Estimating the burden of disease attributable to diabetes in South Africa in 2000

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Objectives. To estimate the burden of disease attributable to diabetes by sex and age group in South Africa in 2000.

Design. The framework adopted for the most recent World Health Organization comparative risk assessment (CRA) methodology was followed. Small community studies used to derive the prevalence of diabetes by population group were weighted proportionately for a national estimate. Population-attributable fractions were calculated and applied to revised burden of disease estimates. Monte Carlo simulation-modelling techniques were used for uncertainty analysis.

Setting. South Africa.

Subjects. Adults 30 years and older.

Outcome measures. Mortality and disability-adjusted life years (DALYs) for ischaemic heart disease (IHD), stroke, hypertensive disease and renal failure.

Results. Of South Africans aged ≥ 30 years, 5.5% had diabetes which increased with age. Overall, about 14% of IHD, 10% of stroke, 12% of hypertensive disease and 12% of renal disease burden in adult males and females (30+ years) were attributable to diabetes. Diabetes was estimated to have caused 22 412 (95% uncertainty interval 20 755 - 24 872) or 4.3% (95% uncertainty interval 4.0 - 4.8%) of all deaths in South Africa in 2000. Since most of these occurred in middle or old age, the loss of healthy life years comprises a smaller proportion of the total 258 028 DALYs (95% uncertainty interval 236 856 - 290 849) in South Africa in 2000, accounting for 1.6% (95% uncertainty interval 1.5 - 1.8%) of the total burden.

Conclusions. Diabetes is an important direct and indirect cause of burden in South Africa. Primary prevention of the disease through multi-level interventions and improved management at primary health care level are needed.

S Afr Med J 2007; 97: 700-706.

Diabetes, a disease with significant morbidity and premature mortality, is affecting increasing numbers of people worldwide. The World Health Organization (WHO) estimated that in 1998 there were 135 million people with diabetes.[1] The estimate rose to 171 million people in 2000 and has been projected to increase to 366 million in 2030.[2] Much of the increase will occur in developing countries, arising from growth and ageing of the population as well as urbanisation associated with increasing trends towards unhealthy diets, obesity and sedentary lifestyles resulting in late-onset diabetes (type 2).[3] The global trend of increasing obesity will exacerbate the situation and is very concerning as the morbidity and health care costs associated with diabetes are considerable. Diabetes is not only the most common cause of non-traumatic amputations and a leading cause of blindness, it also accounts for a significant proportion of end-stage renal disease requiring dialysis and transplantation. Good quality care and management of diabetes can reduce the impact of these complications. However, in developing countries, competing needs restrict the capacity of resource-limited health services to achieve these reductions. Globally, diabetes is also an increasingly important cause of mortality. When the excess mortality attributed to diabetes was taken into account, it was estimated to be the 5th leading cause of death in the year 2000 accounting for 5.2% of all deaths globally,[4] with heart disease, stroke and renal failure largely accounting for the additional deaths.

Unlike the situation with hypertension and high body mass, no national prevalence statistics for diabetes are available in South Africa. However, a number of epidemiological studies have been conducted in selected communities in the 1980s and 1990s.[5-10] These revealed a clear rural-urban gradient with higher prevalence in urban settings, in addition to a gradient across different population groups. Studies reported the highest prevalence in the Indian population, followed by the coloured and then the black population. There is little data on the prevalence of diabetes among whites. Based on the available epidemiological data, approximately 1 - 1.5 million South Africans are considered to have diabetes. The South African National Burden of Disease Study[11] reported that diabetes was the 10th leading cause of death among persons of all ages in 2000, accounting for an estimated 13 500 deaths (2.6% of the total). This estimate reflects deaths where diabetes would be selected as the underlying cause but excludes the excess deaths resulting from the increased risk of mortality

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from cardiovascular disease that is associated with diabetes or diabetes-related renal failure that is misclassified. Although not included in the global risk factor assessment,[12] diabetes was identified by the South African National Department of Health as a risk factor of major concern. The aim of the present study is to quantify the burden of disease in terms of deaths and loss of healthy life years (DALYs) attributed to diabetes by sex and age group in South Africa for the year 2000.

