Estimating the burden of disease attributable to excess body weight in South Africa in 2000

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Objective. To estimate the burden of disease attributable to excess body weight using the body mass index (BMI), by age and sex, in South Africa in 2000.

Design. World Health Organization comparative risk assessment (CRA) methodology was followed. Re-analysis of the 1998 South Africa Demographic and Health Survey data provided mean BMI estimates by age and sex. Population-attributable fractions were calculated and applied to revised burden of disease estimates. Monte Carlo simulation-modelling techniques were used for the uncertainty analysis.

Setting. South Africa.

Subjects. Adults ≥ 30 years of age.

Outcome measures. Deaths and disability-adjusted life years (DALYs) from ischaemic heart disease, ischaemic stroke, hypertensive disease, osteoarthritis, type 2 diabetes mellitus, and selected cancers.

Results. Overall, 87% of type 2 diabetes, 68% of hypertensive disease, 61% of endometrial cancer, 45% of ischaemic stroke, 38% of ischaemic heart disease, 31% of kidney cancer, 24% of osteoarthritis, 17% of colon cancer, and 13% of postmenopausal breast cancer were attributable to a BMI ≥ 21 kg/m². Excess body weight is estimated to have caused 36 504 deaths (95% uncertainty interval 31 018 - 38 637) or 7% (95% uncertainty interval 6.0 - 7.4%) of all deaths in 2000, and 462 338 DALYs (95% uncertainty interval 396 512 - 478 847) or 2.9% of all DALYs (95% uncertainty interval 2.4 - 3.0%). The burden in females was approximately double that in males.

Conclusions. This study shows the importance of recognising excess body weight as a major risk to health, particularly among females, highlighting the need to develop, implement and evaluate comprehensive interventions to achieve lasting change in the determinants and impact of excess body weight.

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For many decades underweight and undernutrition have dominated public health concerns around nutrition and health. It is only during the past 10 years that the health problems associated with overweight and overnutrition have gained global recognition.[1] This is despite rising trends in obesity being widely observed in many regions over the past 25 years;[2,3] Breslow's classic article (1952) that raised concern about substantial proportions of overweight Americans and drew attention to the 'close association' between overweight and excessive mortality from several chronic diseases;[4] and 80-year-old evidence of individuals issued with insurance during 1925 - 1934 being charged higher premiums because of being overweight.[4]

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Historically, excess body weight has been regarded as a 'Western' problem associated with affluence, but it is now also recognised as a leading risk factor for disease in middle-income countries, and is of emerging importance in low-income countries.[5] In a study[6] examining patterns of adult female overweight and underweight in developing regions, overweight was found to exceed underweight in more than half of the world's developing countries. Global trends in diet, moving from more traditional diets to those with increased refined foods, high in free sugar and saturated fat, in combination with reduced physical activity,[2] are believed to have led to a considerable obesity epidemic. Globally at present, an estimated 1.1 billion adults are overweight[1] (including 312 million who are obese[1]), accounting for approximately 26% of the world population.[7]

The 1998 South Africa Demographic and Health Survey (1998 SADHS)[8] provided the first nationally representative anthropometric data measured in adults. In a region of the world where obesity is uncommon,[1] high levels of excess body weight were observed among South Africans, particularly women. The mean body mass indexes (BMIs) in adult women and men ≥ 15 years were 27.3 kg/m² and 23.4 kg/m² respectively. High proportions of adult women (56%) and men (29%) were overweight or obese. Some of the poorer provinces had similarly high rates, with the lowest observed in Limpopo (44% of women and 22% of men). The prevalence of obesity was particularly high among women (30%), being higher in the urban (33%) than non-urban (25%) areas.[8]

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Some similarities but also some diversity in dietary intake exist among the country's historically defined four population groups. Whites, Indians and coloureds were found to consume a typical Western diet, with high fat (> 30% of energy intake (E)), low carbohydrate (< 55% E), low fibre and high free sugar intake (> 10% E).[9,10] Among black Africans, there are two distinct types of eating patterns: the rural population still follows a mainly traditional diet high in carbohydrates (> 65% E), low in fat (< 25% E) and sugar (< 10% E), and moderately high in fibre,[11] whereas urban black Africans have adopted the Western diet pattern.[12] Lack of data on trends in overall energy intake and diet make it difficult to assess their role in the high levels of excess body weight. However, the low levels of physical activity among South African adults must be expected to contribute to excess body weight.[13]

