Original Article

Current and future costs of cancer, heart disease and stroke attributable to obesity in Australia – a comparison of two birth cohorts

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The obesity epidemic appears set to worsen the morbidity and mortality from leading causes of death in Australia – ischaemic heart disease, stroke and obesity-related cancers. The aim of this study was to compare hospital separations, deaths and direct health costs for middle-aged adults (45 to 54 years) in 2004/05 with those attaining age 45 to 54 years in 2024/25 who were born into an obesogenic environment. Using data from National Health Surveys, prevalence of obesity in 2004/05 was calculated for those born in 1950/51-59/60 and four scenarios were considered to project rates in 2024/25 for those born in 1970/71-79/80: an age-cohort model; a linear trend model; a steady state where rates increase to equal those of the older birth cohort at the same age; and a best case where rates remain at 2004/05 levels. Population attributable fractions were calculated by gender and disease using relative risks of disease from the literature, and applied to hospital separations, deaths, and direct health system costs data to estimate the proportion of each attributable to obesity. In 2024/25 the projected number of hospitalizations of 45 to 54 year olds due to the diseases of interest could be more than halved, over 200 lives rescued and $51.5 million (in 2004/05 dollars) saved if further gains in obesity in the younger birth cohort are halted. Instead, if the worst case scenario is realized there will be a more than doubling in costs (in 2004/05 dollars) compared with those born in 1950/51-59/60.

Key Words: obesity, health costs, cancer, stroke, coronary heart disease

INTRODUCTION

The global obesity epidemic threatens to worsen the morbidity and mortality from coronary heart disease, stroke and cancer - leading causes of death.[1] The ballooning of the populations' weight could undo the steady progress that has been made in limiting these chronic diseases. However, not all generations will be vulnerable to the same extent. We have recently reported that younger birth cohorts are gaining weight more rapidly than those born before 1960.[2] It seems that generations growing up or born into the obesogenic environment are more susceptible to its effects. As younger cohorts become overweight and obese in their twenties and thirties, by middle age this is likely to precipitate chronic disease and they will place greater demands on the health system at an earlier age than did the previous generations.

To assess the extent of the extra load on the health system we have estimated 20 year projected prevalence of obesity in a defined Australian cohort born into the obesogenic environment, and used this to determine population attributable risk and resulting number of hospital separations, deaths and direct health costs of obesity-related cancers, cardiovascular disease and stroke. Projected outcomes in 2024/25 for those born from 1st July 1970 to 30th June 1980 were compared with actual outcomes for adults born 20 years earlier (1950/51-59/60). This analysis thus compares the burden of obesity-related disease for two generations born twenty years apart when both are aged 45 to 54 years. Policy makers could use this information to inform decisions regarding potential savings from generation targeted health promotion, or at worst to plan for the extra treatment resources that obesity will incur within 20 years.

MATERIALS AND METHODS

Prevalence of Obesity

Obesity prevalence estimates were calculated using data from the National Health Surveys (NHS) conducted by the Australian Bureau of Statistics (ABS) in 1995,

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2000/01, and 2004/05.[3-5] The NHS are a series of regular population surveys designed to obtain national benchmark information on a range of health issues, allow monitoring of health trends over time, and provide information on health indicators for national health priority areas and important population subgroups. Each survey was conducted using a stratified multistage area sample of private dwellings from urban and rural areas of Australia. Information was collected through personal interviews with usual household members, allocated randomly and evenly over three sub-periods within a ten-month period. Sample sizes were 53 828 persons in 1995, 26 862 in 2000/01 and 25 906 persons in 2004/05, and response rates ranged from 89% to 92%.[6-8] NHS data were accessed with permission of the ABS who supplied de-identified data as Confidentialised Unit Record Files (CURFs) on compact disc (CD-ROM).

