Risk factors of coronary artery disease in different regions of Saudi Arabia

A.K. Osman [1] and M.M. Al-Nozha [2]

عوامل اختطار أمراض الشرايين التاجية في المناطق المختلفة بالمملكة العربية السعودية

علي كرار عثمان ومنصور النزهة

خلاصة: أجري مسح حول التغذية على المستوى الوطني بالمملكة العربية السعودية بين سنة 1989 وسنة 1994. وكان أحد أهدافه بحث مدى انتشار عوامل الاختطار التي ثبت أنها تؤدي إلى التعصُّد بين الذكور البالغين الذين تزيد أعمارهم عن 18 سنة، وهي السمنة وفرط كولستيرول الدم وفرط ثلاثي الغليسيريد بالدم والسكري وارتفاع ضغط الدم الانقباضي والانبساطي. وتبيَّن أن انتشار السمنة كان يرتبط إيجابياً بسائر عوامل الاختطار الخمسة لأمراض الشرايين التاجية التي كانت محل البحث. ولوحظ وجود تباين بين المناطق فيما يتعلق بانتشار عوامل الاختطار المذكورة. لقد أدت الخصائص البيئية في المملكة العربية السعودية إلى تباين أساليب المعيشة وأنماط استهلاك الأغذية بين سكان المناطق المختلفة، الأمر الذي قد يكون سبباً رئيسياً خلف تباين معدلات انتشار عوامل اختطار أمراض الشرايين التاجية وارتفاعها.

ABSTRACT A national nutrition survey was carried out in Saudi Arabia between 1989 and 1994. One objective was to investigate the prevalence of well established atherogenic risk factors among adults 18 years and older, namely obesity, hypercholesterolaemia, hypertriglyceridaemia, diabetes mellitus and high systolic and diastolic blood pressure. Obesity prevalence was positively correlated with all five coronary artery disease risk factors investigated. Variation among regions in relation to the prevalence of these risk factors was observed. Saudi Arabia's ecology has resulted in variation in the lifestyle and food consumption patterns of the people of the different regions, which might be a major underlying cause of the variation and high prevalence of coronary artery disease risk factors.

Les facteurs de risque de coronaropathies dans différentes régions d'Arabie saoudite

RESUME Une enquête nutritionnelle nationale a été réalisée en Arabie saoudite entre 1989 et 1994. Un objectif était d'enquêter sur la prévalence de facteurs de risque athérogènes bien établis chez les adultes de 18 ans et plus, à savoir l'obésité, l'hypercholestérolémie, l'hypertriglycéridémie, le diabète sucré et la pression artérielle systolique et diastolique élevée. Il y avait une corrélation positive entre la prévalence de l'obésité et l'ensemble des cinq facteurs de risque de coronaropathies qui faisaient l'objet de l'enquête. Une variation entre les régions en relation avec la prévalence de ces facteurs de risque a été observée. L'écologie de l'Arabie saoudite a provoqué une variation dans le mode de vie et les caractéristiques de la consommation alimentaire des habitants des différentes régions, ce qui pourrait être la cause sous-jacente majeure de la variation et de la forte prévalence des facteurs de risque des coronaropathies.

[1] *College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia.*
[2] *College of Medicine, King Saud University and King Khalid University Hospital, Riyadh, Saudi Arabia.*
Received: 16/06/99; accepted: 11/11/99

Introduction

Hypertension, hypercholesterolaemia, diabetes mellitus, obesity and smoking are well established atherogenic risk factors. The rapid socioeconomic development during the past 3 decades in Saudi Arabia has been accompanied by drastic lifestyle changes. Diet may be one of the fundamental components of lifestyle contributing to increased risk of coronary heart disease [*1*]. It is evident that Saudis' consumption of foods rich in animal protein, fat and sodium has increased [*2,3*]. These changes have been accompanied by the emergence of noncommunicable diseases such as coronary artery disease (CAD) and stroke.

