Nutritional variation and cardiovascular risk factors in Tanzania — rural-urban difference

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Objective. To assess the relationship between dietary factors and cardiovascular (CVD) risk factors in middle-aged men and women, in urban, rural and pastoral settings in Tanzania.

Design. Cross-sectional epidemiological study designed according to the protocol of the World Health Organisation (WHO) Cardiovascular Diseases and Alimentary Comparison (CARDIAC) study.

Setting. Three centres in Tanzania, namely Dar es Salaam (urban), Handeni (rural) and Monduli (pastoral population).

Subjects. The subjects, aged 47 - 57 years, were recruited randomly from administrative lists available from each centre.

Outcome measures. Blood pressure (BP) was measured using a centrally calibrated automatic BPmachine (Khi machine). Dietary history of the participants was obtained using a standard questionnaire designed on the basis of a seven-day recall system. Height, weight, serum total cholesterol (TC) and high-density lipoprotein cholesterol (HDLC), haemoglobin A_{1c}, sodium, potassium and magnesium were measured.

Results. The prevalence of hypertension (BP ≥ 140/90 mmHg or antihypertensive drug use), obesity (body mass index (BMI) ≥ 30 kg/m^2) and hypercholesterolaemia (TC > 5.2 mmol/l) were lowest in the rural area. Consumption of green vegetables, milk, coconut milk, meat, and fish varied significantly between the three areas. Important determinants for BPamong men were BMI ($p < 0.001$), and salt intake ($p < 0.05$). Among women, TC ($p < 0.05$), age ($p < 0.05$), BMI ($p < 0.001$) and coconut milk consumption ($p < 0.001$) were important BP determinants. Salt intake was positively associated with systolic BP (SBP) and diastolic BP (DBP) in men but not among women (both SBP and DBP $p < 0.05$ respectively). Dietary determinants of serum TC were meat, fish and green vegetable consumption.

Conclusion. Differences in dietary habits contributed significantly to the urban-rural-pastoral variations in CVD risk pattern in Tanzania.

S Afr Med J 2003; **93:** 295-299.

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Although enormous challenges persist in the control of infections in sub-Saharan Africa, non-communicable diseases also constitute an important threat to the health of adult Africans.[1] Rapid increase in the aging population, changing lifestyles and nutrition transition affect the prevalence of cardiovascular disease (CVD) in developing countries.[2] More than a decade ago, the prevalence of hypertension in Tanzania was found to be higher in urban than in rural populations, and hypertension was uncommon in the pastoral population of the Masai.[3] Several other surveys conducted in Tanzania have shown a high prevalence of hypertension, obesity and stroke in the urban area of Dar es Salaam.[4-5] In addition, other studies from Africa have observed higher prevalence rates of hypertension in urban areas.[6,7] Environmental factors, especially dietary ones, strongly influence the risk factors for CVD. High salt intake was found to be an important dietary factor in the causation of hypertension in Tanzania.[8] One previous study conducted in South Africa demonstrated an association between urban living and percentage of energy supplied by fat.[9] Likewise, Mazengo *et al.*[10] found that the intake of high-energy foods such as coconut oil/milk and saturated fatty acid levels were higher in urban than in rural areas.

In order to examine the relationship between dietary factors and the risk factors for CVD, this survey was carried out in three areas in Tanzania, representing urban, rural, and pastoral populations.

Methods

The main objective of the World Health Organisation (WHO) Cardiovascular Diseases and Alimentary Comparison (CARDIAC) study[11] conducted in 1987 was to assess the relationships between biological markers of dietary factors and blood pressure (BP) and age-adjusted mortality for major cardiovascular diseases (ischaemic heart disease and stroke), using a worldwide population database. The MONALISA (MONeo ALImentation SAnae) study ('Health for All') was designed to monitor past trends in CVD risk factors of populations earlier included in the CARDIAC study, by employing a similar protocol to the latter.[11]

Selection of the three study centres was based on the fact that they represent areas in Tanzania with high, low and the lowest CVD risk factor incidences. The CARDIAC study protocol recommended that in countries with marked differences in CVD risk factor incidences, those populations with 'high' and those with 'low' CVD risk factor incidences be taken as appropriate representative samples for that country. The population estimates for the three centres based on the 1988 census in Tanzania were Dar-Temeke 405 753, Handeni 251 855 and Monduli 109 292 people.