For each NHS, self reported weight in kilograms (kg) and height in centimetres (cm) were available as continuous variables for subjects weighing less than 130 kg and with height between 145 and 199 cm. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared, with participants older than 18 years of age and BMI ≥ 30 classed as obese. For participants aged less than 18 years, International Obesity Task Force definitions were used for determining obesity. [9] The prevalence of obesity in the 1950/51-59/60 birth cohort at 45-54 years of age was estimated by sex using 2004/05 NHS data. The prevalence of obesity in the 1970/71-79/80 birth cohort at 45-54 years of age in 2024/25 was projected by sex using data from the respective NHSs. Four forecasting scenarios were considered:

A. An age-cohort logistic regression model of the estimated prevalence of obesity with age grouped in 5-year intervals from 15 to 54, and birth cohorts grouped in 5-year intervals from 1950/51 to 1989/90.[10] Projected rates in 10-year age and birth cohort intervals were estimated by population weighting of appropriate 5-year interval estimates obtained from the model.
B. A simple linear trend model of the estimated prevalence of obesity, with rates assumed to increase consistent with the linear trend observed from 15-24 to 25-34 years of age;
C. A steady state where the prevalence of obesity equals the estimated prevalence of obesity in the 1950/51-59/60 birth cohort at 45-54 years of age;
D. A best case where the prevalence of obesity remains at 2004/05 (25-34 years of age) levels.

Sampling weights were applied to all calculations to ensure that prevalence estimates accurately reflected the population demographic at the time of survey.

The risks of illness associated with obesity

Vascular diseases and cancers associated with obesity were identified i.e. coronary (or ischaemic) heart disease (CHD), stroke, colorectal cancer, post-menopausal breast cancer, uterine cancer and kidney cancer (Table 1). The population attributable risk (PAR) of each condition that can be attributed to obesity was calculated by gender, for the 1950/51-59/60 birth cohort at 45-54 years of age using the relative risk (RR), identified in the epidemiological literature [11] and estimated prevalence of obesity:

PAR = [Prevalence of obesity × (RR – 1) / 1+ prevalence of obesity (RR – 1)] × 100

Separate PAR values were calculated for the 1970/71-79/80 birth cohort from 45-54 years of age using the same RR combined with the projected prevalence of obesity in each of the three scenarios (A B C D) previously described.

Costs of illness attributable to obesity

Counts of hospital separations in Australia were obtained for 2004/05 by gender, age-group and principal Tenth Revision of the International Classification of Diseases (ICD-10) diagnosis code from the Principal Diagnosis Data Cube accessible on the Australian Institute of Health and Welfare (AIHW) website.[12] Hospital separations for the disease of interest associated with obesity were aggregated by gender, for the older cohort during 2004/05 at 45-54 years of age. Assuming that hospital separation rates remain constant (i.e., no significant prevention or treatment advances occur), hospital separations for the younger birth cohort at the same age were estimated by adjusting 2004/05 separations for ABS series B projected population growth to 2024/25.[13]

ABS mortality data was obtained for 2004-05 from the NSW Department of Health, Health Outcomes and Information Statistical Toolkit (HOIST) database. [14] Deaths in 45-54 year olds during 2004/05 were aggregated, by gender, based on ICD-10 coded underlying cause of death. As for hospital separations, deaths in the younger birth cohort at the same age were estimated by assuming constant death rates and adjusting 2004/05 deaths for projected population growth to 2024/25.

In 2005, the Australian Institute of Health and Welfare (AIHW) published direct health system costs for Australia during 2000/01 in nineteen broad disease groups.[15] The report allocated 87.5% of total recurrent health expenditure that included admitted and non-admitted patient hospital expenditure, aged care homes, out-of-hospital medical services (including general practitioners), other professional services, prescription and over-the-counter pharmaceuticals, community mental health and public health cancer screening programs. Disaggregated direct health system costs during 2000/01 by age-group and gender, for diseases of interest associated with obesity were obtained from the AIHW on request. Costs were aggregated for 45-54 year olds during 2000/01 by gender, and disease and injury condition. Direct health system costs for each condition during 2004/05, when the 1950/51-59/60 birth cohort was 45-54 years of age, were extrapolated by adjusting 2000/01 costs for ABS estimated resident population growth[16] and health cost inflation. [17] Assuming no significant treatment advances occur and that economic conditions remain relatively constant, direct health system costs for the younger birth cohort at 45-54 years of age in 2024/25 were similarly projected. In this case, 2000/01 costs were adjusted for ABS estimated population growth[16] and health cost inflation[17] to 2004/05, and ABS series B projected population growth [13] and future health cost inflation from 2005/06 to 2024/25. Future health cost inflation was assumed to equal, on average,

Table 1. The Relative risk (RR) associated with obesity for disease and injury conditions for which obesity has been identified as a risk factor.