Several hospital-based studies have shown a rise in the occurrence of angina, myocardial infarction and nephropathy [*4–9*]. Alwan has reported that there is a progressive increase in the occurrence of cardiovascular diseases and other noncommunicable diseases in the Eastern Mediterranean Region, and Saudi Arabia is no exception [*10*]. Community-based studies, although few, reveal the high prevalence of obesity (13.05% and 20.26% among males and females respectively), increasing with age [*11*]. Data from primary health care clinics have shown that obesity was found among 32.8% [*12*] and 25% [*13*] of attenders. Hypercholesterolaemia and hypertriglyceridaemia were reported among 9.5% and 5% among those attenders respectively [*12*]. The overall prevalence rates of diabetes mellitus and impaired glucose tolerance in Saudi Arabia have been reported to be 17.3% and 1.3% respectively in males and 12.18% and 2.2% respectively in females 30 years and older [*14*]. The prevalence of hypertension (≥ 140/90 mmHg) among Saudis of both sexes aged 18 years and older has been reported to be 20.4% for systolic blood pressure hypertension (SBPH) and 25.9% for diastolic blood pressure hypertension (DBPH), which is similar to rates reported in Western societies [*15*].

The prevalence rates of these CAD risk factors in neighbouring countries are also alarming. In Bahrain, overweight and obesity affect 79% of females and 56% of males aged 30–79 years [*16*]. In the United Arab Emirates, the prevalence of obesity among adults aged 30–64 years has been reported to be 27%, with women more affected. SBPH (≥ 140 mmHg) has been detected in 19%–25% of all participants and diabetes mellitus affected 11% of males and 7% of females [*17*]. The proportionate mortality rate for cardiovascular disease in Kuwait is 37% [*18*].

As Saudi Arabia has a diverse ecology, the aim of our study was to determine the prevalence of CAD cluster risk factors and to examine if there was any regional variation.

Participants and methods

A national nutrition survey was carried out from 1989 to 1994 [*3*]. The information was collected through a community-based study. The study employed geographic and demographic stratification of the population and a cluster sampling method, and households selected were visited by trained health teams. Age, sex, socioeconomic status, occupation and family history of disease were recorded. Physical examination, including clinical examination, anthropometric measurements and signs of malnutrition (as well as nutritional background) was carried out. Blood pressure, total serum cholesterol (TC), fasting blood sugar (FBS) and triglycerides (TG) were measured. A total of 19 598 individuals were examined within 2837 households in 12 regions of Saudi Arabia. Participants were selected randomly according to the density of population in each region.

Complete data were recorded for 13 700 individuals of all ages. A total of 6253 adults were selected and the sample was categorized in age groups of 18–< 21, 21–< 31, 31–< 40 and > 40 years. There were 2673 men and 3590 women.

Body mass index (BMI) is a valid and reliable measure for obesity in adults over age 18 years. Those under this age group will be reported separately. Only factors known to be well established CAD risk factors (except for smoking) were studied. Because smoking is socially and religiously unacceptable, the data collected could not be validated and were therefore excluded.

Anthropometric measurements

Weight was measured by precision dial scale (Seca Optima/Seca Medica 761). Participants were weighed in light clothing as far as possible and without shoes. Weight was recorded to the nearest 0.1 kg. The scales were calibrated before use in each household. Height was measured by Seca scale (Model 220). Individuals were measured barefoot and standing erect, with feet together and head against the measuring rod, looking straight ahead, with arms hanging loosely at the sides and palms facing thighs. The reading was recorded to the nearest 0.5 cm.

BMI is used as a measure of fatness [*19*]. It is calculated as: BMI = weight (kg)/ height^2 (m^2)

Blood pressure

Blood pressure was measured by primary health care physicians with extensive training. Cross-check quality control procedures were used to ensure the validity of the data throughout the country.

In systolic blood pressure measurements, the first Korotkoff phase (K1) was used, defined as the appearance of two consecutive beats. For diastolic blood pressure, the fifth Korotkoff phase (K5) was used, defined as the last beat before the disappearance of the sound. Participants were seated and the right arm was placed on the tabletop. The appropriate cuff size was used. A standard sphygmomanometer was used to determine the pressure necessary to obliterate the radial pulse. Blood pressure was measured to the nearest even number. Three blood pressure measurements were taken with a minimum of 30 seconds rest between each determination, and the values were used for calculation of the mean blood pressure.

Blood samples

Participants were instructed to come to the health centre in the vicinity of their homes in the morning after overnight fasting for 12 hours. At the centre, 5 mL of blood were withdrawn by venepuncture from the antecubital vein and collected in silicon-coated plain tubes. After 1 hour, the serum was separated by centrifugation using a Beckman centrifuge (model TJ-6) at 3000 rpm for 10 minutes. The sera were then separated and stored at –20 °C in each of the health centres. Once the study area was covered, all the samples were collected from all the health centres and were flown in insulated boxes containing ice to the central survey laboratory in Riyadh. Once delivered, they were immediately stored at –20 °C until used for serum TC and TG estimation.