Methods

Comparative risk assessment (CRA) methodology developed by the World Health Organization[12,13] was used. In addition to the burden directly attributed to diabetes estimated in the South African National Burden of Disease study for 2000, the additional attributable burden is assessed by calculating the attributable fraction from estimates of the prevalence of diabetes in the population and the relative risk (RR) of selected health outcomes. Attributable burdens were calculated by applying the relevant population attributable fractions (PAFs) to the estimate of current disease burden.

The prevalence of diabetes was estimated as a weighted average of the results from selected studies to represent subpopulations.[5-9] The only data available to represent black Africans living in a rural area were collected in the former homeland of QwaQwa.[8] The study by Levitt *et al.*[5] demonstrated a clear increase in the prevalence of diabetes associated with the length of stay in the urban area, and the 1998 South African Demographic and Health Survey (SADHS)[14] showed that the prevalence of overweight and obesity among black Africans was twice as high in the urban setting compared with the rural setting. The prevalence data from QwaQwa were surprisingly high and similar to the urban township of Mangaung. This could be attributed to the close proximity of the former homeland to the urban setting. It was therefore decided to conservatively assume that the prevalence of diabetes in the rural area was half that estimated for the urban black population. Population weights for urban black Africans, rural black Africans and the other population groups were based on the Actuarial Society of South Africa population estimate for the year 2000 by age and sex. The population group classification is used in this article to demonstrate differences in the risk factor profile and the subsequent burden. Data are based on self-reported categories according to the population group categories used by Statistics South Africa. Mentioning such differences allows for a more accurate estimate of the overall burden and may assist in higher effectiveness of future interventions. The authors do not subscribe to this classification for any other purpose. The revised World Health Organization criteria[15] were used to define the presence of diabetes, i.e. a venous plasma glucose concentration of ≥ 7 and/or ≥ 11.1 mmol/l taken 2 hours after a 75 g oral glucose challenge.

The outcomes assessed were ischaemic heart disease (IHD), stroke, hypertensive disease and renal failure (nephritis/nephrosis excluding hypertensive renal disease). According to *International Classification of Diseases* (ICD) rules,[16] diabetes should be recorded as the underlying cause of death from end-stage renal failure caused by diabetes. As extensive misclassification has been observed as a result of incomplete certification in other settings,[17,18] and the need for better certification has been identified in South Africa,[19] it was assumed that a proportion of the deaths ascribed to nephritis/nephrosis were likely to have resulted from diabetes. A review of the literature provided several estimates of the RRs of these outcomes.[20-33] However, the Asia Pacific Cohort Studies Collaboration[34] includes most of the prospective observational studies conducted in both Indian and Caucasian populations in the region. It provides reliable evidence on the effects of a variety of modifiable risk factors, including diabetes, on the risks of major cardiovascular diseases and other common causes of death in populations from this region. The age- and sex-specific hazards (Table I) re-categorised to match the burden of disease age groups were used in this study. As there were no relative risks published for hypertensive disease, the RR for all cardiovascular disease was used.

Customised MS Excel spreadsheets were used to calculate the attributable burden using the PAF formula for each age interval:

$$PAF = \frac{P\,(RR-1)}{P\,(RR-1)+1}$$

where P is the prevalence of exposure and RR is the relative risk of disease in the exposed versus unexposed group. PAFs were then applied to revised South African burden of disease estimates for 2000 with methods and assumptions described elsewhere[11] to calculate attributable burden (number of deaths, years of life lost (YLLs) due to premature mortality, years of life lived with disability (YLDs) and DALYs). Because of data limitations, all diabetes burden in adults 30 years and older was assumed to be type 2 diabetes.