Disease	ICD-10	Obese (BMI ≥ 30)	
		Males	Females
Coronary heart disease	I20-I25	1.80	1.20
Stroke	I60-I69, G45-G46	1.50	1.60
Colorectal cancer	C18-C21	1.40	1.40
Post-menopausal breast cancer	C50	-	1.30
Uterine cancer	C54-C55	-	1.75
Kidney cancer	C64-C66, C68	1.00	1.50

ICD-10 = International Classification of Diseases Version 10 code

average annual health cost inflation from 1995/96 to 2005/06 (3.1%).[17] To facilitate a cost comparison between birth cohorts it is necessary to account for the positive time preference of money, in that dollars spent today are more valuable than dollars spent in the future, by discounting future costs.[18] In this case, projected costs from 2024/25 were discounted to 2004/05 using a discount rate equal to the current Australian 15-year nominal bond rate (5.75%)[19] less future health cost inflation as described above.

PAR estimates were applied, by disease condition and birth cohort, to total hospital separations, deaths and direct health system costs at 45-54 years of age, to estimate the proportion attributable to obesity. Sex specific and total results were tabulated and compared by birth cohort and prevalence forecasting scenario.

RESULTS

Table 1 shows by gender, the RR associated with obesity for cardiovascular disease, stroke and four cancers. Obese males have increased risk of developing all conditions except kidney cancer, with RR ranging from 1.4 for colorectal cancer to 1.8 for coronary heart disease. In obese females there is increased risk of developing all conditions with RR ranging from 1.2 for coronary heart disease to 1.75 for uterine cancer.

Table 2 shows by sex and forecasting scenario, the estimated and projected prevalence of obesity in both birth cohorts at 45-54 years of age, and the associated estimated PAR for each disease. At this age, the estimated prevalence of obesity in males and females born from 1950/51-59/60 was 23.3% and 20.1% respectively. The projected prevalence of obesity in the 1970/71-79/80 cohort at 45-54 years of age varied greatly, dependent upon the forecasting scenario. It was greatest for both sexes under scenario A (48.5% males; 41.1% females) due to increases in the prevalence of obesity at any given age for each successively born cohort and a non-linear age effect. As the prevalence of obesity in the 1970/71-79/80 cohort grew rapidly in both males (4.4% to 15.9%) and females (4.8% to 14.0%) from 15-24 to 25-34 years of age, rates were also projected to increase under scenario B (38.8% males; 33.0% females). Assuming scenario C, the prevalence of obesity in the younger cohort will equal that in the 1950/51-59/60 cohort at 45-54 years of age (23.3% males; 20.1% females). Under scenario D, the prevalence of obesity in the 1970/71-79/80 cohort at 45-54 years of age will remain at 2004-05 levels (15.9% males; 14.1% females). As PAR estimates vary according to RR and the prevalence of obesity, the PAR for each condition in the 1970/71-79/80 cohort was greatest under Scenario A, followed by B, C (equal to the PAR in the 1950/51-59/60 cohort) and then D.

Table 3 lists by gender, the estimated proportion of hospital separations, deaths, and health system expenditure for each disease attributable to obesity. For males born from 1950/51-59/60, at 45-54 years of age it is estimated that 2 803 hospital separations, 132 deaths, and $28.3 million of direct health system expenditure was due to obesity-related cancers, stroke and coronary heart disease with the latter accounting for more than 80% of deaths and costs. For males born from 1970/71-79/80, at the same ages it is projected that between 2 294 and 5 750 hospital separations, 108 and 272 deaths, and $25.7 and $64.5 million (in 2004-05 dollars) of direct health system expenditure will be due to obesity-related cancers, stroke and coronary heart disease, contingent upon the prevailing prevalence of obesity. For females born from

Table 2. Estimated and projected prevalence of obesity, and estimated population attributable risk (PAR) of disease and injury conditions associated with obesity at 45-54 years of age, by sex, birth cohort and prevalence forecasting scenario.

