The Global Cardiovascular Diseases Risk Pattern in a Peri-Urban Working-Class Community in South Africa. The Mamre Study

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Objectives: To describe the cardiovascular disease (CVD) risk factors and the global burden of CVD risk in a peri-urban, working-class community of Mamre near Cape Town. To identify additional variables in the data set associated with the global CVD risk factor score. The latter was calculated using the major CVD risk factors in formulas derived from the Framingham global CVD risk calculations.[1] Such variables could possibly be used for global CVD risk calculations, instead of depending on biochemical estimates for these calculations.

Methods: In a random population-based sample of 976 people aged 15 years and older, data on demography, smoking, physical activity, and alcohol use were collected. Blood pressure (BP), anthropometry, levels of serum glucose and lipids, and low-density lipoprotein cholesterol (LDL) particle sizes were also determined. These data allowed calculation of the global CVD risk profile with the Framingham study's formula. The data are age-standardized to the colored (mixed ancestry) population according to the 1996 South African census.

Results: The global CVD risk score suggested that men and women had a 5.2% and 4.2% probability, respectively, of having a CVD event in the next 10 years, while for those 55 years of age and older, the probability increased to more than 30% and 25%, respectively. Hypertension was found in 22% of men and 16% of women. Sixty-two percent of the men and 44% of the women smoked cigarettes, while 6% and 5% had diabetes, respectively. Hypercholesterolemia was present in 47% of men, and 46% of women. Small-dense LDL particles were present in 26% of men and 14% of women. A number of easily measured CVD risk factors could explain 40.3% of the variation of the global CVD risk score. These include aspects of the medical history provided by the patient, the inverse of the amount of physical activity and weight measurements, as well as height, and waist circumference.

Conclusions: The people in Mamre have a high probability of suffering a CVD event in the next 10 years. Age and gender are the primary contributors to the global CVD risk score. The findings suggest the possibility of developing a global CVD risk score based on easily measured CVD risk factors for use in developing countries with limited resources. (*Ethn Dis.* 2004;14:233–242.)

Key Words: Cardiovascular Disease Risk Score, Hypertension, Diabetes, Lipids, South Africa

Introduction

The South African population is undergoing a health transition, which is characterized by the co-existence of poverty-related diseases and emerging chronic diseases associated with industrialization and a Westernized lifestyle. In addition, high injury rates frequently associated with major political transitions are occurring in the population.[2–6] Despite these factors, life expectancy in South Africa increased during the late 1990s, as result of lower rates of child mortality, and increased adult life expectancy.[4,5] However, the rapid spread of HIV/AIDS in the country is having a devastating impact on its health profile and mortality patterns.[7] In developing countries such as South Africa, the demand for health services, stemming from the multiple burdens of diseases, far exceeds the available resources. Clearly, there is a vital need for cost-effective healthcare services, including health-promotion interventions. This is particularly important when providing interventions that target cardiovascular diseases (CVD) and their risk factors, as these chronic conditions consume a large part of South Africa's health budget.[3] Therefore, it is important that the healthcare services target those individuals at highest risk for developing CVD, to ensure that they receive appropriate treatment. Previous studies conducted in the country indicated that the risk factors for CVD are inadequately diagnosed and poorly treated.[8–12]

Traditionally, healthcare services have tended to deal with each CVD risk factor as a distinct entity unrelated to other risk factors. More recently, a number of clinical tools have been devised to analyze all risk factors in order to derive an estimate of the global risk of CVD.[13–15] These global risk scores allow for the identification of those patients who would benefit most from treatment. For patients with one or more know risk factors, Gaziano et al[13] have demonstrated that calculating the global CVD risk scores has a more cost-effective impact. They illustrated that basing treatment decisions on the levels of single CVD risk factors is less cost-effective than the global risk-assessment approach.

However, the use of these global risk-assessment tools require expensive biochemical tests necessary to identify lipid profiles and diabetic status. This is usually not possible in developing countries. For example, in South Africa's first demographic and health survey, con-

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ducted in 1998, it was impossible, both logistically and financially, to collect blood samples from the participants.[8,16] As a consequence, very little research exists on the global risk profile of the different South African population groups.[17,18] Cost-effective research requires the identification of easily measured CVD risk factors, which could replace those based on biochemical analyses.

A comprehensive survey was conducted in 1996 in the community of Mamre, some 55 km from the center of Cape Town. This study provides the opportunity to investigate CVD risk factors in detail. Mamre was founded as a Moravian mission station in 1808, and its residents are primarily descendants of both the Khoi people, who were liberated slaves from Indonesia and worked on the surrounding farms, and the European people who settled in the Cape Colony. Mamre is a stable community of approximately 6,000 people, most of whom have lived there for more than 80% of their lives. Under Apartheid legislation, these people were financially and politically discriminated against on the basis of their racial classification as colored, a unique South African group with Khoi, San, Malay, European, and African ancestry.