It is widely acknowledged that excess body weight is associated with increased risk of disease.[14] Obesity has been specified by the International Statistical Classification of Diseases as a disease in its own right.[15] The World Health Organization (WHO) Comparative Risk Assessment Study (Global CRA)[15] estimates that in adults aged ≥ 30 years, increases in BMI above 21 kg/m² are associated with an estimated 58% of type 2 diabetes mellitus (T2DM), 21% of ischaemic heart disease (IHD), 39% of hypertensive disease, 23% of ischaemic stroke, 12% of colon cancer, 8% of postmenopausal breast cancer, 32% of endometrial cancer, and 13% of osteoarthritis. The disease burden associated with excess body weight has not previously been investigated in South Africa. This study therefore aimed to estimate the burden of disease attributable to excess body weight by age and sex in South Africa for 2000.

Methods

WHO CRA methodology[2,16] was used to estimate the disease burden attributable to this particular risk factor by comparing current local health status with a theoretical minimum counterfactual with the lowest possible risk. The population-attributable fraction (PAF) was determined by the prevalence of exposure to the risk factor in the population and the relative risk (RR) of disease occurrence given exposure. Exposure to excess body weight was measured using the BMI, which standardises weight according to height.

Through analysis of numerous datasets and critical assessments of studies of BMI-associated health hazards, James *et al*.[15] concluded that a universal mean BMI of 21 kg/m² be used as optimal for both sexes throughout the world. This is similar to the lower limit of the normal weight range (21.0 - 23.0 kg/m²) proposed by the WHO Technical Consultation on Obesity.[15] The theoretical minimum risk distribution of BMI was assumed to follow a normal distribution with 21.0 ± 1.0 kg/m² (mean ± standard deviation (SD)). The BMI distribution in the South African population was assumed to be normal with parameters obtained from the 1998 SADHS for each age

and sex group.[8] There are health hazards associated with both low and high BMIs,[17] but this study is only concerned with risks of high BMI, or excess body weight.

Associated health outcomes quantified in our study were those for which sufficient causal evidence was found in the Global CRA,[15] and are listed in Table I. A number of conditions likely to be causal, including gallbladder cancer, dermatitis, menstrual disorders, infertility, breathlessness, back pain, gallstones, and psychological effects such as reactive depression and social isolation,[15,18] were not quantified because of lack of sufficient evidence of the magnitude of the hazardous effect, or difficulty of comparability on an international basis.[2,15] The RRs, also presented in Table I, were obtained from reviews and meta-analyses by the high BMI expert group of the Global CRA.[15] For cardiovascular risks, this drew substantially on the meta-analysis done by the Asia-Pacific Cohort Studies Collaboration (APCSC)[19] using 33 cohorts with over 310 000 participants. For our study, hazard ratios were obtained from re-analyses of the APCSC data, reflecting a smoother estimate of the attenuation of risks across age (S Vander Hoorn, University of Auckland, New Zealand – personal communication, 2005). A recent APCSC study indicates lower RRs per BMI unit for diabetes than what was used in the Global CRA. These, however, were not used in this analysis as they were derived for incidence of T2DM.[20]

Customised MS Excel spreadsheets based on templates used in the Clinical Trial Research Unit at the University of Auckland (S Vander Hoorn – personal communication, 2005) as well as Australian studies (T Vos, University of Queensland, Australia – personal communication, 2005) were used to calculate the attributable burden using a discrete version of the general potential impact fraction (see below), taking into account continuous risk factor disease exposures compared with a theoretical minimum distribution (conferring the lowest possible risk) on a categorical scale.

$$PAF = \frac{\sum_{i=1}^{n} P_i \, RR_i - \sum_{i=1}^{n} P'_i \, RR_i}{\sum_{i=1}^{n} P_i \, RR_i}$$

where n = the number of exposure categories; P_i = the proportion of the population in exposure category i; RR_i = the RR for exposure category i; and P'_i = the proportion of population in exposure category i in the counterfactual distribution. Calculations for categories of single BMI units were done.