	Males (%)					Females (%)				
	1950/51-59/60	1970/71-79/80				1950/51-59/60	1970/71-79/80			
		A†	B‡	C§	D¶		A†	B‡	C§	D¶
Prevalence of obesity 45-54 years of age	23.3	48.5	38.8	23.3	15.9	20.1	41.1	33.0	20.1	14.1
Population attributable risk										
Coronary heart disease	15.7	28.0	23.7	15.7	11.3	3.9	7.6	6.2	3.9	2.7
Stroke	10.4	19.5	16.3	10.4	7.4	10.8	19.8	16.5	10.8	7.8
Colorectal cancer	8.5	16.3	13.4	8.5	6.0	7.5	14.1	11.7	7.5	5.3
Post-menopausal breast cancer	-		-	-	-	5.7	11.0	9.0	5.7	4.1
Uterine cancer	-		-	-	-	13.1	23.6	19.8	13.1	9.5
Kidney cancer	0.0	0.0	0.0	0.0	0.0	9.1	17.0	14.2	9.1	6.6

† Prevalence of obesity projected from age-cohort logistic regression model.
‡ Prevalence of obesity projected to increase consistent with linear trend from 15-24 to 25-34 years of age.
§ Prevalence of obesity projected to equal the prevalence of obesity in the 1950/51-59/60 birth cohort at 45-54 years of age.
¶ Prevalence of obesity projected to remain at 2004/05 (25-34 years of age) level.

Table 3. Estimated hospital separations, deaths and direct health system costs of vascular diseases and cancers associated with obesity attributable to obesity at 45-54 years of age, by sex, birth cohort and prevalence forecasting scenario.

Sex	Disease	Hospital Separations					Deaths					Direct Health System Costs ($M)				
		1950/51-59/60	1970/71-79/80				1950/51-59/60	1970/71-79/80				1950/51-59/60	1970/71-79/80			
			A†	B‡	C§	D¶		A†	B‡	C§	D¶		A†	B‡	C§	D¶
Males	Coronary heart disease	2,449	4,987	4,227	2,805	2,010	106	216	183	122	87	23.7	53.6	45.4	30.1	21.6
	Stroke	223	476	397	255	179	10	21	18	11	8	3.5	8.2	6.8	4.4	3.1
	Colorectal cancer	131	286	237	150	105	16	34	28	18	12	1.1	2.7	2.3	1.4	1.0
	Post-menopausal breast cancer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Uterine cancer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Kidney cancer	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
	Total	2,803	5,750	4,860	3,210	2,294	132	272	229	151	108	28.3	64.5	54.5	35.9	25.7
Females	Coronary heart disease	182	406	331	207	146	5	11	9	6	4	2.1	5.1	4.2	2.6	1.8
	Stroke	184	383	320	209	151	11	23	19	13	9	2.5	5.9	4.9	3.2	2.3
	Colorectal cancer	104	223	184	118	84	11	23	19	12	9	0.9	2.1	1.7	1.1	0.8
	Post-menopausal breast cancer	163	356	292	185	131	14	32	26	16	12	2.4	5.8	4.8	3.0	2.2
	Uterine cancer	75	153	129	85	62	4	8	7	5	3	0.5	1.0	0.9	0.6	0.4
	Kidney cancer	17	35	29	19	14	2	4	3	2	1	0.2	0.4	0.4	0.2	0.2
	Total	725	1,558	1,287	823	589	47	101	84	54	38	8.5	20.4	16.8	10.7	7.7

† Prevalence of obesity projected from age-cohort logistic regression model.
‡ Prevalence of obesity projected to increase consistent with linear trend from 15-24 to 25-34 years of age.
§ Prevalence of obesity projected to equal the prevalence of obesity in the 1950/51-59/60 birth cohort at 45-54 years of age.
¶ Prevalence of obesity projected to remain at 2004/05 (25-34 years of age) level.