In the past, Mamre was considered semi-rural, with the majority of the population employed as laborers on surrounding farms. At present, there is a high rate of unemployment, and the majority of employed persons do more sedentary work in the neighboring towns. The community has also undergone a major environmental transition over the past 20 years, with the provision of tarred roads, electricity, piped water, and sanitation. The sociodemographic profile of Mamre is similar to that found in other colored working-class communities in Cape Town,[19] with the population pyramid resembling that of a developing community. The proportion of the population under the age of 15 is 34%, and 4.4% are over the age of 65 years. Mortality data from this community reflect a triple health burden with injuries, infections, and non-communicable diseases being the primary causes of death.[20]

The CVD risk profile of the colored community of the Cape Peninsula was first studied in 1982.[21–32] A comparison of the findings of the CVD risk profile of the Mamre community in 1996 with those recorded in 1982 will allow for assessment of CVD risk factor trends over that time period.

Since 1990, Mamre has been the site of a community-based, hypertension intervention and tobacco control program.[33] Extensive biochemical assessment was included in the CVD risk-factor survey, conducted at the end of a population-based intervention program. This comprehensive CVD risk-factor survey provides data that, for the first time, describe not only CVD risk factors, but also the global burden of CVD risk, and the lipid profiles of these South Africans. These findings also allow for an exploratory analysis to identify those risk factors that are easily measured, rather than depending on biochemical estimations. The association of these risk factors with the global CVD risk factor score can then be estimated, based on the traditional risk factors used in the Framingham global CVD risk calculations.

METHODS

In 1996, a random sample of 500 plots of land with houses was drawn from the total 1,079 plots with houses identified from maps of the area. All occupants of the selected houses, aged 15 years or older, were invited to participate. Households visited 3 times without success were classified as non-responders. Pregnant women and individuals who were bedridden were excluded.

Trained interviewers administered a questionnaire to collect details of sociodemographics, along with personal and family medical history. Participants were asked to quantify the amount of alcohol consumed during the week and on weekends, and were then defined as either regular or non-regular, and past or present, users of alcohol.

The Stanford Seven Day Physical Activity Recall was modified for use in this community, and administered by the interviewers.[34,35] The questionnaire was validated using a heart rate monitor as reference in people from similar background (R=0.35, P=.006, Keytel et al, unpublished data). The questionnaire has also been shown to yield valid results in many developing country settings. Participants were asked to recall their pattern of physical activity during each day of the preceding week, and to estimate the number of hours spent engaged in sleep, and in moderate, hard, and very hard physical activity during each day. Respondents were cued, using lists of examples of physical symptoms, such as a fast heart rate or sweating, which represented activities in each category.[34] The remaining time represented light activity. Each activity category was allocated a specific metabolic equivalent (MET), expressed as kcal/kg/hr, representing the average intensity of the activities within that category. Each leisure and occupational activity in hours/week was multiplied by the respective MET value to derive an estimate of total daily energy expenditure, expressed as kcal/kg/day. Prevalence of physical activity was quantified as the percentage of persons engaged in moderate-to-vigorous physical activity for 150 or more minutes per week (5 × 30 minutes of ac-

tivity at an intensity equal to or greater than 3 METS).[36]

Trained field workers measured the height and weight of participants, dressed in light clothing without shoes, using a *Seca*-model foot scale and a height measure. Waist circumference was measured to the nearest 0.1 cm, according to standardized methods at the narrowest point between the iliac crest and the lower costal border. However, if no obvious point of narrowing was perceived, the waist circumference was measured halfway between these 2 points. Body mass index (BMI) was calculated by dividing weight (kg) by height squared (m). Overweight was defined as BMI $\geq$25 kg/m^{2,} and obesity as $\geq$30 kg/m^2.

Blood pressure (BP) was recorded 3 times at 2-minute intervals using a mercury sphygmomanometer and an appropriately sized cuff attached to the right arm, with participants sitting for at least 5 minutes. The lowest readings were recorded. Hypertension, defined by earlier WHO criteria, was diagnosed if systolic BP (SBP) $\geq$160 mm Hg, diastolic BP (DBP) $\geq$95mm Hg, or if individuals were receiving treatment for hypertension.