The PAFs were applied to the revised estimates of the burden of disease in South Africa for the selected health outcomes, measured in deaths, years of life lost (YLL), years lived with disability (YLD), and disability-adjusted life years (DALYs).[22] Not all health outcomes of the Global CRA match the conditions in the South African National Burden of Disease study (see explanatory note at bottom of Table III). In addition,

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Table I. Health outcomes and relative risks associated with 1 kg/m² increase in BMI by age and sex

Health outcome and ICD 10 Code[21]	Males (age in years)					Females (age in years)				
	30 - 44	45 - 59	60 - 69	70 - 79	80+	30 - 44	45 - 59	60 - 69	70 - 79	80+
Ischaemic heart disease* (I20-I25)	1.13	1.09	1.07	1.05	1.02	1.13	1.09	1.07	1.05	1.02
Hypertensive disease* (I10-I13)	1.22	1.17	1.14	1.11	1.07	1.22	1.17	1.14	1.11	1.07
Ischaemic stroke* (I63)	1.14	1.10	1.07	1.05	1.03	1.14	1.10	1.07	1.05	1.03
Type 2 diabetes mellitus (E11)	1.36	1.24	1.18	1.27	1.27	1.47	1.34	1.21	1.20	1.20
Osteoarthritis (M15-M19)	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Breast cancer (C50)	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.03	1.03	1.03
Colon cancer (C18)	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
Endometrial cancer (C54-C55)	1.00	1.00	1.00	1.00	1.00	1.10	1.10	1.10	1.10	1.10
Kidney cancer (C64)	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06

Source: Adapted from James *et al.*, 2004.[15]
*Cardiovascular outcomes: Re-analysis of the APCSC including data from 33 cohorts from 8 Asia-Pacific countries, excluding the first 3 years of follow-up, and adjusted for age, sex, cohort and smoking habits (Stephen Vander Hoorn, University of Auckland, New Zealand – personal communication, 2005). T2DM: Japan (Yoshike, as cited in James *et al.*, 2004[15]) and Denmark (Drivsholm *et al.*, as cited in James *et al.*, 2004[15]). Osteoarthritis: United States of America (Must *et al.*, as cited in James *et al.*, 2004[15]). Cancers: Europe (Bergström *et al.*, as cited in James *et al.*, 2004[15]).

total stroke deaths, YLL, YLD and DALYs were adjusted by the proportion of fatal and non-fatal ischaemic stroke by age, using stroke subtype data for AFR-E,[23] since the South African estimates do not distinguish between these subtypes.

Monte Carlo simulation-modelling techniques were used to present uncertainty ranges around point estimates that reflect all the main sources of uncertainty in the calculations. We used the @RISK software 4.5 for Excel,[24] which allows multiple recalculations of a spreadsheet, each time choosing a value from distributions defined for input variables. A normal distribution was specified around mean BMI and standard errors (SEs) by age and sex. For the RR input variables we specified a normal distribution, with the natural logarithm of the published RR estimates as the mean and the SEs calculated from the natural logarithms of the 95% confidence intervals (CIs). SEs from the re-analyses of the APCSC data were used for the cardiovascular outcomes (S Vander Hoorn, University of Auckland, New Zealand – personal communication, 2005). For osteoarthritis and T2DM, 95% CIs were estimated using the variation or the difference in the excess risk, relative to the size of the excess risk for related outcomes for which these data were available. For each of the output variables (namely attributable burden as a percentage of total burden in South Africa, 2000), 95% uncertainty intervals were calculated bounded by the 2.5th and 97.5th percentiles of the 2000 iteration values generated.

Results

The 1998 SADHS[8] data show a wide distribution of observed BMI values for men and women (Fig. 1), with high proportions of the population having values higher than the optimal mean of 21.0 kg/m². Table II shows that the mean BMI (± SE) for both men and women in each age category was well above the level of 21 kg/m², and declined with increasing age. The mean BMI for adults ≥ 30 years was 28.7 ± 0.14 kg/m² for women and 24.1 ± 0.11 kg/m² for men. According to WHO classifications, 27.3% of men and 29.1% of women ≥ 30 years were overweight (25 kg/m² ≤ BMI < 30 kg/m²), and 11.0% of men and 38.6% of women were obese (BMI ≥ 30 kg/m²).

Attributable fractions for all diseases were higher for women than men (Table III). For T2DM and cardiovascular outcomes, PAFs were highest in the 30 - 44-year age group and decreased with advancing age, while cancer-related outcomes and osteoarthritis in males and females peaked in the 45 - 59- and 60 - 69-year age groups respectively. PAFs for hypertensive disease were considerably higher than for IHD and ischaemic stroke.