Serum TC was estimated by an enzymatic colorimetric test in duplicate [*20*] using a cholesterol estimation kit 61 224 (BioMérieux, France). A subsample of 2451 individuals was tested for serum cholesterol level.

Serum TG was estimated by the method of Fossati and Principe in duplicate [*21*] using kit 62 236 (BioMérieux, France). A subsample of 2243 was tested for serum TG.

FBS was measured using haemoglucotest strips and a Reflolux S glucometer (Boehringer Mannheim) in a subsample of 2861 individuals.

Definitions

The following definitions were used.

- Arterial hypertension = systolic blood pressure ≥ 140 mmHg (SPBH) and diastolic blood pressure ≥ 90 mmHg (DPBH)
- Obesity = BMI ≥ 30 kg/m^2
- Hypertriglyceridaemia = TG ≥ 150 mg/dL
- Hypercholesterolaemia = TC ≥ 200 mg/dL
- Diabetes mellitus = FBS ≥ 126mg/dL [*22,23*].

Statistical analysis

All analyses were performed with GLM procedure of Statistical Analyses System (Cary, North Carolina, United States of America). Chi-squared test was used for testing the significance of the difference in percentages of BMI, TC, TG, DBPH and SBPH and FBS in the different regions. Values for these parameters were extracted from a subsample of 2056 individuals and were used to test the correlation between these parameters. Values of $P < 0.05$ were considered to be statistically significant.

Results

Table 1 shows the prevalence (%) of obesity, SBPH and DBPH in the different regions. The prevalence of obesity ranged from 33.9% in Hail to 11.7% in Jizan with an overall prevalence rate of 20.8%. Mecca had the highest prevalence of SBPH (27.9%) and the lowest was reported from Jizan (17.0%). Al-Taif had the highest prevalence of DBPH (36.2%), and Mecca (22.0%), Riyadh (22.1%) and Asir (22.1%) had the lowest. The overall prevalence of high blood pressure among the population was 20.4% and 25.9% for SBPH and DBPH respectively.

Table 2 shows total serum hypercholesterolaemia, hypertriglyceridaemia and diabetes mellitus among populations of the different regions. The highest prevalence of hypercholesterolaemia (58.2%) was recorded in Hail and the lowest in Asir (27.7%), with overall prevalence of 35.4%. Al-Qassim had the highest prevalence of hypertriglyceridaemia (65.4%) and the lowest was reported from Jizan (28.7%), with an overall prevalence of 49.6%. Diabetes mellitus prevalence ranged from 23.2% in Al-Sharqia to 4.5% in Farasan, with an overall prevalence of 13.2%.

There were statistically significant differences between the regions in relation to obesity, hypercholesterolaemia, hypertriglyceridaemia, SBPH and DBPH and diabetes mellitus (Tables 1 and 2).

Table 3 shows that the prevalence of obesity for all adults increased significantly ($P < 0.001$) with age in all regions except for males in Hail and Jeddah and both sexes in Al-Sharqia, Farasan and Tabouk. In all regions, the prevalence was significantly higher in females of every age ($P < 0.001$, $P < 0.02$ and $P < 0.05$) than males, with the exception of Tabouk, Al-Sharqia and Jeddah where the differences were not significant. However, the prevalence of obesity throughout all regions increased significantly with age for both sexes ($P < 0.001$), with overall prevalence rates of 15.6% and 24.9% among males and females respectively.

Table 4 shows the correlation of BMI with TC, TG, SBPH, DBPH and FBS. All five variables were positively correlated with BMI. Pearson correlation coefficient (*r*) and *P*-value for BMI versus TC, TG, SBPH, DBPH and FBS were 0.210 ($P < 0.0001$), 0.196 ($P < 0.0001$), 0.216 ($P < 0.0001$), 0.235 ($P < 0.0001$) and 0.214 ($P < 0.001$) respectively.

Discussion

The present study shows that the cluster of CAD risk factors was highly prevalent among the people of Saudi Arabia. Reports from hospital-based studies show a high prevalence of obesity, hypertriglyceridaemia, hypertension and diabetes mellitus. Similar findings have been reported in a few isolated community-based studies [*11–14*]. Several studies have shown that the prevalence of arterial hypertension in Saudis is relatively high among the middle-aged population and that females are more affected than males [*24–26*]. Reports from neighbouring Arab states show similar alarming rates [*16–18*]. Sedentary lifestyle has been reported to be a causative factor for the high prevalence rates of obesity, hypertension and diabetes mellitus in Bahrain [*16*].

