costly age group in emergency departments was the 45 to 59 year old group. This resulted from the lower costs of osteoarthritis in emergency departments that skewed the inpatient costs to older age groups (Appendices H to K).

Males also accounted for greater costs than females, with costs of $2 million and $1.7 million respectively, producing a male to female ratio of 1.20. The age and gender differences persisted across all of the most costly attributable harms. The 45 to 59 year old age group was the most costly age group for most conditions. As with the inpatient data, female presentations to emergency departments in the 30 to 44 year age group were more costly than males in the same age group. Unlike the inpatient data, however, emergency presentations of females over 80 years were also more costly than males in the same age bracket. Males in all other age groups were more costly (Appendix K).

Table 4. Estimated emergency costs of each disease that is attributable to excess body mass, 2011.

Condition	Total		Population-attributable fraction	Attributed to excess body mass		Percentage of total emergency costs
	Presentations	Costs		Presentations	Costs	
Ischaemic heart disease	8,548	$4,045,299	38.51%	3,324	$1,557,766	0.5%
Ischaemic stroke	2,767	$1,213,256	38.22%	1,078	$463,726	0.2%
Type 2 diabetes mellitus	1,226	$490,255	71.34%	890	$349,744	0.1%
-diabetic renal dialysis	15	$5,940	77.37%	12	$4,596	0.00%
Osteoarthritis	722	$226,717	42.90%	317	$97,253	0.03%
Breast cancer (post menopausal)	44	$18,477	15.44%	7	$2,853	0.00%
Colorectal cancer	267	$120,392	20.93%	56	$25,196	0.01%
Endometrial cancer	13	$5,233	58.26%	8	$3,049	0.00%
Gall bladder disease	3,243	$1,282,013	28.14%	924	$360,745	0.1%
Kidney cancer	64	$18,916	31.37%	21	$5,934	0.00%
Asthma	2,981	$1,031,846	23.00%	687	$237,283	0.08%
Pancreatic cancer	113	$48,382	28.74%	34	$13,904	0.00%
Oesophageal adenocarcinoma	39	$15,719	33.69%	13	$5,295	0.00%
Hypertension	1,122	$366,703	34.92%	391	$128,069	0.04%
Hypertensive heart disease	102	$35,217	60.90%	62	$21,447	0.01%
Ovarian cancer	80	$29,601	12.47%	10	$3,690	0.00%
Congestive cardiac failure	3,421	$1,650,457	24.12%	810	$398,048	0.1%
Obesity	12	$5,640	100%	12	$5,640	0.00%
Total Emergency	902,873	$302,268,911		8,655	$3,684,236	1.2%

Cost estimates for all acute hospital expenditure

The total acute hospital expenditure largely reflects the inpatient costs which are far greater in magnitude. The total acute hospital costs attributed to excess body mass were 5.4 per cent of all costs or $241.0 million.

The main differences between the emergency and inpatient costs were that the emergency costs were from those of a younger age and were more equally distributed between the genders. As previously stated, osteoarthritis-related separations in older age groups made inpatient costs larger among older age groups. Because osteoarthritis did not produce such large costs in the emergency data, a greater proportion of costs were attributed to younger ages. The gender difference was more pronounced across all of the most costly conditions in the inpatient data with a male to female ratio of 1.46 compared to 1.20 for emergency costs. Figure 3 summarises the costs for each age and gender subgroup.

Figure 3. Costs to the acute hospital system by age and gender, 2011.

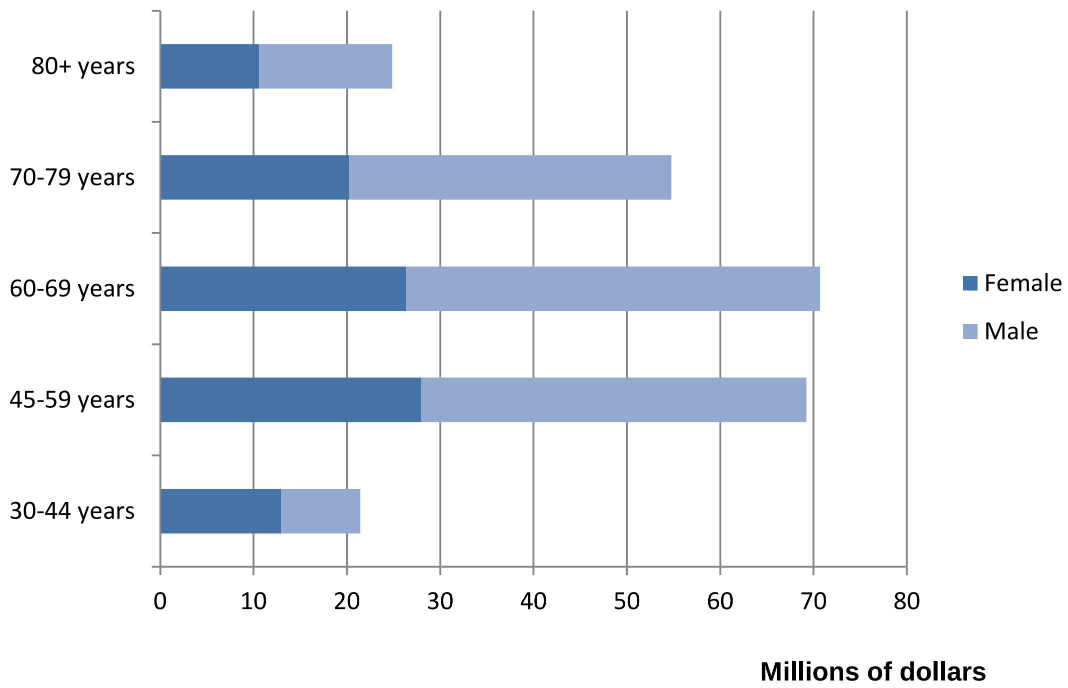
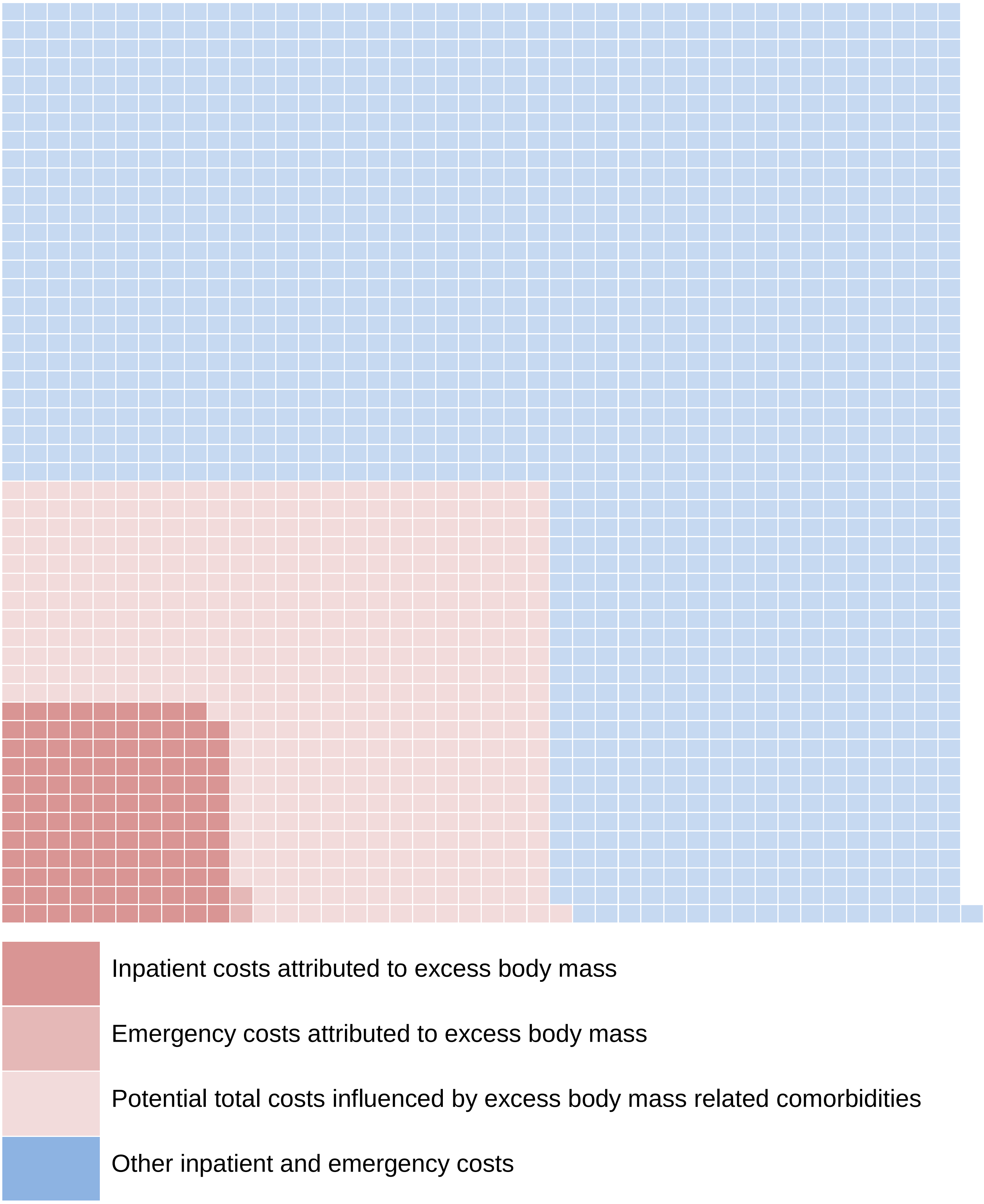