A fasting venous blood sample for lipid determination was collected with minimal stasis. The blood was centrifuged within 6 hours to separate the plasma. The plasma was frozen at -20°C and sent to a central laboratory for analysis. The total cholesterol (TC) levels were measured by an enzymatic (cholesterol esterase and oxidase) spectrophotometric technique on the Beckman CX4 (Beckman Instruments Inc, Palo Alto, Calif). High-density lipoprotein cholesterol (HDL) was measured after precipitation of very-low-density lipoprotein (VLDL) and LDL by magnesium-dextran sulfate. Triglyceride (TG) levels were also measured by an enzymatic (lipase, glycerol kinase, glycerophosphate oxidase, and horseradish peroxidase) spectrophotometric technique on the Beckman CX4. Low-density lipoprotein cholesterol (LDL) was calculated using the Friedewald formula [TC $-$ (HDL + TG/2.2)]. This formula was applied if the plasma TG concentration did not exceed 4.5 mmol/L, and it was assumed that chylomicronemia was insignificant. No participants were found to have plasma TG levels that exceeded 4.5 mmol/L.

The frozen plasma was thawed and the lipoproteins were pre-stained with Sudan Black in ethylene glycol. The samples were loaded into wells in a non-denaturing polyacrylamide minigel with a gradient of 2–8 g/dL, which separates several species of LDL. The apparatus was placed in a refrigerator and run overnight (18 hours). The gels were inspected and the bands of LDL were classified in a blinded fashion. Markers of the usual variation of LDL were used to standardize findings from the different gels.

After an overnight fast, an oral glucose tolerance test was performed, with participants ingesting 75 g glucose in 250 mL of water. Fasting blood samples were drawn, and again at 2 hours post-glucose, and were analyzed using standard laboratory techniques. Diabetes and impaired glucose tolerance (IGT) were defined according to the 1999 WHO criteria.[37]

Each participant's risk for experiencing a CVD event (defined as angina, fatal and non-fatal stroke, and fatal and non-fatal myocardial infarction, or cardiac death) during the 10 years following the study was calculated using formulas from the Framingham Study's data.[1] The estimation of risk for each participant was based on the use of a logistic function with age, SBP, and total cholesterol level used as continuous variables, and smoking and diabetes status used as dichotomous variables. Mean HDL levels from the study were used in the risk equation. The estimates assume no prior treatment, and the absence of any prior CVD. Means and standard deviations (SD) were calculated for the continuous variables, and frequencies were calculated for reporting of the CVD risk profile by age and gender. The prevalence rates for the total sample were age-standardized against the colored population of South Africa, as identified by the 1996 census,[38] and a hypothetical world population.[39]

Both Backward Elimination (BE) and Best Subset (BS) procedures were used to select those risk factors that are easy to measure, and that best predicted the variation in the response variable "global CVD risk" in a linear regression model. The former procedure, BE, begins with an equation containing all predictor variables, and then removes unneeded predictors, one at a time. On the other hand, the BS procedure chooses the best K variables subset based on both R^2 and the smallest Cp value is taken to be the best. In these analyses, both BE and BS approaches chose the same subset of 7 variables as the best possible subset.

The Ethics Committee of the University of Cape Town approved the protocol of the study. All participants gave written consent to participate in the study, after the significance of the study and all the procedures were explained to them.

RESULTS

There were 974 participants from a potential sample of 1500 (response rate was 65%); 428 were men (44%), with 546 women (56%). Compared to the total population's age distribution, participants aged >45 years were over-represented by 11% in the sample, while those aged 15–29 years were under-represented by 10%.

Table 1 exhibits the lipid profile of the community according to age and gender. The mean total cholesterol level for both men and women was 5.1 (SD 0.5) mmol/L, and the mean HDL level for men and women was 1.4 (SD 0.2) mmol/L and 1.3 (SD 0.2) mmol/L, respectively. This high level of HDL contributed to a high mean HDL/TC ratio of 27.7% for men, and 26.6% for wom-