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Table II. Mean ± standard errors of BMI (kg/m²) by age and sex from the 1998 South Africa Demographic and Health Survey

	30 - 44 yrs	45 - 59 yrs	60 - 69 yrs	70 - 79 yrs	80+ yrs	30+ yrs
Males	24.3 ± 0.2	25.3 ± 0.3	24.5 ± 0.3	24.7 ± 0.4	22.4 ± 0.6	24.1 ± 0.11
Females	28.6 ± 0.2	29.5 ± 0.2	29.5 ± 0.3	27.5 ± 0.5	25.9 ± 0.9	28.7 ± 0.14

Table III. Population-attributable fractions (PAFs), expressed as a percentage, for selected health outcomes by age and sex, South Africa, 2000

Health outcome	Males (age in years)						Females (age in years)						Persons (age in years)
	30 - 44	45 - 59	60 - 69	70 - 79	80+	30+	30 - 44	45 - 59	60 - 69	70 - 79	80+	30+	30+
Ischaemic heart disease	44.7	40.3	24.0	18.1	4.2	32.3	68.3	59.4	47.2	29.1	11.2	45.0	37.7
Hypertensive disease	68.5	65.5	45.1	39.4	14.7	56.4	88.8	83.9	75.9	58.8	37.8	73.8	67.6
Ischaemic stroke	48.3	43.8	26.5	20.4	5.1	35.8	72.0	63.3	51.2	32.5	13.5	52.2	45.4
Type 2 diabetes mellitus	88.7	79.6	55.7	75.8	47.9	75.3	99.6	98.3	90.4	83.8	78.7	93.8	86.9
Osteoarthritis	15.3	18.4	14.8	15.7	7.9	16.5	28.1	30.4	30.8	25.3	21.0	29.1	24.0
Postmenopausal breast cancer	-	-	-	-	-	-	-	15.6	23.8	19.3	15.8	13.3	13.2
Colon cancer	11.4	13.9	11.2	11.9	5.9	12.1	21.6	23.5	23.8	19.3	15.8	21.8	17.3
Endometrial cancer	-	-	-	-	-	-	59.0	62.3	63.1	55.3	48.5	60.5	60.5
Kidney cancer	22.8	27.2	21.7	23.1	11.8	24.3	39.9	42.8	43.3	36.5	30.9	40.8	31.1

Note: PAFs for colon cancer were applied to the combined colon and rectum cancer burden to match the South African National Burden of Disease 2000 list. PAFs for endometrial cancer were applied to the corpus uteri burden, and PAFs for T2DM were applied to the total diabetes burden. PAFs for postmenopausal breast cancer in the 45 - 59-year age group were adjusted downwards by 33% to allow for premenopausal women in the age group.
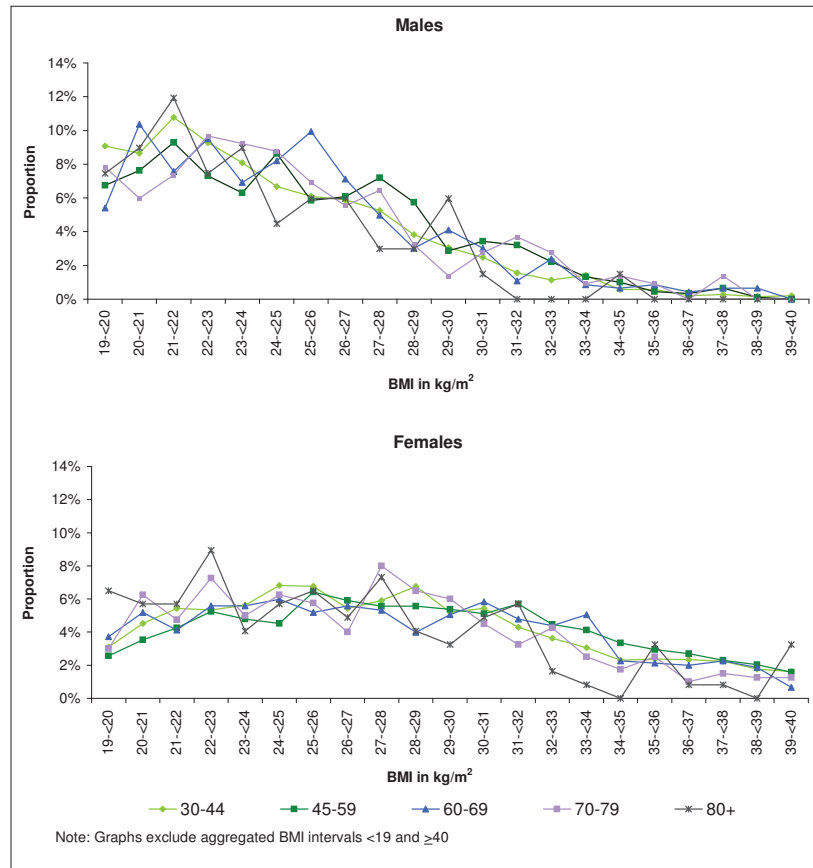
Fig. 1. Distribution of BMI by age group in males and females ≥ 30 years, 1998 SADHS.