Participants were recruited from administrative lists of all men and women above the age of 30 years. Invitation letters were sent to approximately 100 men and 100 women aged 47 - 57 years, selected randomly from the lists of names and ages for each of the three centres. The CARDIAC study[11] protocol used a narrow age limit because the importance of prevention of the onset of CVD through lifestyle modifications is most important in this middle-aged group.

In order to eliminate observer bias, BP was measured using a centrally calibrated automatic BP machine (Khi machine).[12] BP was taken after the participant had been seated for about 5 - 10 minutes. The average of the three BP readings was used in this analysis.

Twenty-four-hour urine was collected using urine bags (U-container N, Ono Medical Company, Osaka, Japan). Subjects who failed to complete 24-hour urine collection were excluded from further salt intake analysis. The criteria for a complete 24-hour urine collection were defined as creatinine coefficients (creatinine (mg / day) / body weight (kg)) of 14.4 - 33.6 in men and 10.8 - 25.2 in women.[11] Blood samples were taken after fasting for at least 10 - 14 hours. All collected urine and blood samples were frozen at –20°C before analysis.

Various biological markers of diet from urine (sodium, potassium, sodium / potassium ratio, magnesium, urea nitrogen) were analysed. Blood analysis included serum total cholesterol (TC), high-density lipoprotein cholesterol (HDLC) and haemoglobin A_{1c} (HbA_{1c}). All laboratory measurements were conducted centrally at the WHO Collaborating Centre for Research on Primary Prevention of Cardiovascular Diseases, Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan. Standardised biological methods were used to analyse TC and HDLC (enzymatic methods, Kit determiner TC 555, Kyowa Medics, Tokyo); sodium, potassium, magnesium, and urea nitrogen (atomic absorption, z-8000 Hitachi, Tokyo); and HbA_{1c} (high-performance liquid chromatography, HLC-723Ghb, Toyosoda, Tokyo). Details of these analytical methods were described in the CARDIAC study protocol.[11]

In order to obtain dietary histories of the participants, a questionnaire was used designed on the basis of a 7-day recall system. In summary, participants were asked to state the frequency of intake of each of the selected food types and beverages within 1 week from the time an interview was conducted. The intake of milk and fermented milk was quantified in millilitres per day. It was estimated that a glass (commonly available in the study areas) was approximately 200 ml, and where there was the highest consumption of milk per day the amount was quantified using a 1-litre bottle.

The parameters were categorised as follows: BP was either normal (< 140 / 90 mmHg), or hypertensive (≥ 140 / 90 mmHg), thus including borderline cases and respondents on antihypertensive therapy.[13] Body mass index (BMI) (weight (kg) divided by the square of height (m^2) ≥ 30 kg / m^2) was classified as obese for men and women.[14] Serum TC was either high (≥ 5.2 mmol / l) or normal (< 5.2 mmol / l) according to a previous study conducted in Tanzania.[15] Urinary sodium / potassium ratio (urinary Na / K) > 3 was defined as high, and ≤ 3 as normal.[11] Frequency of food intake was coded as either ≥ 3 days / week or < 3 days / week. Subjects with an HbA_{1c} of ≥ 7.0% were regarded as having longstanding hyperglycaemia.[16]

Statistical analysis

Data were analysed using the Stat View 5 programme for microcomputers, SAS Institute Inc.[17] Averages were presented as means ± standard deviation (SD) for each centre and were compared using analysis of variance. Prevalence was calculated by contingency table analysis using the χ^2 test. Correlations between continuous variables were evaluated using the correlation coefficient (*r*). The influences of different dietary factors and BMI on systolic blood pressure (SBP), diastolic blood pressure (DBP) and serum TC were evaluated using multiple regression analysis after adjusting for age. Separate analyses were performed for each gender and area.