Table 1. Lipid profile of the Mamre community

	Men									Women								
Number	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community
Number	128	93	82	69	32	26	430			140	112	105	90	63	36	546	976	
Total cholesterol (TC) mean (SD) in mmol/L	4.5 (0.9)	5.2 (1.2)	5.7 (1.1)	5.6 (1.1)	5.5 (1.1)	5.4 (1.1)	5.2 (1.2)	5.1 (0.5)	5.0 (0.5)	4.5 (0.8)	4.7 (0.8)	5.3 (1.0)	6.0 (1.1)	6.5 (1.3)	6.3 (1.0)	5.3 (1.2)	5.1 (0.5)	5.0 (0.5)
% With TC ≥5 mmol/L	25.0	55.9	72.0	71.0	62.5	57.7	52.8	49.4	47.2	25.2	35.7	63.8	77.8	88.9	91.7	55.2	49.1	46.2
HDL cholesterol mean (SD) in mmol/L	1.4 (0.4)	1.3 (0.4)	1.5 (0.6)	1.3 (0.6)	1.2 (0.4)	1.3 (0.4)	1.3 (0.5)	1.4 (0.2)	1.4 (0.2)	1.3 (0.3)	1.2 (0.3)	1.3 (0.5)	1.4 (0.4)	1.3 (0.3)	1.3 (0.4)	1.3 (0.4)	1.3 (0.2)	1.3 (0.2)
% With HDL ≤0.9 mmol/L	7.0	12.9	18.3	26.1	25.0	23.1	15.8	14.3	13.0	11.5	20.5	10.5	12.2	14.3	13.9	13.8	13.8	13.8
Low density lipoprotein (LDL) mean (SD) in mmol/L	2.7 (0.8)	3.3 (1.2)	3.6 (1.1)	3.6 (1.1)	3.8 (1.1)	3.6 (1.0)	3.3 (1.1)	3.2 (0.5)	3.1 (0.5)	2.8 (0.7)	3.1 (0.8)	3.5 (1.0)	4.1 (1.1)	4.6 (1.1)	4.4 (1.0)	3.5 (1.1)	3.4 (0.5)	3.3 (0.5)
% With LDL ≤4.2 mmol/L	96.1	90.3	73.2	79.7	75.0	73.1	84.9	86.9	88.2	97.1	91.1	78.1	56.7	41.3	47.2	75.8	80.7	83.8
HDL/TC ratio (%)	30.8	26.9	26.4	24.2	22.8	24.1	27.1	27.7	28.1	30.2	26.7	25.4	23.8	20.5	21.3	25.8	26.6	26.9
% With HDL/TC ratio ≤25% for women										26.6	44.6	52.4	63.3	82.5	80.6	51.4	46.6	44.4
≤20% for men	10.2	21.5	32.9	40.6	37.5	46.2	26.1	23.3	21.1	—	—	—	—	—	—	—	—	—
% With small dense LDL particles	13.6	34.4	36.3	40.3	21.4	34.6	28.6	27.0	26.2	6.6	12.6	16.4	31.1	33.3	16.7	17.6	15.6	14.2
% With intermediate LDL particles	29.6	37.8	32.5	37.3	35.7	30.8	33.7	33.4	33.3	27.7	34.2	42.3	36.7	42.9	52.8	36.8	35.2	35.0
% With large LDL particles	56.8	27.8	31.3	22.4	42.9	34.6	37.7	39.6	40.6	65.7	53.2	41.4	32.2	23.8	30.6	45.7	49.3	50.9
Mean fasting triglycerides (SD) in mmol/L	0.9 (0.5)	1.3 (1.0)	1.4 (1.0)	1.6 (1.0)	1.2 (0.6)	1.1 (0.6)	1.2 (0.9)	1.2 (0.4)	1.2 (0.4)	0.7 (0.4)	0.8 (0.4)	1.0 (0.4)	1.2 (0.6)	1.3 (0.6)	1.2 (0.4)	1.0 (0.5)	0.9 (0.2)	0.9 (0.2)
% With triglycerides ≥2.3 mmol/L	2.3	11.8	14.6	24.6	6.3	7.7	10.9	10.0	9.2	0.0	1.8	1.9	5.6	7.9	2.3	2.8	(0.1)	1.8

en. More than 80% of both men and women had a LDL level less than 4.2 mmol/L, which is the cut point suggested by the Lipid and Atherosclerosis Society of South Africa to identify those at risk for CVD.[24] Of the men, 27% had small-dense LDL particles, while this was the case in only 15.6% of women. Older women, but not men, had a higher proportion of small-dense LDL particles. For men, the proportion of small-dense LDL particles reached a plateau by the age of 25. About 40% of men and 49% of women had large LDL particles. An association between the lipid variables and the global CVD risk score, identified by means of univariate analyses, found that the HDL level was not associated with the global CVD risk score (P=.1294). However, the serum triglyceride level was associated with the global risk score (Spearman correlation coefficient=0.4646, P<.0001), and the LDL particle size was inversely associated (Spearman correlation coefficient=−0,29464, P<.0001) with the global CVD risk score.

The patterns of the other major CVD risk factors and the global CVD risk score, calculated from Framingham based formulas, are shown in Table 2. More men than women had hypertension, with the prevalence rate increasing markedly in the older age groups. Although smoking was more common in men than women, the rate in women was high, up to the age of 54 years. However, women who smoked used fewer cigarettes per day than men. Diabetes and glucose intolerance was common in the older participants.

The scatter plot in Fig.1 illustrates the dominant influence that age had on increasing the global CVD risk, and the higher level of this risk in men, compared to women. Most people younger than 35 years had less than a 10% risk of developing CVD in the next 10 years, while for people aged 55 years and older, more than 90% of men, and more than 60% of women, had a 20% or greater risk of developing CVD in the next 10 years.