Figure 4 highlights in a schematic way the relative contribution of excess body mass to the costs of the acute hospital system. The costs of attributable harm related diagnoses are also included to suggest the sizeable influence that excess body mass may have on other separations.

Figure 4. Costs attributed to excess body mass as a proportion of all acute hospital costs, 2011.



Inpatient costs attributed to excess body mass

Emergency costs attributed to excess body mass

Potential total costs influenced by excess body mass related comorbidities

Other inpatient and emergency costs

1 square = 2 million dollars

Projected costs and separations attributable to excess body mass

Projected acute hospital costs attributable to excess body mass for 2021 were estimated at $488.4 million in constant prices (2011/2012 financial year). This represents a 102.6 per cent increase. Other than asthma and hypertensive heart disease, all conditions were predicted to increase in costs over this period (Figure 5).

The condition with the highest rate of increase was diabetic renal dialysis with a 392.9 per cent increase over the 10-year period. This was due largely to a predicted increase in the number of separations rather than an increase in cost per session or the fraction attributable to excess body mass. Conditions directly related to excess body mass were predicted to grow rapidly with a projected increase in cost of 219.6 per cent, owing mostly to a projected increase in the number of separations (Figure 5).

The most costly conditions attributable to excess body mass in 2021 were predicted to be diabetic renal dialysis, osteoarthritis, ischaemic heart disease and type 2 diabetes. If diabetic renal dialysis was grouped with type 2 diabetes, this would account for 36.0 per cent of the predicted costs related to excess body mass in 2021 (Figure 5).

The 60 to 69 year old age group is expected to remain the most costly age grouping. The difference between age groups will narrow, with the costs for the older and younger age groups increasing at faster rates. The costs for those aged 70 to 79 years and over 80 years are predicted to increase by 116.2 and 204.6 per cent respectively. This is in contrast to the 45 to 59 and 60 to 69 year old age group costs that are predicted to increase by 73.8 per cent and 73.1 per cent respectively. The 30 to 44 year old group was predicted to increase by 139.9 per cent (Appendix L).

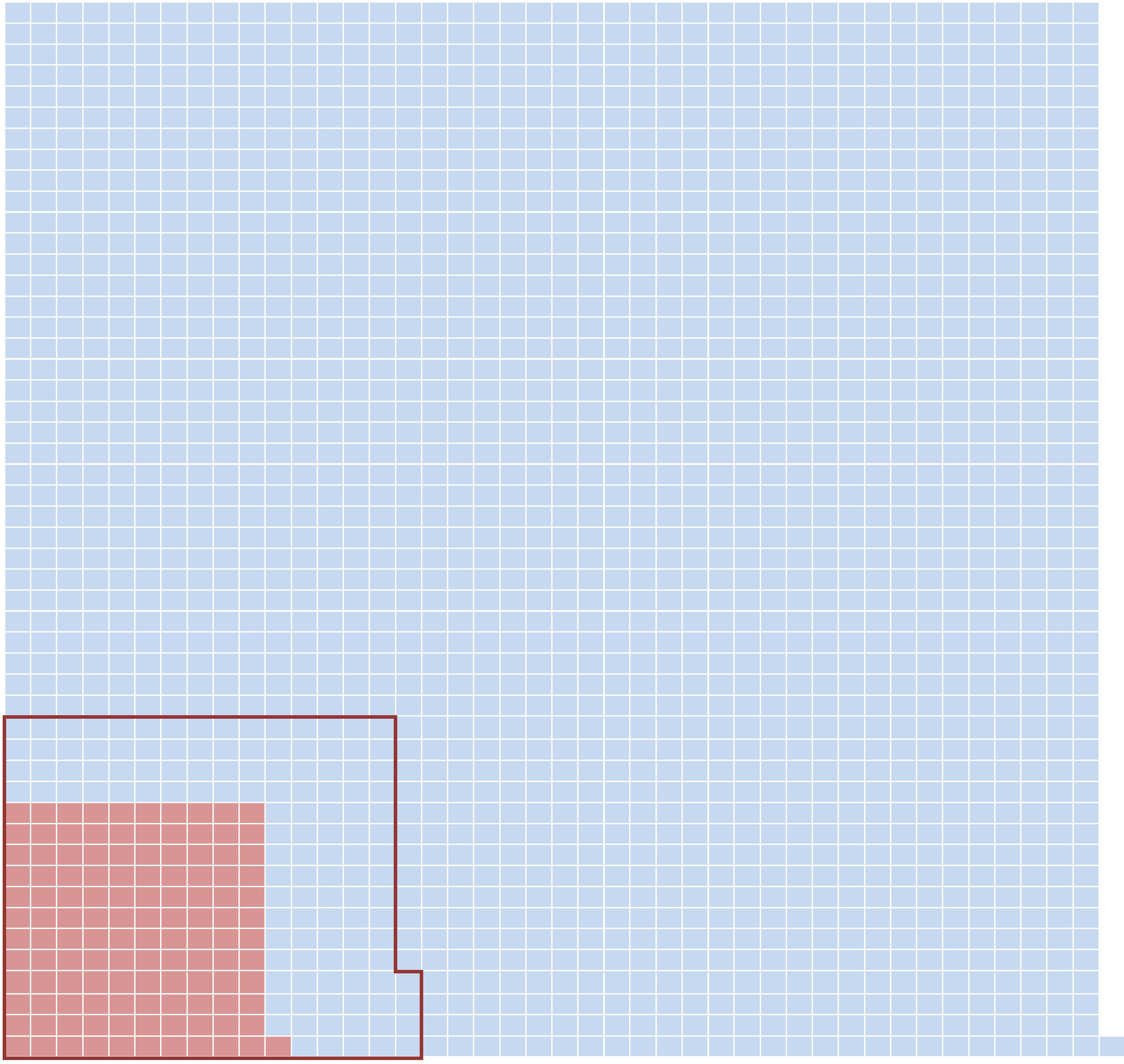
The gender difference in costs was predicted to increase with the male to female ratio increasing from 1.46 in 2011 to 1.50 in 2021 and was reflected in gender differences across most conditions. This gender difference was most pronounced in the costs for those aged over 80 years where the male to female ratio was 1.84. It was reversed in those aged 30 to 44 years with a male to female ratio of 0.60 (Appendix L).