PAFs were highest for T2DM, with 94% of the burden in females and 75% in males attributable to a BMI above 21 kg/m².

Applying the PAFs to the estimates of burden, excess body weight accounted for 11 579 male and 24 924 female deaths, constituting 4.2% of total male and 10.1% of total female deaths in South Africa in 2000 (Table IV). As most excess body weight-related deaths and non-fatal events occur in middle and older age, the YLL, compared with deaths, comprise a smaller proportion of the total (2.4% of total male YLL, 5% of total female YLL). The proportion of DALYs due to excess body weight was twice as high in women (3.9%) than men (1.9%). In females, T2DM accounted for the highest number of deaths (*N* = 7 620) and DALYs (*N* = 96 098), followed by hyper-tensive disease. In contrast, IHD accounted for most attributable deaths (*N* = 4 106) and DALYs (*N* = 52 843) in males, followed by T2DM and then hypertensive disease. Cancers accounted for 4.4% of the total burden in females, compared with 1.1% in males (Fig. 2). A large part of this difference is likely accounted for because 2 of the 4 related cancers analysed were female-specific.

The age distribution of deaths attributable to excess body weight by disease outcome and sex are presented in Fig. 3, highlighting the higher total burden in women. In men, most deaths occurred in the 45 - 59-year age group and then declined with increasing age. In women, deaths peaked in the 60 - 69-year age group and continued to take a high toll in older age groups.

Table IV. Burden of disease attributable to excess body weight in males, females and persons ≥ 30 years, South Africa, 2000

Health outcome	Males				Females				Persons			
	Deaths	YLLs	YLDs	DALYs	Deaths	YLLs	YLDs	DALYs	Deaths	YLLs	YLDs	DALYs
Colon cancer	124	1 221	62	1 283	277	2 431	168	2 598	402	3 652	230	3 881
Postmenopausal breast cancer	0	0	0	0	498	4 968	379	5 347	498	4 968	379	5 347
Endometrium cancer	0	0	0	0	367	3 776	1 012	4 788	367	3 776	1 012	4 788
Kidney cancer	49	524	31	555	53	584	67	651	103	1 108	98	1 206
Type 2 diabetes mellitus	3 197	35 863	9 636	45 499	7 620	76 224	19 875	96 098	10 817	112 086	29 511	141 597
Ischaemic heart disease	4 106	49 370	3 472	52 843	4 980	48 628	5 100	53 729	9 086	97 999	8 573	106 571
Ischaemic stroke	1 845	21 769	5 050	26 819	4 255	44 563	10 920	55 483	6 099	66 333	15 969	82 302
Hypertensive disease	2 258	26 803	735	27 538	6 873	64 584	1 454	66 037	9 131	91 386	2 189	93 575
Osteoarthritis	0	0	6 358	6 358	1	1	16 709	16 711	1	1	23 068	23 069
Total burden	**11 579**	**135 550**	**25 345**	**160 895**	**24 924**	**245 760**	**55 684**	**301 443**	**36 504**	**381 310**	**81 029**	**462 338**
95% uncertainty interval												
Upper	12 765	149 709	28 412	176 641	27 004	256 996	60 528	313 961	38 637	395 583	86 299	478 847
Lower	9 560	107 797	20 611	129 847	20 274	194 609	46 751	246 916	31 018	321 202	70 487	396 512
% of total burden	**4.2%**	**2.4%**	**0.9%**	**1.9%**	**10.1%**	**5.0%**	**2.0%**	**3.9%**	**7.0%**	**3.6%**	**1.5%**	**2.9%**
95% uncertainty interval												
Upper	4.7%	2.6%	1.0%	2.1%	10.9%	5.2%	2.2%	4.1%	7.4%	3.7%	1.6%	3.0%
Lower	3.5%	1.9%	0.8%	1.5%	8.2%	4.0%	1.7%	3.2%	6.0%	3.0%	1.3%	2.4%