The pattern of the easily measured CVD risk factors in the Mamre community is shown in Table 3. The anthropometry of the Mamre women revealed obesity as very common, with 28.4% of them having a BMI of 30 or greater. In contrast, only 8.6% of men were obese. The level of physical activity that could provide protection against developing CVD was very low in the Mamre community. Women exercised much less than men, and the older participants were the least active group in Mamre. Only about 50% of young men, aged 15–25 years, and 22% of young women, engaged in protective amounts of physical activity.

Although 10% of the participants reported a positive family history of ischemic heart disease (IHD), very few participants reported a personal history of IHD. Self-reports of hypertension and diabetes were frequent. However, further investigation revealed that, of those who reported having hypertension or diabetes, only 50.7% and 93.2%, respectively, were found to actually have these 2 conditions. Of those who were diagnosed as having hypertension or diabetes, 55.2% and 59.4%, respectively, reported no medical history of these conditions.

Table 4 displays the results of the linear regression analyses, showing the easily measurable CVD risk factors that were associated with the global CVD risk score. Seven easily measured variables were identified, which accounted for 40.3% of the variation of the global CVD risk score. These variables are: a self-reported history of angina; a self-reported history of hypertension; a self-reported history of diabetes; the inverse of physical activity energy expenditure (in mMETS/day); height in meters; weight in kg and waist circumference.

The variables that were considered for the variation of the global CVD risk score, but not found to be associated are: a self-reported family history of IHD, stroke, or diabetes; a self-reported personal history of stroke, hypercholesterolemia, or obesity, and BMI.

DISCUSSION

During the second half of the 20th century, the standard of living for the colored community in South Africa improved significantly. This has been associated with the signs of a health transition, which include an increasingly atherogenic lifestyle, and the emergence of CVD risk factors, which predisposes individuals to CVD morbidity and mortality, after an incubation period of many decades. This community is well ahead of the Black African community in the health transition in South Africa.

These data on the CVD risk profile of the adult community of Mamre, about 50 km from Cape Town, were collected in one of the few studies among South Africa's colored community in the country. The CVD risk profile of the colored community of the Cape Peninsula was first recorded in 1982.[21] The similar sociodemographic profiles of the community of Mamre, and the colored community of Cape Town, as well as the fact that large colored suburbs in Cape Town are only 4 km from Mamre, provides an opportunity to examine and compare trends in CVD risk factors from the Mamre study in 1996, and the 1982 data from Cape Town's colored community.

The overall lipid profile of the Mamre participants was not markedly atherogenic, as evidenced by the small proportion of participants exhibiting LDL levels above 4.2 mmol/L, small dense LDL particles, or protective HDL/TC ratios. The lipid profile found in Mamre is similar to that recorded in the colored community of the Cape Peninsula 14 years earlier.[31] This finding suggests that the high level of HDL found in this population is sufficient to maintain low LDL levels by means of the reverse cholesterol transport system in this group of people who have been undergoing the health transition.

Smoking rates in Mamre were higher than those in the colored community in the rest of the country, with 63% of

Table 2. Additional CVD-risk factors included in the Framingham global CVD-risk formulae of the Mamre community