Figure 5 summarises the projected costs of each attributable harm, ranked and compared against the 2011 costs. Figure 6 shows, in a schematic manner, the difference between total costs attributable to excess body mass in 2011 and in 2021.

Figure 5. Projected inpatient and emergency costs and ranking of each condition that was attributable to excess body mass, 2011 and 2021.

Year 2011		**Year 2021**		**% increase**
1. Osteoarthritis	$84,633,216	1. Diabetic renal dialysis	$139,903,140	392.9%
2. Ischaemic heart disease	$50,510,400	2. Osteoarthritis	$133,585,902	57.8%
3. Diabetic renal dialysis	$28,385,285	3. Ischaemic heart disease	$64,127,717	27.0%
4. Type 2 diabetes	$16,190,398	4. Type 2 diabetes	$35,904,649	121.8%
5. Gall bladder disease	$13,382,479	5. Obesity	$34,356,781	219.6%
6. Obesity	$10,749,139	6. Gall bladder disease	$19,166,583	43.2%
7. Congestive cardiac failure	$8,967,621	7. Ischaemic stroke	$15,189,953	74.4%
8. Ischaemic stroke	$8,708,470	8. Congestive cardiac failure	$14,992,984	67.2%
9. Colorectal cancer	$7,501,672	9. Colorectal cancer	$11,508,137	53.4%
10. Breast cancer	$3,062,834	10. Breast cancer	$5,768,493	88.3%
11. Kidney cancer	$2,510,508	11. Kidney cancer	$4,597,773	83.1%
12. Endometrial cancer	$1,530,503	12. Pancreatic cancer	$2,834,798	97.0%
13. Pancreatic cancer	$1,438,705	13. Endometrial cancer	$2,052,332	34.1%
14. Asthma	$1,458,637	14. Oesophageal adenocarcinoma	$1,349,502	149.8%
15. Hypertension	$802,633	15. Asthma	$1,300,113	-10.9%
16. Oesophageal adenocarcinoma	$540,317	16. Ovarian cancer	$605,217	40.4%
17. Ovarian cancer	$431,161	17. Hypertensive heart disease	$587,820	144.3%
18. Hypertensive heart disease	$240,647	18. Hypertension	$546,530.75	-31.9%
Total	$241,044,625	Total (constant prices)	$488,378,428	102.6%

Figure 6. Costs attributed to excess body mass as a proportion of all acute hospital costs, 2011 and 2021.



2011 combined inpatient and emergency costs

2021 projected combined inpatient and emergency costs

2011 other inpatient and emergency costs

1 square = 2 million dollars

Discussion

This report estimated the costs attributable to excess body mass in the acute hospital system. It was found that $241.0 million, or 5.4 per cent of combined emergency and inpatient costs, were attributable to excess body mass. If current trends in costs, separations and population body mass continue then this cost will increase to $488.4 million in 2021 (in constant prices).

These results are consistent with the results of previous cost-of-illness studies mentioned in the introduction section. A South Australian study, whose population estimate of excess body mass was slightly lower than the current study, estimated that 4.6 per cent of inpatient expenditure was attributable to excess body mass using a similar methodology to this current study (Larg & Moss, 2011). All other previous Australian studies had vastly differing methodologies and reported different costs, such as Medicare-related costs (for example Access economics, 2008). The international studies quoted in the introduction mostly resulted in estimates ranging between 2.30 and 5.83 per cent with one study returning an estimated cost of 11 per cent (Withrow & Alter, 2011; Anis et al., 2010; Bahia et al., 2012). This current study was therefore consistent with these previous studies.

This study has some limitations, mostly arising from its methodology, data sources and estimations. Firstly, it included only attributable harms for which more than one study had confirmed the relative risk from excess body mass. It is therefore likely that other attributable harms exist which, if included, would reflect more accurately the true cost of excess body mass. Also the costs of each presentation and separation are estimated costs only. The non-metropolitan emergency data was, in general, of limited detail with some hospitals not including ICD10 codes for presentations. Also, there was a tendency for emergency presentations to be coded with non-specific ICD10 diagnoses, therefore likely underestimating the number of presentations for each condition. The predicted costs also assume that the previous temporal trends in body mass, unit costs and number of separations will continue and that emergency department costs will grow at the same rate as inpatient costs. Lastly this study considered only a primary diagnosis with an attributable harm — not the potential cost that excess body mass could generate by complicating other unrelated admissions. In general these limitations would likely result in an underestimation of the true cost of excess body mass to the acute hospital system.

With continued research it is expected that the costs attributed to excess body mass will increase to a level more reflective of the true cost of excess body mass. The South Australian cost-of-illness study mentions 14 more attributable harms which may, with further research, emerge as new attributable harms (Larg & Moss, 2011). The partly published global burden of disease study also includes four further attributable harms, with the evidence yet to be published, that are not included in this study (Lim et al., 2012). The addition of further attributable harms would reduce the degree to which the current study underestimates the true cost of excess body mass.

This study highlights the urgent need to develop policies and programs to reduce excess body mass in the West Australian population. It is widely accepted that policy change to address excess body mass must be broad in scope. A National Health and Medical Research Council-funded study (King et al., 2010) organises a number of disparate issues and strategies into nine areas that are necessary for action to reduce excess body mass. These are:

- early life exposures and growth patterns
- addressing community understanding and social norms through mass media
- exposure to marketing of foods and lifestyles
- improved physical activity and nutrition in everyday life
- planning healthy active environments
- food supply
- food access and availability
- food purchase and consumption
- action in high-risk groups.