1950/51-59/60, at 45-54 years of age it is estimated that 725 hospital separations, 47 deaths, and $8.5 million of direct health system expenditure was due to obesity-related cancers and vascular disease. For females born from 1970/71-79/80, at the same ages it is projected that between 589 and 1 558 hospital separations, 38 and 101 deaths, and $7.7 and $20.4 million (in 2004-05 dollars) of direct health system expenditure will be due to obesity-related cancer and vascular disease, contingent upon the prevailing prevalence of obesity.

DISCUSSION

This study indicates that the projected number of hospitalizations due to obesity-related heart disease, stroke and cancers for the generation born into the obesogenic environment and aged 25 to 34 years in 2004/05 could be more than halved and over 200 lives saved in 2024/25 if interventions can arrest further weight gain. While overly optimistic, if health promotion efforts stabilize the prevalence of obesity at 2004-5 levels it will result in an estimated saving of $51.5 million (in 2004-05 dollars) direct health system annual costs for these diseases. Instead, if the worst projected rate of obesity is instead realized there will be a more than doubling of the cost (in discounted terms) compared with those of the generation born before, from 1950/51 to 1959/60. Successive birth cohorts are demonstrating even more rapid rises in obesity [2] prevalence and the future health care costs for these generations could be huge.

This study has only produced estimates of direct costs because of the complexity and further assumptions required to estimate indirect expenditure such as carer costs, welfare payments and lost productivity and taxation. However, an Australian study published in 2006 has estimated indirect costs to be 3.3 times the direct costs. [20] If it is assumed indirect costs are this much higher then the total cost of obesity-related heart disease, stroke and cancer in 2024/25 for 45 to 54 year olds under scenario A will rise to $365.0 million (in 2004/05 dollars) compared with $158.5 million for 45 to 54 year olds in 2004/05. A substantial rise in both direct and indirect costs of illness for the younger generation will place unprecedented challenges on a system that must deal with an aging population and hence more illness and disability. A number of other studies reach similar conclusions that the burden of disease increases with aging populations and health consequences of rising obesity.[21-32] A case study in China found that by 2025 the total costs of obesity in China would rise to 9.23% of gross national product compared with 4.06% in 2000.[33]

There are other obesity-related diseases that do not have the same mortality as cancer and ischaemic vascular diseases which have not been included here. Musculoskeletal disorders accounted for 9.2% of health expenditure in Australia, third to cardiovascular and neurological diseases. [15] We have previously reported that national hospital separations for obesity-related osteoarthritis among people aged 45–55 years will rise from 2 551 in 2004/05 to 4 216 in 2024/25, and that the direct health system cost (in 2004/05 dollars) will rise to $44.4 million from an estimated $25.5 million in 2004/05.[34] Mental disorders ranked fifth after injury for health expenditure. [15] With the odds ratio of depression for obese persons estimated to range from approximately 1.2–1.4[35,36] any increase in the prevalence of obesity will increase the PAR and hence expenditure. Type 2 diabetes has the highest relative risk of obesity-related diseases at 3.2.[11] While the mortality burden (years life lost) in Australia places it at ninth, the burden as disability adjusted life years ranks it as second highest cause of disability for males and fourth for females[1] and the costs are therefore set to soar as obesity does.[37]

Costing obesity provides a useful measure of the economic burden of obesity, but a potentially more valuable use of economic principles is in evaluating solutions to the epidemic.[38] The barrier is that there is a relative lack of evidence for public health based approaches.[39] Haby *et al.* have published some work addressing cost benefits of 13 potential interventions in children and adolescents.[40] They reported that two prevention-type interventions and one surgical intervention for obesity (laparascopic gastric banding) were most likely to be cost effective. They acknowledge the assumptions made in their modeling were immense given the lack of evidence. Until such evidence becomes available policy makers still need to make decisions about programs and budgets for the prevention of obesity. While the current study does not propose the type of intervention, it indicates the best option for generations to target for intervention. By providing information about hospital separations, mortality and health costs by birth cohort, this analysis indicates that targeting younger generations born into the obesogenic environment may be more cost effective than targeting older ones. Further analysis of the cost of treatments for weight reduction for those already obese versus prevention of weight gain are required. Sustained weight loss among obese persons could also lead to substantial economic benefits.[28]