	Men *N* = 430									Women *N* = 546								
	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community (Census 1996)	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community (Census 1996)
Number	128	93	82	69	32	26	430			140	112	105	90	63	36	546		
Systolic BP (SD)	120.5 (12.4)	126.2 (17.7)	133.3 (19.5)	145.3 (26.3)	151.6 (20.5)	167.4 (31.0)	133.3 (23.6)	130.3 (9.5)	127.9 (9.1)	112.2 (11.4)	117.8 (15.5)	126.8 (21.6)	131.5 (23.0)	155.2 (29.2)	155.1 (34.3)	127.2 (25.5)	123.6 (9.9)	121.7 (9.7)
Diastolic BP mean in mm Hg (SD)	67.8 (10.9)	79.0 (12.7)	82.7 (10.4)	88.8 (14.6)	85.9 (12.6)	88.2 (13.8)	79.0 (14.5)	77.3 (6.3)	76.1 (6.4)	65.5 (9.6)	71.4 (10.7)	7.3 (11.9)	78.9 (12.1)	83.1 (13.7)	77.7 (14.3)	74.0 (13.0)	72.6 (5.4)	72.1 (5.6)
% With hypertension ((HT) (BP) ≥160/95 mm Hg + Rx)	1.6	10.8	14.8	42.0	46.9	61.5	19.6	15.4	11.9	0.7	2.7	12.4	13.5	39.7	44.4	12.8	9.5	7.7
% With total HT (BP ≥140/90 mm Hg + Rx)	7.0	19.4	30.5	58.0	78.1	76.9	31.9	26.3	21.7	3.6	9.8	21.0	30.0	66.7	58.3	23.4	18.4	15.6
% Who smoke cigarettes	50.0	66.7	76.8	71.0	68.8	56.0	63.9	62.6	61.9	42.9	49.1	50.5	35.6	17.5	11.1	39.4	41.6	43.9
Number of cigarettes (mean) (SD) smoked by smokers	8.2 (5.1)	10.5 (6.9)	12.0 (6.5)	12.0 (7.8)	17.4 (17.7)	29.9 (38.4)	12.1 (12.4)	11.2 (4.4)	10.6 (3.8)	4.4 (2.4)	7.7 (4.1)	8.3 (5.4)	8.4 (4.4)	8.6 (5.0)	5.8 (4.4)	7.1 (4.5)	6.8 (1.9)	6.8 (2.15)
% With diabetes (fasting blood glucose ≥7.0 mmol/L and/or 2-hour glucose level ≥11.1 mmol/L)	0.8	4.3	9.8	15.9	18.8	30.8	8.8	7.0	5.5	0.0	0.9	4.8	14.4	38.1	30.6	9.9	7.0	5.0
% With impaired IG/IFG*	5.5	7.5	13.4	17.4	15.6	7.7	10.2	9.5	8.8	2.2	1.8	7.6	14.4	7.9	5.6	6.1	5.4	4.9
Mean ≤ fasting glucose level (SD)	5.4 (0.6)	5.8 (1.6)	6.1 (2.1)	6.3 (2.2)	6.2 (1.9)	7.0 (3.7)	5.9 (1.9)	5.8 (0.7)	5.7 (0.7)	5.2 (0.4)	5.4 (1.8)	5.7 (1.3)	6.6 (2.8)	8.3 (4.3)	7.0 (3.5)	6.0 (2.5)	5.8 (0.9)	5.7 (0.9)
Mean global CVD risk (SD)	0.23 (0.4)	2.3 (3.2)	8.5 (5.6)	18.2 (9.8)	31.0 (9.5)	44.9 (11.1)	10.1 (14.0)	7.4 (5.2)	5.2 (4.3)	0.13 (0.2)	1.2 (1.2)	5.0 (4.9)	10.7 (8.3)	24.5 (11.5)	28.8 (13.5)	7.7 (11.4)	5.6 (4.2)	4.2 (3.6)
Global ten-year CVD risk <10%	100.0	97.9	74.4	23.2	3.1	0.0	69.1	77.1	84.5	100.0	100.0	91.4	63.3	6.4	11.1	75.6	83.2	88.8
Global ten-year CVD risk ≥10%–19.9%	0.0	1.1	18.3	42.0	3.1	0.0	19.5	15.9	11.9	0.0	0.0	6.7	24.4	33.3	19.4	17.3	12.3	8.5
Global ten-year CVD risk ≥20%	0.0	1.1	7.3	34.8	93.8	100.0	11.4	7.0	3.6	0.0	0.0	1.9	12.2	60.3	69.4	7.2	4.5	2.7

* Fasting sugar 6.1–6.9 mmol/L and/or 2-hour glucose level ≥7.8–11.0 mmol/L.

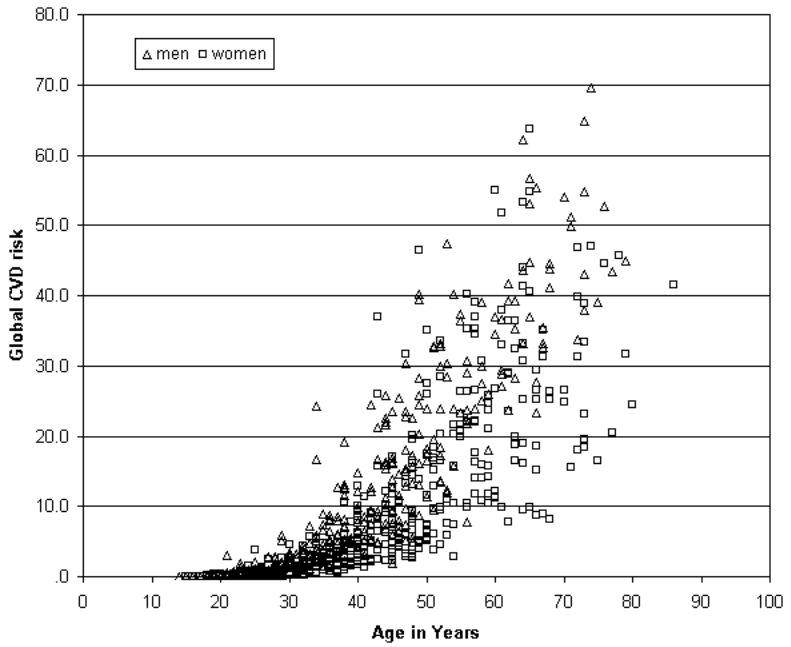

Fig 1. Global CVD risk score for men and women in relation to their age

men and 41% of women smoking in 1996, compared to 1998 national figures of 55% and 36%, respectively.[16] However, these rates were lower than those found in the Mamre baseline survey in 1989. This decrease reflects a successful community-based smoking cessation program.[40] The higher smoking rates emphasize the need for effective enforcement of the tobacco-control legislation introduced in South Africa in 1999, and for increasing the taxation on tobacco products.