The cost of programs to address these broad areas can be analysed using the opportunity costs, which are minimal estimates, presented in this current study to partially suggest their cost effectiveness.

Due to costs, and projected increases in costs, type 2 diabetes and renal dialysis related to this condition require specific attention. General programs that aim to reduce the population prevalence of excess body mass could have important positive effects on type 2 diabetes. Lifestyle interventions that have targeted decreasing body mass have been effective in reducing progression to type 2 diabetes in individuals and have been shown to be cost effective (Shaw & Chisholm, 2003; Ratner, 2006). Population-based programs that reduce excess body mass could therefore potentially reduce the prevalence of type 2 diabetes in the longer term. Even if an effective population-based program was implemented to reduce rates of excess body mass in the population, due to the potential delay in these positive effects and the continued worsening of complications of those already with the condition, strategies other than primary prevention would also be required. Even small improvements in glycaemic levels can result in improvements in rates of complications (Stratton et al., 2000). Programs that improve glycaemic control by a small amount on a population level, such as widespread improvement in monitoring and treatment, may substantially reduce the requirements for renal dialysis.

As echoed by the study by King et al. (2010), the national preventative taskforce (NPHT, 2009) and similar international reports (Butland et al., 2007), policies and resulting programs must be broad in scope and implemented over a long period.

This study details the minimum current costs and future projected costs if excess body mass is not addressed in a prolonged, comprehensive and effective manner and reinforces further the importance of sustained investment in preventative health.

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Appendix

Appendix A- Details of attributable harms (Malignancy related).

Attributable harm	ICD-10	Relative Risk Source	Comment
Breast cancer (post menopausal)	C50 Malignant neoplasm of breast	Australian Burden of Disease spreadsheet	Post menopausal rates were accounted for by excluding cases under 45 and adjusting down cases 45-59 years as per the Australian Burden of Disease spreadsheet.
Colorectal cancer	C18 Malignant neoplasm of colon	Australian Burden of Disease spreadsheet	Nil
	C19 Malignant neoplasm of rectosigmoid junction		
	C20 Malignant neoplasm of rectum		
	C21 Malignant neoplasm of anus and anal canal		
Endometrial cancer	C54 Malignant neoplasm of corpus uteri	Australian Burden of Disease spreadsheet	The 2003 Australian Burden of Disease study (Begg et al., 2007) included all C54 and the World Health Organization study (James et al., 2004) included all of C54 and C55. The South Australian study included only the more specific C54.1 (Larg & Moss, 2011) which was used in this study. C54.1 was 76.77 per cent of all inpatient separations coded C54 or C55.
	C54.1 Endometrium		
	C55 Malignant neoplasm of uterus, part unspecified		
Kidney cancer	C64 Malignant neoplasm of kidney, except renal pelvis	Guh et al., 2009	Nil
	C65 Malignant neoplasm of renal pelvis		
	C66 Malignant neoplasm of ureter		
	C68 Malignant neoplasm of other and unspecified urinary organs		
Pancreatic cancer	C25 Malignant neoplasm of pancreas.	Guh et al., 2009	Nil
Oesophageal adenocarcinoma	C15 Malignant neoplasm of oesophagus	Renehan et al., 2008	The Australian Burden of Disease study (Begg et al., 2007) used all Oesophageal Cancer. As the study by Renehan demonstrates, excess body mass is a risk factor for adenocarcinoma only. In inpatient data this was accounted for by using morphology codes for each admission to select only separations related to adenocarcinoma. For emergency presentations the rate of 47.53 per cent (the inpatient rate) was applied to estimate the percentage of presentations attributable to adenocarcinoma.
Ovarian cancer	C56 Malignant neoplasm of ovary	Guh et al., 2009	Nil
	C57.0 Fallopian tube		
	C57.1 Broad ligament		
	C57.2 Round ligament		
	C57.3 Parametrium		
	C57.4 Uterine adnexa, unspecified		

Appendix B- Details of attributable harms (Cardiovascular related)

Attributable harm	ICD-10	Relative Risk Source	Comment
Ischaemic heart disease	I20 Angina pectoris I21 Acute Myocardial Infarction I22 Subsequent Myocardial Infarction I23 Certain current complications following acute myocardial infarction I24 Other acute ischaemic heart disease I25 Chronic ischaemic heart disease	Australian Burden of Disease spreadsheet	Nil
Ischaemic stroke	I60 Subarachnoid haemorrhage from carotid siphon and bifurcation I61 Intracerebral haemorrhage I62 Other non-traumatic intracranial haemorrhage I63 Cerebral infarction I64 Stroke, not specified as haemorrhage or infarction I65 Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction I66 Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction I67 Other cerebrovascular diseases I68 Cerebrovascular disorders in diseases classified elsewhere I69 Sequelae of cerebrovascular disease 169.3 Sequelae of cerebral infarction G45 Transient cerebral ischaemic attacks and related syndromes	Australian Burden of Disease spreadsheet	As the Australian Burden of Disease spreadsheet specified ischaemic stroke, only ICD10 codes related to ischaemic stroke were included. Some reports, such as the 2003 Australian Burden of disease study (Begg et al., 2007), included all ICD10 codes for stroke. I63, I69.3 and G45 were used in this study as the relative risk data was derived for ischaemic stroke only.
Hypertension	I10 Essential (primary) hypertension	Guh et al., 2009	Nil
Hypertensive heart disease	I11 Hypertensive heart disease I13 Hypertensive heart and renal disease I15 Secondary hypertension -excluded as not likely related to excess body mass	Australian Burden of Disease spreadsheet	Although I11, I13 and I15 were included in the Australian Burden of Disease study (Begg et al., 2007), I15 was excluded because it was unlikely to be related to excess body mass or to hypertensive heart disease. I11 and I13 accounted for 88.99 per cent of I11, I13 and I15 separations.
Congestive heart failure	I50 Heart failure	Guh et al., 2009	Nil

Appendix C- Details of attributable harms (Other)

Attributable harm	ICD-10	Relative Risk Source	Comment
Osteoarthritis	M15 Primary generalized (osteo)arthrosis M16 Coxarthrosis [arthrosis of hip] M17 Gonarthrosis [arthrosis of knee] M18 Arthrosis of first carpometacarpal joint M19 Other arthrosis	Guh et al., 2009	As the relative risk in the Guh (et al., 2009) study was for all osteoarthritis, ICD10 codes for all related conditions were included.
Gall bladder disease	K80 Calculus of gall bladder with acute cholecystitis K81 Cholecystitis K82 Other diseases of gall bladder K83 Other diseases of biliary tract	Guh et al., 2009	Nil
Asthma	J45 Asthma J46 Status asthmaticus	Guh et al., 2009	Nil
Obesity	E66.0 Obesity due to excess calories E66.2 Extreme obesity with alveolar hypoventilation E66.8 Other obesity E66.9 Obesity unspecified	Assumed 100 per cent	These ICD10 codes were used in the SA study (Larg & Moss, 2011) except for E66.0 which was added in this study. E66.0 accounted for < 5 separations.
Type 2 diabetes	E11 Non-insulin-dependent diabetes mellitus E12 Malnutrition-related diabetes mellitus E13 Other specified diabetes mellitus	Australian Burden of Disease spreadsheet	Nil
Renal dialysis from type 2 diabetes	Z49 Care involving dialysis	Australian Burden of Disease spreadsheet	Total dialysis costs were determined using this ICD10 code. Data from the ANZDATA renal dialysis register in 2011 for WA was used to determine the proportion of these separations due to type 2 diabetes. Once this was determined the population-attributable fraction of type 2 diabetes was applied as per the Australian Burden of Disease study (Begg et al., 2007).