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 version 4.5 for Excel,[35] which allows multiple recalculations of a spreadsheet, each time choosing a value from distributions defined for input variables. For the prevalence of diabetes in adults aged 30+ we assumed that the weighted national estimates could vary by 20%, and specified a triangular distribution with three points (minimum, most likely and maximum). For the RR input variables we specified a normal distribution around the logged point estimate and its standard error derived from the published values and their 95% confidence intervals (CIs) (Table I). For each of the output variables (namely attributable burden as a percentage of total

Table I. Adjusted hazard ratios for cardiovascular and renal disease

Sex/Age (years)	Hazard ratio	95% CI
All ischaemic heart disease events (I20-I25)		
Males	2.03	(1.60 - 2.59)
Females	2.54	(1.84 - 3.49)
< 60	4.38	(2.63 - 7.31)
60 - 74	2.44	(1.84 - 3.22)
75+	1.57	(1.14 - 2.16)
Cerebrovascular deaths (I60-I69)		
Males	2.04	(1.46 - 2.84)
Females	2.00	(1.37 - 2.92)
< 60	2.57	(1.00 - 6.59)
60 - 74	2.69	(1.91 - 3.80)
75+	1.30	(0.86 - 1.96)
Non-fatal cerebrovascular events (I60-I69)		
Male + female	2.09	(1.65 - 2.64)
All cardiovascular disease (I00-I26, I28-I84, I86-I99, J81)		
< 60	3.47	(2.30 - 5.21)
60 - 74	2.27	(1.87 - 2.75)
75+	1.49	(1.20 - 1.84)
Renal disease excluding cancer (N00-N19)		
Male + female	2.93	(1.70 - 5.04)

Source: Asia Pacific Cohort Studies Collaboration;[34] ICD-10 codes.[16]

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 estimated prevalence of diabetes among South African adults 30 years and older was 5.5% in 2000 and varied by age and sex, as can be seen from Fig. 1. The prevalence increased with age for both males and females, and although it was similar for males and females in the younger age groups, there was a marked difference over the age of 60 years.

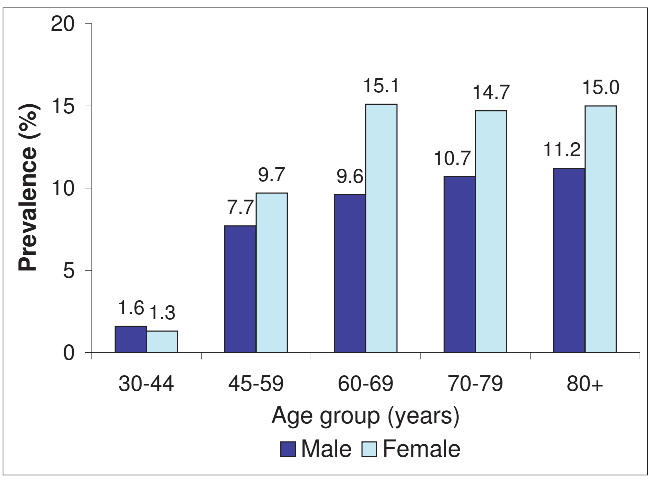

Fig. 1. Estimated prevalence of diabetes by age and sex, South Africa, 2000.

The prevalence of diabetes varied by population group, as shown in Table II. The Indian population group had the highest prevalence of diabetes. The prevalence was consistently higher for women of all population groups except for Indians. The prevalence of diabetes was also highest in the older age groups (60 years and older). In Indians there was also a marked increase in the 45 - 49-year age groups for both men and women.

Table III gives a summary of the attributable burden in terms of deaths and DALYs resulting from each of the related conditions. Compared with other conditions, the PAFs were highest for IHD for both males and females. In adults 30 years and older, diabetes caused 13 166 deaths in 2000 directly and a further 9 246 could be attributed through IHD, stroke, hypertensive disease and renal failure. Thus 22 412 (95% uncertainty interval 20 755 - 24 872) or 4.3% (95% uncertainty interval 4.0 - 4.8%) of all deaths were attributed to diabetes in South Africa in 2000. Almost half of the attributable deaths occurred among adults of working age: 47.2% of those who died were under 65 years. Fig. 2 shows the age and sex distribution of the deaths and highlights that the peak burden for men was in the age range 45 - 59 years, while for women it was higher and occurred in the age range 60 - 69 years. There were more attributable deaths in females than in males, and overall diabetes accounted for 5.7% of all female and 3.0% of all male deaths in South Africa in 2000.