There were no differences between the levels of SBP and DBP as measured in 1982 and 1996.[32] However, the mean age-specific levels of SBP and DBP were higher in both men and women in Mamre, compared to the levels in the same age groups recorded in the national DHS in 1998.[8] These differences can possibly be explained by the high levels of factors predisposing to the development of hypertension in Mamre. Obesity with associated low levels of physical activity, and high rates of alcohol consumption, were the predominant associated risk factors for hypertension, for women and men, respectively (Table 3). Temple et al pointed out that the developments in Mamre in the years before the survey resulted in many changes, contributing to the present situation, in which the community is less active and consumes more energy-dense food.[41] High levels of risk factors for hypertension also lead to an increased risk for developing diabetes, and indeed, diabetes was found to be common (Table 2).[42]

The data on the global CVD risk score of the Mamre community are the first published for any South African community. The score showed the global risk of developing a CVD event over the next 10 years to be relatively low, with a mean score of 7.4% and 5.6% for men and women, respectively. However, the overall risk score increased substantially with increasing age, to the extent that men older than 45 years, and women older than 55 years, had a global risk that was higher than 20% among 35% or more of the participants. The National Cholesterol Education Program of the NIH in the United States recommends that medication be initiated at this level of risk. If this suggestion were followed, a substantial proportion of older people would require medication for dyslipidemia, at a cost that would be prohibitive for South Africa.[11,43]

The linear regression model identified 7 easily measured variables independently associated with the global CVD risk score in the people of Mamre, and which explain 40.3% of the variation between the scores. Asking for a simple medical history, administering a questionnaire on the physical activity pattern, and measuring height, weight, and waist circumference, are the variables that can identify these risk factors. In the univariate analyses, a significant positive association was found between the global CVD risk score and weight, waist circumference, and BMI, while a significant negative association was found for height. When the regression analysis was performed, the best predictive model excluded BMI, and suggested a negative association with weight, as shown in Table 4. This strategy for measuring CVD risk proved useful in the study population, and may represent an ideal compromise between measuring CVD risk with acceptable accuracy, while avoiding expensive laboratory tests in studies conducted in communities with limited resources.

Previously conducted large cohort studies could be re-examined to help identify easily measurable risk factors in settings with scarce resources. Data collected for this new global CVD risk assessment formula could be included with the current variables in the global risk formulas. Cardiovascular disease (CVD) events can then be assessed by replacing assessment of risk factors that require laboratory tests, such as diabetes and total cholesterol, with analysis of the easily measured risk factors identified by the logistic regression, along with the risk factors already in the formula, they are age, gender, smoking status, and SBP. Countries with scarce resources will benefit from this assessment method that also tests the generalizabil-