Appendix D. Estimated inpatient costs of malignancy-related attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Breast cancer (post menopausal)	F45-59	965	$7,737,178	15.6%	151	$1,207,000
	F60-69	662	$4,764,699	23.8%	158	$1,133,998
	F70-79	351	$2,466,009	21.1%	74	$520,328
	F80+	171	$1,233,879	16.1%	28	$198,655
	Total	2,149	$16,201,765	18.9%	410	$3,059,981
Colorectal cancer	M30-44	54	$664,417	20.8%	11	$138,199
	M45-59	311	$3,628,163	22.5%	70	$816,337
	M60-69	468	$6,073,319	22.2%	104	$1,348,277
	M70-79	387	$5,606,634	23.4%	91	$1,311,952
	M80+	245	$3,985,565	19.3%	47	$769,214
	F30-44	54	$800,169	20.1%	11	$160,834
	F45-59	217	$2,897,639	23.3%	51	$675,150
	F60-69	278	$3,307,960	23.8%	66	$787,294
	F70-79	310	$4,315,390	21.1%	65	$910,547
	F80+	269	$3,470,009	16.1%	43	$558,671
	Total	2,593	$34,749,264	21.5%	559	$7,476,476
Endometrial cancer	F30-44	12	$109,115	58.0%	7	$63,287
	F45-59	84	$773,209	65.0%	55	$502,586
	F60-69	86	$801,172	65.0%	56	$520,762
	F70-79	47	$431,830	58.0%	27	$250,462
	F80+	42	$388,487	49.0%	21	$190,359
	Total	271	$2,503,813	61.0%	165	$1,527,454
Kidney cancer	M30-44	22	$400,598	26.0%	6	$104,155
	M45-59	120	$1,512,896	29.0%	35	$438,740
	M60-69	98	$1,325,627	29.0%	28	$384,432
	M70-79	88	$1,112,304	31.0%	27	$344,814
	M80+	42	$505,744	25.0%	11	$126,436
	F30-44	13	$172,361	42.0%	5	$72,392
	F45-59	64	$853,030	47.0%	30	$400,924
	F60-69	52	$643,373	48.0%	25	$308,819
	F70-79	49	$556,885	43.0%	21	$239,460
	F80+	22	$248,242	34.0%	7	$84,402
	Total	570	$7,331,059	34.2%	196	$2,504,575
Pancreatic cancer	M30-44	8	$78,911	32.0%	3	$25,252
	M45-59	53	$577,244	36.0%	19	$207,808
	M60-69	79	$631,948	35.0%	28	$221,182
	M70-79	83	$913,759	40.0%	33	$365,504
	M80+	59	$468,078	32.0%	19	$149,785
	F30-44	1	$5,886	20.0%	0	$1,177
	F45-59	37	$362,604	24.0%	9	$87,025
	F60-69	57	$578,748	25.0%	14	$144,687
	F70-79	68	$703,440	21.0%	14	$147,722
	F80+	60	$497,736	15.0%	9	$74,660
	Total	505	$4,818,353	29.6%	148	$1,424,801
Oesophageal adenocarcinoma	M30-44	1	$7,081	31.0%	0	$2,195
	M45-59	50	$460,649	34.0%	17	$156,621
	M60-69	48	$347,360	34.0%	16	$118,102
	M70-79	64	$395,922	36.0%	23	$142,532
	M80+	31	$199,210	30.0%	9	$59,763
	F30-44	0	0	0	0	0
	F45-59	2	$2,858	36.0%	1	$1,029
	F60-69	6	$72,501	36.0%	2	$26,100
	F70-79	5	$62,224	32.0%	2	$19,912
	F80+	5	$36,536	24.0%	1	$8,769
	Total	212	$1,584,340	33.8%	72	$535,022
Ovarian cancer	F30-44	22	$309,463	11.0%	2	$34,041
	F45-59	70	$784,424	13.0%	9	$101,975
	F60-69	123	$1,334,055	14.0%	17	$186,768
	F70-79	52	$566,318	12.0%	6	$67,958
	F80+	40	$408,101	9.0%	4	$36,729
	Total	307	$3,402,361	12.6%	39	$427,471

Appendix E. Estimated inpatient costs of cardiovascular related attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Ischaemic heart disease	M30-44	428	$3,428,856	65.3%	279	$2,239,043
	M45-59	2,571	$22,502,264	56.6%	1455	$12,736,282
	M60-69	2,810	$26,772,282	43.8%	1231	$11,726,260
	M70-79	2,344	$21,878,130	34.6%	811	$7,569,833
	M80+	1,515	$11,378,114	14.0%	212	$1,592,936
	F30-44	182	$1,342,850	69.0%	126	$926,566
	F45-59	937	$6,618,764	61.5%	576	$4,070,540
	F60-69	1,089	$8,065,918	48.0%	523	$3,871,641
	F70-79	1,275	$9,693,673	31.2%	398	$3,024,426
	F80+	1,510	$9,959,232	12.0%	181	$1,195,108
	Total	14,661	$121,640,084	40.2%	5,792	$48,952,634
Ischaemic stroke	M30-44	47	$290,529	69.1%	32	$200,756
	M45-59	262	$2,504,285	60.5%	159	$1,515,092
	M60-69	334	$2,977,789	47.6%	159	$1,417,428
	M70-79	371	$2,953,831	38.5%	143	$1,137,225
	M80+	410	$3,286,319	16.7%	68	$548,815
	F30-44	45	$310,629	73.3%	33	$227,691
	F45-59	149	$993,548	65.9%	98	$654,748
	F60-69	210	$1,774,984	52.3%	110	$928,316
	F70-79	332	$2,672,591	34.7%	115	$927,389
	F80+	583	$4,909,170	14.0%	82	$687,284
	Total	2,743	$22,673,674	36.4%	999	$8,244,744
Hypertension	M30-44	28	$102,334	25.0%	7	$25,583
	M45-59	69	$280,949	28.0%	19	$78,666
	M60-69	41	$149,754	27.0%	11	$40,434
	M70-79	46	$158,034	31.0%	14	$48,990
	M80+	30	$128,992	24.0%	7	$30,958
	F30-44	34	$112,709	38.0%	13	$42,830
	F45-59	61	$219,356	43.0%	26	$94,323
	F60-69	59	$182,659	44.0%	26	$80,370
	F70-79	80	$277,153	39.0%	31	$108,090
	F80+	125	$414,401	30.0%	38	$124,320
	Total	573	$2,026,340	33.3%	193	$674,564
Hypertensive heart disease	M30-44	1	$5,572	87.0%	1	$4,848
	M45-59	4	$29,661	81.0%	3	$24,025
	M60-69	5	$34,324	72.0%	4	$24,714
	M70-79	4	$36,388	68.0%	3	$24,744
	M80+	10	$81,346	44.0%	4	$35,792
	F30-44	0	0	0	0	0
	F45-59	3	$22,072	89.0%	3	$19,644
	F60-69	4	$24,166	79.0%	3	$19,091
	F70-79	7	$45,314	61.0%	4	$27,641
	F80+	11	$101,844	38.0%	4	$38,701
	Total	49	$380,687	57.6%	29	$219,200
Congestive cardiac failure	M30-44	50	$471,789	25.0%	13	$117,947
	M45-59	216	$2,287,478	27.0%	58	$617,619
	M60-69	384	$3,126,068	27.0%	104	$844,038
	M70-79	640	$5,456,107	30.0%	192	$1,636,832
	M80+	1,128	$8,931,898	23.0%	259	$2,054,337
	F30-44	49	$522,124	25.0%	12	$130,531
	F45-59	117	$1,054,543	29.0%	34	$305,817
	F60-69	187	$1,722,526	30.0%	56	$516,758
	F70-79	400	$3,330,102	25.0%	100	$832,526
	F80+	1,199	$8,900,992	17.0%	204	$1,513,169
	Total	4,370	$35,803,628	23.9%	1,032	$8,569,574