Results

In total, 445 people are included in this analysis, 160 from Dar es Salaam (urban) (81 men and 79 women), 184 from Handeni (rural) (93 men, 91 women) and 101 from Monduli (pastoral) (40 men, 61 women). The mean age for men was 51.6 ± 3.2 years and for women 51.8 ± 3.4 years. As shown in Table I, for both men and women, the SBP and DBP were higher in the urban area than in the rural and pastoral populations (all $p < 0.001$). In addition, women from the rural area had higher mean BPlevels than women from the pastoral population (SBP $p < 0.0001$, DBP $p < 0.05$). Likewise, BMI was higher in the urban area in both genders ($p < 0.0001$) and higher among women in the rural area than in the pastoral population ($p < 0.001$). Mean serum TC levels were lower in the rural area for both genders (all $p < 0.0001$). In both men and women, the mean HDLC levels were significantly lower in participants from the rural area (men $p < 0.05$, women $p < 0.0001$, respectively). The mean HbA1c per cent was higher among men from the pastoral population than from the rural area ($p < 0.05$) and significantly higher among women in the pastoral and urban populations than in the rural population (pastoral $p < 0.001$, urban $p < 0.05$). The 24-hour urine characteristics of the population (results not shown) indicated higher mean sodium chloride excretion and mean sodium / potassium ratio among urban dwellers in both genders (all $p < 0.05$). Urinary magnesium excretion among men was significantly higher in the rural ($p < 0.05$) and pastoral populations ($p < 0.001$) than in the urban area. BMI ($p < 0.0001$) and TC ($p < 0.001$) correlated positively with BP in both genders, while sodium /potassium ratio ($p < 0.05$) correlated directly with BP among men only (results not shown).

Table II shows the pattern of food consumption in number of days per week. The frequency of consumption of green vegetables was significantly lower in the pastoral population in both genders ($p < 0.0001$). The use of coconut milk for food seasoning was highest in the urban area for both men and women (all $p < 0.0001$, respectively). Daily protein consumption in the form of whole milk was significantly higher among the pastoral population than the other two populations for both genders (all $p < 0.0001$, respectively). The consumption of fish in days / week was significantly higher for each gender in both urban and rural populations compared with the pastoral population where fish is unpopular. Men and women from the urban area consumed meat more frequently than participants from the rural population ($p < 0.05$). Meat consumption ($p < 0.05$), fish intake ($p < 0.05$) and coconut milk consumption ($p < 0.05$) correlated directly with BPamong women, while only meat correlated with BPamong male subjects.

Age-adjusted multiple regression analysis (results not shown) indicated that age ($p < 0.05$), BMI ($p < 0.001$), TC ($p < 0.05$) and coconut milk consumption ($p < 0.001$) were important BPdeterminants among women. Sodium / potassium ratio ($p < 0.05$) and BMI ($p < 0.001$) were important

Table I. Distribution of cardiovascular risk factors by gender and area (mean ± SD)*

	Area			Significance		
Parameters	Rural (Handeni)	Pastoral (Monduli)	Urban (Dar es Salaam)	Rural v. pastoral	Pastoral v. urban	Urban v. rural
Men / women (*N*)	93 / 91	40 / 61	81 / 79			
SBP(mm Hg)						
Men	122.2 ± 18.3	116.8 ± 16.7	140.4 ± 24.8	0.3997	< 0.0001	< 0.0001
Women	128.3 ± 23.2	111.5 ± 19.1	141.3 ± 27.5	0.0002	< 0.0001	0.0003
DBP(mm Hg)						
Men	69.1 ± 10.2	68.9 ± 13.0	79.7 ± 16.6	0.9972	0.0003	< 0.0001
Women	74.6 ± 12.9	67.4 ± 14.9	81.2 ± 21.4	0.0474	< 0.0001	0.0377
BMI (kg / m^2)						
Men	21.1 ± 2.9	20.6 ± 3.4	24.9 ± 4.4	0.8289	< 0.0001	< 0.0001
Women	24.2 ± 6.9	20.1 ± 4.2	29.3 ± 6.7	0.0007	< 0.0001	< 0.0001
TC (mmol / l)						
Men	3.4 ± 0.9	5.3 ± 1.3	4.9 ± 1.2	< 0.0001	0.0725	< 0.0001
Women	4.3 ± 1.3	5.4 ± 1.2	5.3 ± 1.2	< 0.0001	> 0.9999	< 0.0001
HDLC (mmol / l)						
Men	1.0 ± 0.7	1.1 ± 0.4	1.3 ± 0.4	0.7507	0.4267	0.0302
Women	1.0 ± 0.4	1.3 ± 0.5	1.3 ± 0.4	0.0004	0.9514	< 0.0001
Haemoglobin A_{1c} (%)						
Men	4.8 ± 1.1	5.7 ± 0.5	5.3 ± 1.5	0.0394	0.5728	0.0599
Women	4.8 ± 0.7	5.6 ± 0.5	5.2 ± 1.2	0.0002	0.2118	0.0267

Subjects aged 47 - 57 years were included in the analysis. Subjects on antihypertensive drug treatment were excluded.
SBP= systolic blood pressure; DBP=diastolic blood pressure; BMI = body mass index; TC = total cholesterol.