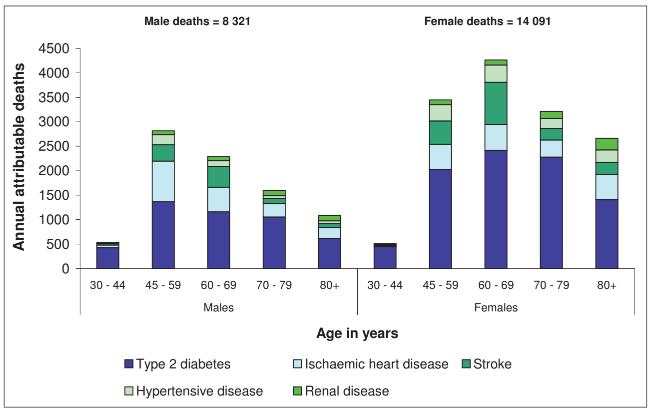

Fig. 2. Diabetes-attributable mortality by cause, age and sex, South Africa, 2000.

A total of 258 028 DALYs (95% uncertainty interval 236 856 - 290 849) were attributable to diabetes. Although IHD accounted for more deaths than stroke in females, the DALYs for stroke were higher than those for IHD because of the greater disability component (YLDs) for stroke. Since most diabetes-related deaths occur in the elderly, the loss of life years accounts for a lower proportion of the total DALYs than deaths, i.e. 1.6% (95% uncertainty interval 1.5 - 1.8%) of the total.

Table II. Prevalence (%) of diabetes by population group, age and sex, South Africa, 2000

Population group	Age group	Males	Females	Persons
Urban black African	30 - 44	2.2	1.5	1.8
	45 - 59	9.2	13.0	11.2
	60 - 69	10.8	16.7	14.1
	70 - 79	10.8	16.7	14.3
	80+	10.8	16.7	14.7
	30+	5.4	7.3	6.4
Non-urban black African	30 - 44	1.1	0.8	0.9
	45 - 59	4.6	6.5	5.6
	60 - 69	5.4	8.4	7.1
	70 - 79	5.4	8.4	7.2
	80+	5.4	8.4	7.4
	30+	2.7	3.7	3.2
Coloured	30 - 44	0.8	0.4	0.6
	45 - 59	8.4	8.7	8.6
	60 - 69	12.5	33.3	24.3
	70 - 79	26.9	19.4	22.3
	80+	26.9	19.4	21.9
	30+	5.1	7.3	6.2
White	30 - 44	0.5	0.8	0.7
	45 - 59	7.3	8.2	7.7
	60 - 69	10.0	13.9	12.1
	70 - 79	10.8	16.7	14.3
	80+	10.8	16.7	14.9
	30+	5.1	7.3	6.2
Asian/Indian	30 - 44	9.6	9.8	9.7
	45 - 59	25.2	18.4	21.7
	60 - 69	30.0	30.0	30.0
	70 - 79	30.0	30.0	30.0
	80+	30.0	30.0	30.0
	30+	18.0	16.4	17.1
South Africa	30 - 44	1.6	1.3	1.4
	45 - 59	7.7	9.7	8.7
	60 - 69	9.6	15.1	12.6
	70 - 79	10.7	14.7	13.1
	80+	11.2	15.0	13.8
	30+	4.7	6.2	5.5

Discussion

This study estimated that over 20 000 deaths, accounting for 4.3% of all deaths in South Africa in 2000, could be attributed to diabetes when excess mortality was taken into account. This places diabetes as the 7th commonest cause of death in this country, which is lower than the 5th place accorded to diabetes in the global study for the same year. In that report, Roglic *et al*.[4] found that diabetes had a global mortality of 2.9 million deaths and accounted for 5.2% of all deaths. Not surprisingly, the South African estimates from our study fall between the lowest mortality (2.4%) reported for the poorest African and Western Pacific countries, and the highest mortality (~9%) in the Arabian Peninsula, East Mediterranean region, Canada and the USA. Interestingly, the global mortality attributable to HIV/AIDS and diabetes are similar, unlike the situation in South Africa where the former accounted for 6 times more deaths than diabetes in 2000.