Appendix F. Estimated inpatient costs of other attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Type 2 diabetes mellitus	M30-44	106	$840,344	81.5%	86	$684,880
	M45-59	349	$3,532,441	84.3%	294	$2,977,848
	M60-69	369	$3,975,199	72.2%	266	$2,870,094
	M70-79	260	$3,094,446	62.0%	161	$1,918,556
	M80+	204	$2,379,679	54.2%	111	$1,289,786
	F30-44	88	$754,374	87.3%	77	$658,569
	F45-59	260	$2,352,944	91.2%	237	$2,145,885
	F60-69	157	$1,542,394	79.8%	125	$1,230,830
	F70-79	186	$1,862,024	56.1%	104	$1,044,595
	F80+	216	$2,169,383	47.0%	102	$1,019,610
	Total	2,195	$22,503,228	70.4%	1,564	$15,840,654
Diabetic renal dialysis	M30-44	2,950	$1,937,592	81.5%	2404	$1,579,137
	M45-59	11,368	$7,547,045	84.3%	9583	$6,362,159
	M60-69	8,551	$5,592,557	72.2%	6174	$4,037,826
	M70-79	9,449	$6,206,546	62.0%	5858	$3,848,058
	M80+	7,695	$4,989,693	54.2%	4171	$2,704,414
	F30-44	4,030	$2,667,532	87.3%	3518	$2,328,756
	F45-59	4,938	$3,241,732	91.2%	4503	$2,956,460
	F60-69	4,963	$3,225,507	79.8%	3961	$ 2,573,954
	F70-79	3,672	$2,365,815	56.1%	2060	$1,327,222
	F80+	2,201	$1,410,006	47.0%	1035	$662,703
	Total	59,816	$39,184,025	72.4%	43,266	$28,380,689
Osteoarthritis	M30-44	366	$2,783,650	59.0%	216	$1,642,353
	M45-59	1,501	$19,978,768	62.0%	931	$12,386,836
	M60-69	1,817	$31,902,019	62.0%	1127	$19,779,252
	M70-79	1,288	$23,889,825	63.0%	811	$15,050,590
	M80+	413	$7,685,567	57.0%	235	$4,380,773
	F30-44	260	$2,290,989	31.0%	81	$710,207
	F45-59	1,522	$20,413,235	35.0%	533	$7,144,632
	F60-69	1,911	$31,007,194	35.0%	669	$10,852,518
	F70-79	1,603	$28,564,061	33.0%	529	$ 9,426,140
	F80+	725	$12,164,087	26.0%	189	$3,162,663
	Total	11,406	$180,679,395	46.8%	5,320	$84,535,963
Gall bladder disease	M30-44	426	$2,910,379	14.0%	60	$407,453
	M45-59	642	$4,697,874	16.0%	103	$751,660
	M60-69	483	$3,945,363	15.0%	72	$591,804
	M70-79	428	$3,569,809	18.0%	77	$642,566
	M80+	281	$2,286,197	13.0%	37	$297,206
	F30-44	1,448	$9,498,077	35.0%	507	$3,324,327
	F45-59	1,219	$8,585,934	41.0%	500	$3,520,233
	F60-69	600	$4,369,227	42.0%	252	$1,835,075
	F70-79	352	$2,664,331	36.0%	127	$959,159
	F80+	346	$2,563,893	27.0%	93	$692,251
	Total	6,225	$45,091,085	28.9%	1,827	$13,021,734
Asthma	M30-44	149	$643,901	16.0%	24	$103,024
	M45-59	104	$681,083	17.0%	18	$115,784
	M60-69	40	$209,502	17.0%	7	$35,615
	M70-79	27	$114,740	19.0%	5	$21,801
	M80+	20	$98,682	15.0%	3	$14,802
	F30-44	303	$1,156,971	24.0%	73	$277,673
	F45-59	272	$1,251,393	29.0%	79	$362,904
	F60-69	107	$483,184	30.0%	32	$144,955
	F70-79	76	$355,982	25.0%	19	$88,996
	F80+	60	$309,998	18.0%	11	$55,800
	Total	1,158	$5,305,436	23.0%	270	$1,221,354
Obesity	M30-44	107	$1,017,633	100.0%	107	$1,017,633
	M45-59	140	$1,397,237	100.0%	140	$1,397,237
	M60-69	53	$511,543	100.0%	53	$511,543
	M70-79	2	$19,623	100.0%	2	$19,623
	M80+	1	$4,910	100.0%	1	$4,910
	F30-44	375	$3,687,462	100.0%	375	$3,687,462
	F45-59	319	$3,243,114	100.0%	319	$3,243,114
	F60-69	80	$809,336	100.0%	80	$809,336
	F70-79	5	$52,640	100.0%	5	$52,640
	F80+	0	0	100.0	0	0
	Total	1,082	$10,743,499	100.0%	1,082	$10,743,499

Appendix G. Separations and estimated inpatient costs by age and gender, 2011.