Table II. Distribution of food consumption in days a week stratified by gender and area of study (mean ± SD)

Food factors	Area			Significance		
	Rural (Handeni)	Pastoral (Monduli)	Urban (Dar es Salaam)	Rural v. pastoral	Pastoral v. urban	Urban v. rural
Men / women (N)	93 / 91	40 / 61	81 / 79			
Green vegetables (d / wk)						
Men	4.9 ± 2.2	1.1 ± 1.7	3.7 ± 2.3	< 0.0001	< 0.0001	0.0014
Women	4.9 ± 2.1	1.5 ± 1.3	4.3 ± 2.3	< 0.0001	< 0.0001	0.3087
Coconut milk (d / wk)						
Men	1.7 ± 2.1	—	3.9 ± 2.7	0.0003	< 0.0001	< 0.0001
Women	2.0 ± 1.9	0.1 ± 0.9	4.1 ± 2.6	< 0.0001	< 0.0001	< 0.0001
Whole milk (ml / day)						
Men	154.9 ± 845.3	1307.5 ± 1844.9	45.6 ± 105.9	< 0.0001	< 0.0001	0.7678
Women	85.6 ± 198.6	804.9 ± 890.2	65.8 ± 134.8	< 0.0001	< 0.0001	0.9652
Fish (d / wk)						
Men	2.4 ± 1.9	—	2.7 ± 1.8	< 0.0001	< 0.0001	0.5639
Women	2.1 ± 1.6	0.1 ± 0.3	3.1 ± 1.9	< 0.0001	< 0.0001	0.0002
Meat (d / wk)						
Men	1.5 ± 1.5	1.7 ± 2.5	2.4 ± 1.8	0.7053	0.2276	0.0074
Women	1.8 ± 1.7	1.1 ± 1.9	2.5 ± 1.9	0.1318	0.0001	0.0374

Subjects aged 47 - 57 years were included in the analysis.

determinants for BPamong men. Meat intake ($p < 0.05$) was associated positively with TC levels and negatively with fish consumption ($p < 0.05$) in men. BMI ($p < 0.001$) was associated positively with TC levels and negatively with green vegetable consumption ($p < 0.05$) in both genders.

As shown in Fig. 1, the prevalences of hypertension and obesity were higher in the urban area than in the rural and pastoral populations respectively (all $p < 0.0001$). The prevalence of hypercholesterolaemia was lower in the rural population than in the urban and pastoral populations (all $p < 0.0001$). The prevalence of hyperglycaemia was higher among women in the urban area and the Masai men; however, the difference was not statistically significant.

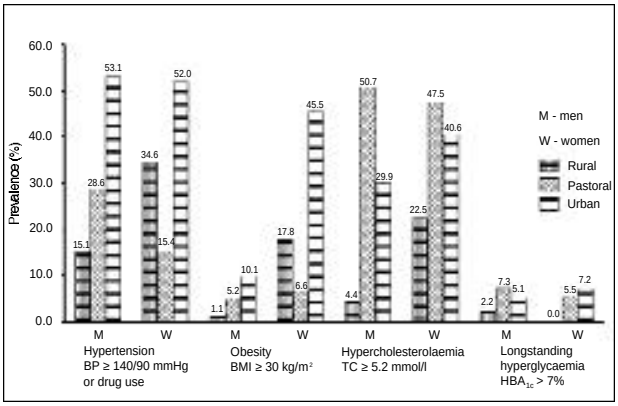

Fig. 1. Prevalence of CVD risk factors by gender and area.