Yet our estimates for mortality attributable to diabetes may well be conservatively low. Firstly, they are based on cross-sectional prevalence data obtained 5 - 15 years previously as current diabetes prevalence data were not available. Given global trends, these prevalences are likely to underestimate the prevalences for 2000. Secondly, RRs for IHD, stroke and renal disease from the Asia Pacific region were used because of the absence of available data from Africa.[34] However, the INTERHEART study[33] indicates that the RR for IHD at least may be higher for the black African population. Similarly, it is quite conceivable that the RR for deaths due to renal disease may be higher in South Africa than the Asia Pacific region. Although South Africa has well-developed public and private health sectors, there is strict rationing of renal replacement to the ~80% of the population served by the public sector. In this sector, renal replacement treatment is generally limited to patients under 60 years old who have stable employment and social support. The age cut-off tends to exclude the majority

Table III. Burden attributable to diabetes by sex, South Africa, 2000

Health outcome	Males			Females			Persons		
	PAF (%)	Deaths	DALYs	PAF (%)	Deaths	DALYs	PAF (%)	Deaths	DALYs
Ischaemic heart disease	13	1 881	21 688	15	1 932	18 310	14	3 813	39 998
Stroke	8	966	11 289	11	1 839	20 331	10	2 805	31 620
Hypertensive disease	11	458	5 134	12	1 168	11 027	12	1 627	16 161
Renal disease*	11	405	3 156	14	596	4 216	12	1 001	7 372
Type II diabetes†	100	4 610	60 423	100	8 556	102 454	100	13 166	162 877
Total		**8 321**	**101 690**		**14 091**	**156 338**		**22 412**	**258 028**
95% uncertainty interval		7 597 - 9 378	91 391 - 117 425		13 047 - 15 618	144 989 - 175 341		20 755 - 24 872	236 856 - 290 849
% of total		**3.0%**	**1.2%**		**5.7%**	**2.0%**		**4.3%**	**1.6%**
95% uncertainty interval		2.8 - 3.4%	1.1 - 1.4%		5.3 - 6.3%	1.9 - 2.3%		4.0 - 4.8%	1.5 - 1.8%

*Renal disease/failure PAFs applied to nephritis/nephrosis burden (revised South African National Burden of Disease Study 2000).[11]
†Type II diabetes PAFs were applied to the total diabetes burden in adults 30 years and older (revised South African National Burden of Disease Study 2000).[11]
PAF = population-attributable fraction; DALYs = disability-adjusted life years.

of people with endstage diabetic renal disease. Indeed, Moosa and Kidd[36] reported that only 6.2% of patients accepted for renal replacement therapy at a public sector tertiary hospital were diabetic. In contrast, approximately half of patients receiving long-term dialysis in the private sector have diabetes (Dr Charles Swanepoel, University of Cape Town – personal communication, 2007), akin to the situation in the developed countries.

The South African diabetes age-standardised mortality rate of about 50 per 100 000 population is the 25th highest in the world,[37] considerably higher than would be expected for a country with a diabetes prevalence in the mid-third of countries globally. The high mortality relative to the prevalence may well be a reflection of the suboptimal health care delivery for diabetes in this country.[38-40] Inadequate glycaemia control, inadequate levels of hypertension control (which co-exists in 50 - 60% of people with type 2 diabetes), infrequent examination for complications of diabetes despite their common occurrence and lack of access to lipid-lowering therapy have all been reported by these studies.

It is quite possible to reduce the burden due to diabetes in South Africa. There are unequivocal data that public health interventions can have a considerable impact on outcome in people with diabetes. In a recent review, Narayan *et al.*[41] examined the cost-effectiveness of interventions for preventing and treating diabetes in developing regions of the world and stratified these according to their feasibility and implementation priority. Feasibility was evaluated according to the level of difficulty in reaching the target population, the technological requirements or expertise, and the cultural acceptability and capital needed. In this exercise, interventions such as glycaemia control in people with a haemoglobin (HbA_{1c}) level of > 9%, blood pressure control in people with blood pressure > 160/95 mmHg and foot care in people with ulcers were assessed as highly feasible and cost-saving, and were also graded as having the greatest implementation priority in all developing regions of the world. South Africa has a considerably better health structure and greater resource allocation to health than the other sub-Saharan African countries. Thus it is conceivable that further interventions could be undertaken. The next stratum of interventions all cost $160 per DALY or less and include preconception care for women of reproductive age (cost-saving), lifestyle interventions for preventing type 2 diabetes (cost $60) and influenza vaccines among the elderly with type 2 diabetes (cost $160 per DALY).