Age-gender group	Separations	Costs	Male to female ratio
M30-44	3,249	$8,292,459	-
M45-59	12,904	$40,582,713	-
M60-69	9,383	$43,950,999	-
M70-79	8,252	$34,083,620	-
M80+	5,195	$14,059,926	-
F30-44	4,839	$12,646,342	-
F45-59	7,212	$27,493,989	-
F60-69	6,175	$25,971,274	-
F70-79	3,703	$19,975,214	-
F80+	2,050	$10,303,853	-
All 30-44	8,088	$20,938,801	0.66
All 45-59	20,117	$68,076,702	1.48
All 60-69	15,558	$69,922,273	1.69
All 70-79	11,955	$54,058,834	1.71
All 80+	7,245	$24,363,779	1.36
Total male	38,983	$140,969,718	-
Total female	23,979	$96,390,671	-
Total	62,962	$237,360,389	1.46

Appendix H. Estimated emergency department costs of malignancy-related attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Breast cancer (post menopausal)	F45-59	20	$7,950	15.6%	3	$1,240
	F60-69	5	$2,140	23.8%	1	$509
	F70-79	4	$2,038	21.1%	0.9	$430
	F80+	10	$4,184	16.1%	2	$674
	Total	44	$18,477	15.44%	7	$2,853
Colorectal cancer	M30-44	11	$5,137	20.8%	2	$1,068
	M45-59	18	$8,985	22.5%	4	$2,022
	M60-69	60	$26,180	22.2%	13	$5,812
	M70-79	34	$15,447	23.4%	8	$3,615
	M80+	31	$14,557	19.3%	6	$2,810
	F30-44	9	$2,921	20.1%	2	$587
	F45-59	19	$7,924	23.3%	4	$1,846
	F60-69	16	$7,366	23.8%	4	$1,753
	F70-79	24	$11,026	21.1%	5	$2,326
	F80+	46	$20,848	16.1%	7	$3,357
	Total	267	$120,392	20.9%	56	$25,196
Endometrial cancer	F30-44	0	0	58.0%	0	$0
	F45-59	0	0	65.0%	0	$0
	F60-69	3	$1,142	65.0%	2	$742
	F70-79	8	$3,355	58.0%	5	$1,946
	F80+	2	$737	49.0%	1	$361
	Total	13	$5,233	58.3%	8	$3,049
Kidney cancer	M30-44	8	$2,525	26.0%	2	$657
	M45-59	22	$6,766	29.0%	6	$1,962
	M60-69	5	$2,099	29.0%	1	$609
	M70-79	11	$2,082	31.0%	3	$645
	M80+	4	$1,509	25.0%	1	$377
	F30-44	0	0	42.0%	0	0
	F45-59	0	0	47.0%	0	0
	F60-69	4	$1,047	48.0%	2	$503
	F70-79	10	$2,213	43.0%	4	$951
	F80+	1	$675	34.0%	0.4	$229
	Total	64	$18,916	31.4%	21	$5,934
Pancreatic cancer	M30-44	4	$1,918	32.0%	1	$614
	M45-59	12	$5,849	36.0%	4	$2,106
	M60-69	23	$10,927	35.0%	8	$3,824
	M70-79	19	$4,104	40.0%	8	$1,641
	M80+	8	$3,612	32.0%	3	$1,156
	F30-44	0	0	20.0%	0	0
	F45-59	7	$3,227	24.0%	2	$775
	F60-69	14	$6,552	25.0%	3	$1,638
	F70-79	11	$5,353	21.05	2	$1,124
	F80+	15	$6,839	15.0%	2	$1,026
	Total	113	$48,382	28.7%	34	$13,904
Oesophageal adenocarcinoma	M30-44	0	0	31.0%	0	0
	M45-59	10	$4,021	34.0%	3	$1,367
	M60-69	8	$3,688	34.0%	3	$1,254
	M70-79	9	$2,885	36.0%	3	$1,039
	M80+	5	$2,383	30.0%	2	$715
	F30-44	0	0	31.0%	0	0
	F45-59	3	$1,287	36.0%	1	$463
	F60-69	1	$773	36.0%	0.5	$278
	F70-79	1	$191	32.0%	0.3	$61
	F80+	1	$491	24.0%	0.3	$118
	Total	39	$15,719	33.7%	13	$5,295
Ovarian cancer	F30-44	6	$2,265	11.0%	0.6	$249
	F45-59	26	$9,500	13.0%	3	$1,235
	F60-69	24	$9,422	14.0%	3	$1,319
	F70-79	14	$4,311	12.0%	2	$517
	F80+	10	$4,102	9.0%	0.9	$369
	Total	80	$29,601	12.5%	10	$3,690

Appendix I. Estimated emergency department costs of cardiovascular-related attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Ischaemic heart disease	M30-44	313	$147,297	65.3%	204	$96,185
	M45-59	1,598	$769,665	56.6%	904	$435,630
	M60-69	1,194	$566,341	43.8%	523	$248,058
	M70-79	1,205	$525,279	34.6%	417	$181,747
	M80+	989	$491,485	14.0%	138	$68,808
	F30-44	139	$62,318	69.0%	96	$42,999
	F45-59	614	$278,102	61.5%	378	$171,033
	F60-69	616	$285,577	48.0%	296	$137,077
	F70-79	741	$343,340	31.2%	231	$107,122
	F80+	1,139	$575,896	12.0%	137	$69,108
	Total	8,548	$4,045,299	38.5%	3,324	$1,557,766
Ischaemic stroke	M30-44	67	$25,504	69.1%	46	$17,623
	M45-59	281	$126,761	60.5%	170	$76,690
	M60-69	355	$152,391	47.6%	169	$72,538
	M70-79	368	$160,896	38.5%	142	$61,945
	M80+	339	$153,954	16.7%	57	$25,710
	F30-44	73	$27,013	73.3%	54	$19,800
	F45-59	202	$82,021	65.9%	133	$54,052
	F60-69	234	$101,200	52.3%	122	$52,928
	F70-79	323	$138,875	34.7%	112	$48,190
	F80+	527	$244,643	14.0%	74	$34,250
	Total	2,767	$1,213,256	38.2%	1,078	$463,726
Hypertension	M30-44	57	$18,379	25.0%	14	$4,595
	M45-59	147	$43,750	28.0%	41	$12,250
	M60-69	74	$24,091	27.0%	20	$6,505
	M70-79	69	$17,896	31.0%	21	$5,548
	M80+	43	$14,413	24.0%	10	$3,459
	F30-44	111	$35,317	38.0%	42	$13,420
	F45-59	152	$46,511	43.0%	65	$20,000
	F60-69	152	$50,437	44.0%	67	$22,192
	F70-79	166	$59,200	39.0%	65	$23,088
	F80+	152	$56,709	30.0%	46	$17,013
	Total	1,122	$366,703	34.9%	391	$128,069
Hypertensive heart disease	M30-44	0	0	87.0%	0	0
	M45-59	23	$7,201	81.0%	19	$5,833
	M60-69	11	$3,916	72.0%	8	$2,820
	M70-79	17	$6,873	68.0%	12	$4,674
	M80+	19	$6,481	44.0%	8	$2,852
	F30-44	2	$418	92.0%	1	$384
	F45-59	2	$755	89.0%	1	$672
	F60-69	1	$583	79.0%	1	$461
	F70-79	4	$1,460	61.0%	3	$890
	F80+	22	$7,531	38.0%	9	$2,862
	Total	102	$35,217	60.9%	62	$21,447
Congestive cardiac failure	M30-44	30	$14,413	25.0%	7	$3,603
	M45-59	176	$83,685	27.0%	47	$22,595
	M60-69	307	$138,966	27.0%	83	$37,521
	M70-79	500	$346,196	30.0%	150	$103,859
	M80+	854	$372,602	23.0%	196	$85,698
	F30-44	39	$19,708	25.0%	10	$4,927
	F45-59	101	$39,073	29.0%	29	$11,331
	F60-69	166	$74,867	30.0%	50	$22,460
	F70-79	314	$133,650	25.0%	78	$33,412
	F80+	935	$427,297	17.0%	159	$72,640
	Total	3,421	$1,650,457	24.1%	810	$398,048

Appendix J. Estimated emergency department costs of other attributable harms, 2011.