Discussion

The objective of this analysis was to examine whether any association existed between dietary factors and the pattern of CVD risk factors among middle-aged men and women living in three different areas in Tanzania. Our findings add to the evidence that apart from other factors diet plays an important role in the pattern of CVD risk factors. In addition, this study provides evidence that in Tanzania the prevalences of hypertension and obesity have increased in the urban area, compared with rates found in the same area more than a decade ago.[3]

The current nutritional trend in developing countries is toward higher fat and more refined diets that contribute to increased risk of chronic diseases such as hypertension and diabetes mellitus.[18] We have clearly demonstrated a higher mean frequency of consumption of meat and coconut milk in the urban population, and that a direct association exists between BP and meat intake in both genders and coconut milk consumption among women only. Bourne *et al*.[9] compared the dietary composition for adults in Cape Town in 1990 with that in 1940, confirming a 14% reduction in carbohydrate intake and 63% increase in fat intake over this 50-year timespan. Thus, the high prevalence of hypertension and obesity in Dar es Salaam may be partly explained by the high-calorie diets popular in this area.

People from the rural area consumed green vegetables more frequently, and it is known that vegetables contain a significant amount of magnesium, calcium and potassium, which are

important in the pathogenesis of hypertension.[19] The moderate mean BPlevels among subjects in the rural area may partly be due to the protective effect of these cations. Participants from the pastoral population consumed high amounts of fresh milk and had the lowest BPlevels. Leanness has been found to be a predictor of the response to calcium supplementation.[20] Thus leanness among the pastoral Masai coupled with high consumption of milk rich in calcium has facilitated the maintenance of low BPlevels over years.

Mtabaji *et al.*[3] demonstrated the importance of salt in causing raised blood pressure in Tanzania. In this analysis we have demonstrated the importance of salt consumption, here measured as urinary Na / K, in predicting the mean BPlevel (both SBP and DBP) among men but not women. One study failed to demonstrate any significant relationship between BPand estimates of salt intake among women.[21] An association between dietary salt and BPis well documented.[3,21] Areduction in the intake of dietary salt has been associated with a significant reduction in BP. Therefore, an explanation for the differences observed in this study in the prevalence of hypertension and mean BPlevels between the rural, pastoral and urban populations might be provided, at least in part, by differences in salt intake.

In parallel with dietary changes, there is a rapidly increasing prevalence of obesity worldwide. In South Africa, more than 44% of black females and 8% of males were recently reported to have BMI > 30 kg / m^2.[22] When we analysed dietary factors that contributed greatly to the mean BMI levels in our population (results not shown), we found that the frequent consumption of meat, fish (usually deep-fried) and coconut milk was associated with BMI increase. Thus, a much higher prevalence of obesity in the urban area than in the rural or pastoral areas could be partly explained by such variations in dietary habits and different levels of physical activity.

Several studies from Africa have reported higher mean serum TC levels in urban areas or in areas of relatively high socio-economic status.[7,15] In our study, the most important dietary determinants of serum TC were meat (positively) and fish and vegetables (negatively). In addition, we found significantly higher mean serum TC levels in the urban and pastoral areas. The traditional diet of the Masai pastoralists is essentially high in cholesterol from whole milk, blood and meat, with fewer green leafy vegetables. The most recent data indicate that there have been significant increases in mean TC levels and prevalence of hypercholesterolaemia among the Masai in Tanzania over the past decade.[23] It is well documented that the fermented milk common in the Masai diet is an important factor in lowering serum TC.[24] The Masai usually include significant amounts of plant additives in their diet, known to contain hypocholesterolaemic saponins and phenolics.[25] Thus, the high TC among men in the Masai tribe could be due to an additional intake of dietary fat, a reduction in fermented milk consumption, or a reduction in intake of dietary plant additives. Further work is needed to identify important contributing factors to the dietary changes among the Masai.

In conclusion, the three populations demonstrated marked differences in their dietary behaviour, which was reflected in their pattern of risk factors for CVD. These results strengthen the evidence that diet has an independent effect on BP. Such effect may seem to be small compared with that of obesity, but it is not irrelevant. Therefore, carefully designed nutritional interventions could have a major impact on future CVD risk patterns in Tanzania.

Funding was received from the World Health Organisation through its Centre for Primary Prevention of Cardiovascular Diseases, currently based in Kyoto, Japan, under the chairmanship of Professor YYamori.

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Accepted 3 October 2002.