YLL = years of life lost (premature death); YLD = years lived with disability; DALYs = disability-adjusted life years.
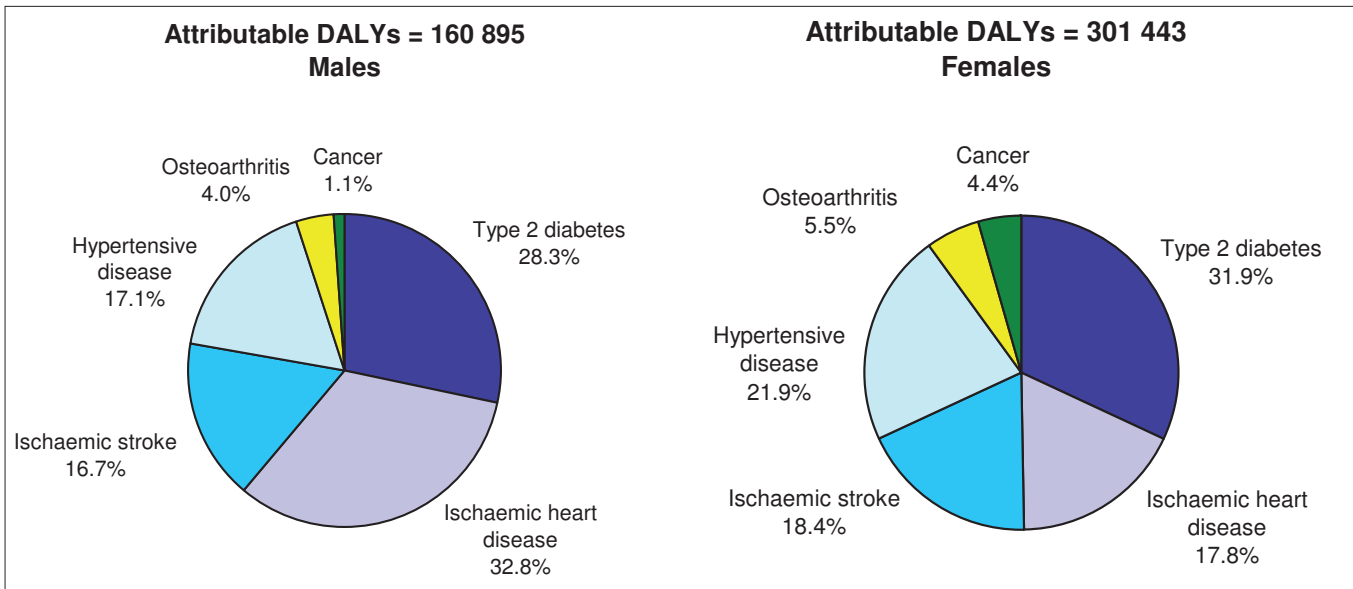

Fig. 2. Burden of disease attributable to excess body weight in males and females ≥ 30 years, South Africa, 2000.

Discussion

The prevalence of excess body weight in adult South Africans 30 years or older was high, particularly among women. Between 397 000 and 479 000 DALYs were attributable to excess body weight in the year 2000. Compared with other risk factors investigated in the South African CRA study, excess body weight ranked fifth in terms of both deaths and DALYs. Among women, double the number of deaths and DALYs were attributed to excess body weight than in men. Excess body weight accounted for 1 in every 10 female deaths in the country. This gender difference is generally not seen in developed countries, where mean BMI tends to be similar in males and females. The proportions of

T2DM, cardiovascular conditions and selected cancers attributed to excess body weight in South Africa are higher than global estimates,[15] particularly in the women.