Condition	Group	Total		Population-attributable fraction	Attributed to excess body mass	
		Separations	Costs		Separations	Costs
Type 2 diabetes mellitus	M30-44	114	$34,441	81.5%	93	$28,070
	M45-59	231	$86,282	84.3%	194	$72,736
	M60-69	184	$73,446	72.2%	133	$53,028
	M70-79	108	$46,579	62.0%	67	$28,879
	M80+	95	$42,225	54.2%	51	$22,886
	F30-44	72	$26,351	87.3%	62	$23,004
	F45-59	126	$49,775	91.2%	115	$45,394
	F60-69	79	$32,154	79.8%	63	$25,659
	F70-79	91	$39,089	56.1%	51	$21,929
	F80+	127	$59,913	47.0%	60	$28,159
	Total	1,226	$490,255	71.3%	890	$349,744
Diabetic renal dialysis	M30-44	2	$802	81.5%	1	$654
	M45-59	6	$2,500	84.3%	5	$2,108
	M60-69	0.04	$12	72.2%	0.03	$8
	M70-79	2	$687	62.0%	1	$426
	M80+	2	$642	54.2%	1	$348
	F30-44	2	$464	87.3%	1	$405
	F45-59	0.7	$235	91.2%	0.7	$215
	F60-69	1	$462	79.8%	1	$368
	F70-79	0	0	56.1%	0	0
	F80+	0.6	$137	47.0%	0.3	$64
	Total	15	$5,940	77.4%	12	$4,596
Osteoarthritis	M30-44	16	$4,805	59.0%	9	$2,836
	M45-59	76	$22,798	62.0%	47	$14,135
	M60-69	70	$20,949	62.0%	44	$12,988
	M70-79	79	$21,456	63.0%	50	$13,517
	M80+	55	$17,267	57.0%	32	$9,842
	F30-44	23	$7,629	31.0%	7	$2,365
	F45-59	109	$30,628	35.0%	38	$10,720
	F60-69	81	$26,069	35.0%	28	$9,124
	F70-79	89	$31,372	33.0%	29	$10,353
	F80+	124	$43,744	26.0%	32	$11,373
	Total	722	$226,717	42.9%	317	$97,253
Gall bladder disease	M30-44	288	$113,225	14.0%	40	$15,852
	M45-59	349	$145,439	16.0%	56	$23,270
	M60-69	211	$90,953	15.0%	32	$13,643
	M70-79	216	$77,566	18.0%	39	$13,962
	M80+	165	$73,998	13.0%	21	$9,620
	F30-44	919	$336,575	35.0%	322	$117,801
	F45-59	559	$214,061	41.0%	229	$87,765
	F60-69	188	$77,619	42.0%	79	$32,600
	F70-79	133	$55,959	36.0%	48	$20,145
	F80+	215	$96,617	27.0%	58	$26,087
	Total	3,244	$1,282,013	28.1%	924	$360,745
Asthma	M30-44	491	$164,343	16.0%	79	$26,295
	M45-59	233	$85,535	17.0%	40	$14,541
	M60-69	88	$32,144	17.0%	15	$5,465
	M70-79	60	$21,917	19.0%	11	$4,164
	M80+	35	$13,057	15.0%	5	$1,950
	F30-44	1,054	$352,647	24.0%	253	$84,635
	F45-59	627	$218,408	29.0%	182	$63,338
	F60-69	202	$68,080	30.0%	61	$20,424
	F70-79	106	$40,477	25.0%	26	$10,119
	F80+	84	$35,237	18.0%	15	$6,343
	Total	2,981	$1,031,846	22.9%	687	$237,283
Obesity	M30-44	0	0	100.0%	0	0
	M45-59	0	0	100.0%	0	0
	M60-69	2	$1,002	100.0%	2	$1,002
	M70-79	0	0	100.0%	0	0
	M80+	0	0	100.0%	0	0
	F30-44	4	$1,873	100.0%	3	$1,873
	F45-59	1	$738	100.0%	1	$738
	F60-69	3	$1,491	100.0%	3	$1,491
	F70-79	2	$536	100.0%	2	$536
	F80+	0	0	100.0%	0	0
	Total	12	$5,640	100.0%	12	$5,640

Appendix K. Estimated emergency department costs by age and gender, 2011.

Age-gender group	Presentations	Costs	Male to female ratio
M30-44	500	$198,051	-
M45-59	1,542	$687,245	-
M60-69	1,053	$465,073	-
M70-79	933	$425,660	-
M80+	532	$236,239	-
F30-44	855	$312,452	-
F45-59	1,186	$470,817	-
F60-69	787	$331,528	-
F70-79	665	$283,141	-
F80+	603	$274,032	-
All 30-44	1,355	$510,502	0.63
All 45-59	2,728	$1,158,061	1.46
All 60-69	1,840	$796,601	1.40
All 70-79	1,598	$708,801	1.50
All 80+	1,135	$510,271	0.86
Total male	4,560	$2,012,267	-
Total female	4,095	$1,671,969	-
Total	8,655	$3,684,236	1.20

Appendix L. Predicted costs in 2021 by age and gender as compared to 2011.

Age-gender group	2011 costs	2021 (constant price) costs	Percentage increase
M30-44	$8,490,510	$19,269,563	127.0%
M45-59	$41,269,958	$72,881,131	76.6%
M60-69	$44,416,072	$77,689,968	74.9%
M70-79	$34,509,280	$74,038,663	114.5%
M80+	$14,296,165	$49,116,073	243.6%
F30-44	$12,958,794	$32,179,693	148.3%
F45-59	$27,964,806	$47,455,779	69.7%
F60-69	$26,302,802	$44,737,208	70.1%
F70-79	$20,258,354	$44,368,554	119.0%
F80+	$10,577,885	$26,641,795	151.9%
All 30-44	$21,449,304	$51,449,256	139.9%
All 45-59	$69,234,764	$120,336,910	73.8%
All 60-69	$70,718,874	$122,427,176	73.1%
All 70-79	$54,767,634	$118,407,218	116.2%
All 80+	$24,874,050	$75,757,868	204.6%
Total male	$142,981,985	$292,995,398	104.9%
Total female	$98,062,640	$195,383,029	99.2%
Total	$241,044,625	$488,378,428	102.6%

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