Table 3. Easily measured CVD risk factors in the Mamre community

	Men *N* = 430									Women *N* = 546								
	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community (Census 1996)	15–24	25–34	35–44	45–54	55–64	≥65	Crude Rate	Age Standardized World	Age Standardized Colored Community (Census 1996)
Mean height (SD) in meters	1.71 (0.07)	1.7 (0.07)	1.69 (0.06)	1.7 (0.07)	1.69 (0.07)	1.66 (0.06)	1.7 (0.07)	1.7 (0.03)	1.7 (0.03)	1.59 (0.06)	1.6 (0.06)	1.58 (0.06)	1.59 (0.06)	1.56 (0.06)	1.53 (0.07)	1.58 (0.06)	1.59 (0.03)	1.59 (0.03)
Mean weight (SD) in kg	63.6 (13.7)	69.0 (13.2)	71.3 (15.4)	73.2 (18.4)	71.7 (14.2)	65.9 (11.6)	68.5 (15.1)	68.0 (6.5)	67.6 (6.7)	5.0 (13.6)	71.0 (20.0)	69.5 (14.3)	75.7 (17.2)	73.6 (16.0)	68.4 (17.5)	68.0 (17.6)	66.7 (7.6)	66.3 (8.0)
Mean BMI (SD) (weight/height)^2	21.7 (4.3)	23.8 (4.1)	24.8 (4.7)	25.4 (6.0)	25.1 (5.2)	24.0 (4.0)	23.7 (4.9)	23.5 (2.1)	23.3 (2.2)	22.6 (4.9)	27.8 (7.1)	27.8 (5.8)	30.2 (6.6)	30.4 (6.5)	28.9 (6.8)	27.2 (6.8)	26.5 (2.9)	26.3 (3.0)
% Obese BMI ≥30	5.5	7.5	14.6	14.5	12.9	0.0	9.3	8.9	8.6	10.0	32.1	31.4	47.8	50.8	41.7	31.7	28.4	26.8
% Overweight BMI ≥25–≤30	10.2	28.0	28.1	31.9	38.7	38.5	24.7	22.5	21.2	12.9	25.0	33.3	26.7	28.6	25.0	24.1	22.9	23.1
% Normal weight BMI ≥18.5–≤25	64.1	58.1	51.2	43.5	38.7	50.0	54.3	56.0	57.4	57.9	38.4	31.4	25.6	20.6	27.8	37.2	40.3	41.2
Mean waist circumference (SD) in cm	74.7 (9.9)	81.5 (9.5)	85.6 (11.4)	89.8 (13.1)	91.0 (12.2)	89.3 (12.5)	82.7 (12.5)	81.4 (5.4)	80.4 (5.4)	70.8 (9.7)	82.0 (14.2)	84.0 (10.7)	90.5 (14.0)	93.2 (11.9)	91.5 (12.5)	82.8 (14.5)	80.9 (6.2)	80.1 (6.4)
% With waist ≥102 cm for men ≥88 cm for women	2.3	1.1	8.5	14.5	12.5	11.5	6.5	5.5	4.5	7.1	26.8	33.3	51.1	71.4	61.1	34.8	29.6	26.9
Mean waist/hip ratio (SD)	0.8 (0.05)	0.9 (0.05)	0.9 (0.06)	0.9 (10.07)	0.9 (0.06)	0.9 (0.09)	0.9 (0.08)	0.9 (0.03)	0.9 (0.03)	0.7 (0.05)	0.8 (0.06)	0.8 (0.07)	0.8 (0.06)	0.9 (0.07)	0.9 (0.06)	0.8 (0.07)	0.8 (0.03)	0.8 (0.03)
% With waist/hip ratio ≥1.0 for mean and ≥0.85 for women	—	—	4.9	15.9	6.3	26.9	5.58	4.1	2.8	2.9	9.8	17.1	32.2	55.6	44.4	20.7	16.5	13.9
% With ≤150 min/wk total	39.8	39.8	57.3	55.1	65.6	76.0	49.7	49.7	49.7	65.0	77.7	82.8	82.2	87.3	91.7	78.2	78.2	78.2
% With ≤150 min/wk leisure time moderate-vigorous activity	54.7	62.4	76.8	79.7	87.5	96.0	69.5	69.5	69.5	67.9	83.9	90.5	96.7	90.5	100.0	85.0	85.0	85.0
% Who reported a family history of CVD	3.9	12.9	15.9	11.6	15.6	8.0	10.5	9.8	9.5	2.9	12.5	11.4	22.2	19.1	11.1	12.1	10.8	10.1
% With an early family history of CVD (≤50 years old)	20.0	33.3	46.2	12.5	20.0	0.0	28.9	29.8	31.6	50.0	42.9	25.0	20.0	8.3	25.0	25.8	28.3	30.8
% Who reported medical history of IHD	0.0	1.1	2.4	0.0	9.4	7.7	1.9	1.4	1.1	0.0	0.0	1.0	0.0	7.9	0.0	1.5	0.8	0.6
% Who reported a personal history of hypertension	1.6	4.3	13.4	34.8	18.8	38.5	13.3	10.7	8.2	1.4	14.3	16.2	26.7	60.3	38.9	20.3	16.2	13.9
% Who reported a personal history of diabetes	0.0	2.2	2.4	7.3	9.4	11.5	3.5	2.7	2.0	0.0	0.9	1.9	7.8	23.8	11.1	5.3	3.8	2.7
% Who use alcohol	53.1	78.5	70.7	62.3	50.0	44.0	62.7	63.1	64.0	33.6	23.2	36.2	23.3	12.7	8.3	26.2	27.8	29.2

Table 4. Linear regression model identifying easily measurable risk factors associated with the global CVD risk score (9) in adults aged 15 years and older of the Mamre community

	$R^2 = 0.4043$		
Variable	Estimate	Standard Error	*P* Value
Intercept	−44.6639	6.80858	.0001
A self-reported history of angina	7.9163	2.7538	.0041
Patients aware of suffering of hypertension	7.0076	0.9219	<.0001
Patients aware of suffering of diabetes	11.3643	1.6098	<.0001
Energy expenditure (kilojoules) during exercise	−0.0175	0.0048	.0003
Height in meter	14.0312	3.9059	.0003
Weight in kg	−0.5731	0.0428	<.0001
Waist circumference in cm	0.8317	0.0528	<.0001

ity of identifying high CVD risk in communities. This method has the potential to make a major contribution to the rational allocation of limited resources, helping to ensure cost-effective management of those patients with the highest risk of developing CVD.

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