The present study found that the largest proportion of deaths attributable to excess body weight occurred in the 45 - 59-year age group. This results from the age structure of the population, as well as the fact that the relationship between obesity and its co-morbidities is generally stronger among younger adults (< 55 years of age).[25] It emphasises that young adults, who are less likely to be conscious of and concerned about associated health effects, need to be alerted to the early onset of such effects. The attenuation of the RR with age is common, and is likely to be
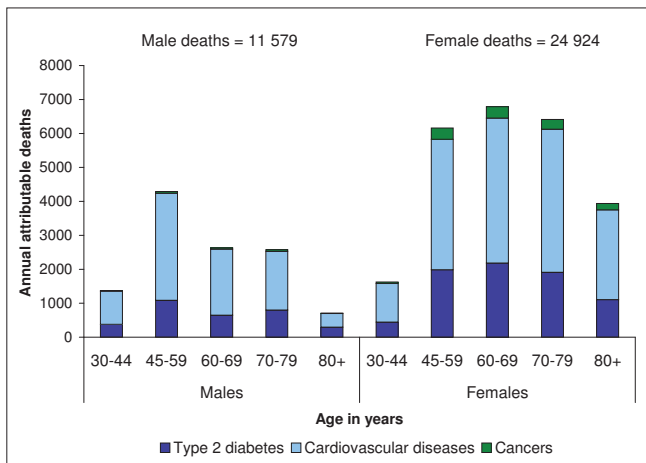
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Fig. 3. Deaths attributable to excess body weight in South Africans, by age and sex, 2000.

related to competing risks at older age, but further research would be useful.

It is important to note that in South Africa, despite high levels of excess body weight, undernutrition, including nutritional deficiencies, is still prevalent, and remains a major cause of death and disability in children.[26] Indeed, a complex picture emerges of the co-existence of over- and undernutrition in the same community, and even in the same household.[27] As childhood obesity is a strong precursor of obesity in adulthood,[28] the prevalence of excess body weight in South African children is of growing concern. A recent national study in children aged 1 - 9 years showed the prevalence of underweight (< 2SD weight for age) to be 12%, and stunting (< 2SD height for age) 22%, whereas prevalence of combined overweight and obesity (age-adjusted BMI ≥ 25) was 17%, with higher prevalence in urban areas.[27] Among school-going adolescents aged 12 - 19 years in 2002, 7% of male and 25% of female learners were overweight or obese.[29]

US-based studies have shown that the fast-food industry markets heavily to children and adolescents;[30] portion sizes and the caloric content of fast foods have increased appreciably;[30] fast-food restaurants cluster in areas within a short walking distance from schools;[30] snacks, fast foods and sweets dominate food advertisements viewed by children;[31] and television advertising influences food and beverage preferences, purchase requests, and beliefs of children.[32] Research has shown that the school environment plays a vital role in shaping children's health behaviours.[33] Many developed countries are responding, and for example the European Charter on Counteracting Obesity[34] highlights that special attention is needed for children. However, much less attention has been given to this in developing countries, and South Africa clearly needs to give this some consideration.

Global responses to address health threats associated with excess body weight include the World Health Assembly's Global Strategy on Diet, Physical Activity and Health,[35] and the work

of the Public Health Approaches to the Prevention of Obesity Working Group of the International Obesity Task Force (IOTF)[36] which has identified targets for action, action principles and action recommendations for the prevention of obesity. In South Africa the National Department of Health (DOH) has included specific objectives in the Integrated Nutrition Programme aimed at reducing obesity in the female population to 25% by 2007. The DOH has also formulated a series of clinical guidelines for the prevention and management of overweight, and has launched the National Food-Based Dietary Guidelines.[37] Programmes have been initiated in the private sector: major health insurers have introduced wellness programmes that encourage ongoing health-risk appraisal, including the measurement of BMI and body fat levels. Continuing professional education on the prevention and management of excess body weight has been provided to doctors, nurses and allied health professionals.[37] However, schoolchildren are neglected as a target group, and there are no obesity programmes yet at schools. Recently, Government engaged in promoting physical activity for health. The Department of Education and Department of Sport and Recreation developed a policy framework on physical activity, while the Ministry of Sport and Recreation issued a White Paper and the Sport and Recreation Act, important instruments promoting the theme of 'Getting the nation to play'.[37] In addition, physical activity for health has been promoted at a population level through the 'Vuka! South Africa, Move for your Health' campaign initiated by the Department of Health.

An array of socio-economic, environmental, behavioural and cultural factors contribute to increased levels of excess body weight.[2] In South Africa one such cultural factor may be the acceptance and perceived advantages of being overweight among many black African women, associating an over-weight body image with dignity, respect, wealth, strength, happiness and health, as well as with being treated well by their husbands.[38,39] Weight loss associated with HIV and AIDS has added to the complexity of perceived body image.[38] A recent study[40] among female community health workers shows that lack of knowledge on nutrition and the health risk of high fat intake in combination with easy access to cheap, unhealthy food, particularly in urban settings, limit the ability to make healthy food choices. These studies highlight the importance of the Global Strategy[35] aimed at developing an enabling environment for action that will lead to more healthy diets and increased physical activity. They also point to the need for research to identify reasons for the country's particularly high levels of excess body weight and associated burden in females.