There are several limitations of this study including its assumptions regarding advances in treatment and preventative measures. It is likely the next 20 years will see developments in the treatment and prevention of obesity-related cancer and cardiovascular disease, which may also be more cost effective than current treatments. Other limitations are uncertainty regarding projected population growth, as the series used in this study is only one of three possible developments published by the ABS. While three scenarios representing possible worst, steady state and best case outcomes for the future prevalence of obesity were considered, they remain projections and as such are subject to uncertainty in treatment of obesity, environmental changes such as a food availability and affordability, and further technological advance increasing sedentary behaviours that could substantially alter the gradient of the rate of increase. Limitations of the NHS datasets include that height and weight are self-reported rather than based on examination, and the ABS does not provide weight in kg for individuals weighing more than 130 kg due to privacy concerns. As such, the prevalence of obesity may be slightly underestimated here. This study has also not included the cost of being overweight (BMI 25 to 29.9 kg/m^2). As the relative risks for coronary heart disease (RR=1.35 for males, RR=1.40 for females), stroke (RR=1.35 for both sexes), and colorectal cancer (RR=1.20), are also estimated to be greater for overweight persons,[11] any increase in the future prevalence of overweight will most likely further increase hospital separations, deaths, and direct health system costs for these conditions.

With more recent birth cohorts born into the obesogenic environment gaining weight more rapidly the current obesity epidemic appears set to continue and worsen. By taking an age-specific approach focusing on two birth, cohorts one born into the obesogenic environment the other twenty years before, and current and projected costs of obesity-related cancer, coronary heart disease and stroke, this analysis has demonstrated that the Australian health system will face considerably larger resource and financial challenges in the near future because of obesity. It is prudent to support research and intervention programs aimed at the younger adult population and families to stem the ever increasing gains in body mass index. In the more distant future this would allow resources to be redirected to other diseases not amenable to public health intervention and prevention.

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AUTHOR DISCLOSURES
None to declare.

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Original Article

Current and future costs of cancer, heart disease and stroke attributable to obesity in Australia – a comparison of two birth cohorts

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與肥胖有關的現今與未來癌症、心臟病及中風之花費–澳洲兩個出生世代的比較

肥胖流行性的出現，惡化了澳洲首要死因的發生率和死亡率，即缺血性心臟病、中風和與肥胖相關的癌症。本研究的目的是比較 2004/05 年 45-54 歲中年人和生長於肥胖促成環境而在 2024/25 年達到 45-54 歲族群之住院人次、死亡及直接醫療花費。使用國家健康調查(National Health Surveys)的資料，計算出生於 1950/51-59/60 年的人在 2004/05 年的肥胖盛行率；對於出生於 1970/71-79/80 年的人以四個情境來預測 2024/25 年的肥胖盛行率：一個年齡世代模式、一個線性趨勢模式、一個穩定的狀態，肥胖比例增加至與同年齡的年長世代相當、和一個最好的情況，肥胖率維持在 2004/05 年的程度。人群歸因危險度按性別和疾病分開估算，根據文獻，肥胖對這些疾病都有高的相對危險比。估算得到的歸因危險度則被用來評估與肥胖相關的疾病之住院人次、死亡及直接醫療花費比率。如果在年輕世代中肥胖率不再上升，預測 2024/25 年，因為相關的疾病而住院的 45-54 歲人次可能減半，超過 200 個生命被挽救，同時可節省 51.5 百萬元。反之，如果是最糟的情境實現，將會比出生於 1950/51-59/60 年的人支出(以 2004/05 年幣值)兩倍以上的花費。

關鍵字：肥胖、醫療費用、癌症、中風、冠狀動脈心臟病