A recent analysis,[42] based on the evidence that cardiovascular mortality risk increases continuously with blood glucose levels, commencing well below the diagnostic threshold for diabetes, found that higher-than-optimal blood glucose concentrations globally contributed a further 1 490 000 deaths from IHD and 709 000 deaths from stroke to the 959 000 deaths directly attributed to diabetes globally. These data indicate that a significant proportion of all deaths due to IHD (21%) and stroke (13%) can be accounted for by non-optimal blood glucose levels and highlight the need for an integrated approach to the management of these interrelated diseases. Development of the chronic care model at the primary care level – including adequately trained nurses and other support staff, equipment and supply of drugs should assist in this regard. This challenge will be exacerbated by the potential growing numbers of HIV-positive people receiving antiretroviral treatment, as a proportion of those using protease inhibitors may be expected to develop diabetes.[43]

There is also the issue of diabetes prevention. A number of randomised trials[41] have reported that intensive lifestyle intervention delays or prevents type 2 diabetes. There is a considerable challenge in extending these findings to the general population and it would require major partnerships between government, communities, non-governmental organisations (NGOs) and industries, supporting shifts in social policy, such as creating environments conducive to increasing possibilities for safe physical activity and eating healthily. The national Department of Health has already launched the healthy lifestyle programme, but its implementation and uptake are uncertain. In the same vein, the first national guidelines for the management of diabetes at the primary care level were published in 1997, but this did not appear to impact on the quality of care because of problems with implementation. Indeed, sufficient policies for the management and prevention of diabetes and other chronic diseases have been developed at a national level. These however remain to be implemented by the provinces and local authorities. Clearly a new framework is critical to drive the successful implementation of national policies and guidelines. This requires an integrated platform between different levels of government, NGOs and industry to co-ordinate the implementation of these policies. Importantly, measures to evaluate these must also be put in place.

Conclusions and recommendations

In conclusion, the burden due to diabetes is unacceptably high in South Africa. Intensive efforts are required to improve health care delivery such that the proportions of people achieving targets for blood pressure and blood glucose control, as well as receiving appropriate screening for complications with subsequent intervention, can achieve levels that will impact on morbidity and mortality. Colagiuri *et al.*[44] argue that changes in social policy will be the key to changing the social and physical environment required to achieve widespread reductions in the incidence and prevalence of diabetes.

The launch of the Diabetes Strategy for Africa in December 2006[45] is timeous as it outlines a plan of action and calls on governments, NGOs and industry to implement an integrated and comprehensive approach to reduce the burden of diabetes in the region. It advocates the continuum of interventions from primary prevention right through to palliative care. South Africa is well ahead in the diabetes epidemic but also has many of the resources required to place it at the forefront of implementing the plan of action.

The other members of the Burden of Disease Research Unit of the South African Medical Research Council: Pam Groenewald, Nadine Nannan, Michelle Schneider, Beatrice Nojilana, Jane Joubert, Karin Barnard and Elize de Kock, are thanked for their valuable contribution to the South African Comparative Risk Assessment Project. Ms Leverne Gething is gratefully acknowledged for editing the manuscript. Ms Ria Laubscher and Dr Lize van der Merwe of the MRC Biostatistics Unit made contributions via their statistical expertise and assistance and Professor Nigel Unwin of Newcastle University kindly reviewed the article. Our sincere gratitude is also expressed for the valuable contribution of Associate Professor Theo Vos, University of Queensland School of Population Health. We thank him not only for providing technical expertise and assistance, but also for his enthusiasm and support from the initial planning stages of this project.

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