Rodgers *et al.*[5] refers to trials that have recorded beneficial health effects through weight reduction achieved by a combination of personal interventions, including dietary counselling and therapy involving decreased daily calorie intake and a reduction in saturated and total fats. These measures may be complemented by behavioural strategies around stress management, social support, self-monitoring of eating habits,

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and problem solving. However, overall, the effects of lifestyle modification to reduce weight and maintain such weight loss, are relatively poor.[5] Many studies have found that weight returns to baseline levels after several years. Dietician-led treatments, brief training interventions, inpatient care, shared care, and reminder systems may be worth further investigation.[41] Randomised controlled trials with pharmacological agents for weight loss have suggested modest weight-loss effects.[5] Although surgery may not be regarded as a solution in developing countries, trials on persons with BMI $\geq$ 35 kg/m^2 have demonstrated about 23 - 37 kg more weight loss than conventional treatment, and that this loss was maintained for 8 years.[42] Population-wide initiatives to address the root causes of CVD, including the societal determinants of high salt and saturated fat intake, high-energy diets, and decreasing levels of physical activity should complement the management of individuals with high absolute risk of CVD also taking into account high blood pressure and high cholesterol.[5] A population-based intervention in China, the Tianjin Project, showed a significant reduction in sodium intake in men, and after 5 years, decreasing rates of hypertension and obesity.[43] However, Flegal *et al.*[44] indicated that relatively little is known about effective prevention and management of excess body weight on a population-wide basis. Research is needed to develop and evaluate multi-level interventions that are appropriate for different settings in South Africa.

This is the first study to quantify the adverse health outcomes associated with excess body weight in South Africa. However, the study has some limitations. This article does not consider the joint effects of the cluster of risk factors that share a common causal pathway in the development of CVD and T2DM. BMI was used as a measure of excess body weight, and although BMI correlates highly with body fatness,[45] it does not distinguish between weight associated with lean mass and fat mass. Central obesity, measured by waist circumference or waist-to-hip ratio, may be a better predictor of CVD than BMI or total body fatness.[46] While the IOTF suggests that BMI (as used in the Global CRA as a proxy for body fatness) is the most appropriate simple indicator of weight-for-height relating to health outcomes at a population level,[15] there is a need for further epidemiological data based on more sensitive measures.

Conclusions and recommendations

It is concluded that excess body weight results in a substantial burden of death, premature death and disability in adults in South Africa, and may be expected to grow with continued development. Moreover, South African studies show concerning levels of excess body weight in children. While some action has been taken to counter the associated burden, excess body weight is likely to continue contributing to ill health in both poor and wealthier sectors of the population, and there is a need for increasing the priority given to such action.

Considering reviews and recommendations by the Disease Control Priorities Project, interventions that are likely to counter

the burden from this risk factor include educating people on energy balance and healthy food choices (in particular in schools, the workplace and health care providers); marketing that promotes healthy food choices (including clear labelling of energy content for all packaged foods, including fast foods where reasonable); healthy advertising (including standards that limit the promotion of foods high in refined starch, sugar, and saturated and trans-fats to children); improving availability and reducing the cost of healthy foods; improving the processing and manufacturing of food (including replacing unhealthy with healthy fats and oils, fortifying foods, and setting standards for the amount of sodium in processed foods); modifying town, road and building designs to promote safe walking, cycling, and the use of stairs, and to improve access to public transportation; implementing policies with an economic incentive for healthier choices; and surveillance systems to monitor relevant indicators.[5,47] Challenges in South Africa are expected to include the social acceptance of being overweight; issues regarding food security, pricing and availability of healthier foods; food labelling, advertising and marketing; and sustaining intervention efforts.

It is, however, acknowledged that high levels of excess body weight in a population is a complex issue that raises complex questions about reshaping public policy across a number of sectors to deal effectively with the manifestations of the risk factor and the forces that shape it.[48] No country yet has been successful in reversing obesity trends,[48] pointing to these complexities. While it seems natural to recommend further research in seeking successful interventions, it is acknowledged that there is difficulty in deciding whether evidence must precede interventions, or whether policy changes must happen alongside seeking such evidence through research. It is therefore clear that strong leadership is needed in South Africa to guide action around the prevention and management of this risk factor and its determinants and impact, particularly in the presence of other cardiovascular risk factors.

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