We also found regional variations in the prevalence of CAD risk factors. Hail had the highest prevalence of obesity (33.9%) and hypercholesterolaemia (58.2%). Al-Qassim had the highest prevalence of hy-

Table 1 **Prevalence (%) of obesity, diastolic hypertension (DBPH) and systolic hypertension (SBPH) by region**

Region	Obesity	BMI ≥ 30 kg/m²		DBPH	DBP ≥ 90 mmHg		SBPH	SBP ≥ 140 mmHg	
	Total no.	No.	%	Total no.	No.	%	Total no.	No.	%
Al-Qassim	396	105	26.5	403	138	34.2	403	83	20.6
Riyadh	1238	268	21.7	1251	276	22.1	1260	228	18.1
Hail	357	121	33.9	365	100	27.4	365	99	27.1
Tabouk	234	59	25.20	234	66	28.2	235	54	23.0
Al-Sharqia	477	132	27.7	479	123	25.7	481	95	19.8
Jizan	435	51	11.7	435	108	24.8	435	74	17.0
Asir	902	146	16.2	907	200	22.1	906	157	17.3
Medina	570	86	15.1	585	147	25.1	584	119	20.4
Al-Taif	640	153	23.9	646	234	36.2	646	158	24.50
Mecca	519	100	19.3	519	114	22.0	519	145	27.9
Jeddah	372	61	16.4	356	95	26.7	356	53	14.9
Farasan	70	11	15.7	73	18	24.70	73	13	17.8
Total	6210	1293	20.8	6253	1619	25.9	6263	1278	20.4
P-value[a]		< 0.001			< 0.001			< 0.001	

[a]*Chi-squared, the significance of the differences of percentage of obesity, DBPH, SBPH among the regions*

pertriglyceridaemia (65.4%). Jizan and Asir had among the lowest prevalence rates for the cluster of CAD risk factors. Al-Sharqia had the highest prevalence rate for diabetes mellitus (23.2%) and the second-highest prevalence rates for obesity (27.7%) and hypercholesterolaemia (54.2%). Traditional consanguinity and a genetic basis [*27*] could partly explain the high prevalence of diabetes mellitus and obesity in this region.

The ecology of Saudi Arabia ranges from inland desert to temperate highlands in the south-west, lowlands in the south and coastal regions in the east, south and west. The people of these regions differ in relation to ethnicity, climatic conditions, eating habits and socioeconomic status. Variations in the prevalence rates of major CAD risk factors among and within populations by sex, ethnicity, social class and geographic regions have also been reported in the WHO/MONICA project [*26*].

Our study shows that BMI was positively correlated with TC, TG, blood pressure and FBS. It is clear from this that obesity, which is a reflection of lifestyle and food consumption patterns, might contribute to the high prevalence rates for hypertension,

Table 2 **Prevalence (%) of hypercholesterolaemia, hypertriglyceridaemia and hyperglycaemia by region**

Region	Hypercholesterolaemia	TC ≥ 200 mg/dL		Hypertriglyceridaemia	TG ≥ 150 mg/dL		Hyperglycaemia	FBS ≥ 126 mg/dL	
	Total no.	No.	%	Total no.	No.	%	Total no.	No.	%
Al-Qassim	184	60	32.6	182	119	65.4	320	61	19.1
Riyadh	315	89	28.2	350	150	42.8	160	16	10.0
Hail	55	32	58.2	56	26	46.4	29	2	6.9
Tabouk	39	14	35.9	49	25	51.0	84	17	20.2
Al-Sharqia	155	84	54.2	220	104	47.3	358	83	23.2
Jizan	192	64	33.3	192	55	28.7	154	15	9.7
Asir	372	103	27.7	370	142	38.4	590	50	8.5
Medina	287	80	27.9	261	79	30.3	539	76	14.1
Al-Taif	338	150	44.4	340	154	45.3	538	54	10.0
Mecca	384	147	38.3	381	228	59.8	–	–	–
Jeddah	45	16	35.6	18	6	33.3	–	–	–
Farasan	85	29	34.1	85	25	29.4	89	4	4.5
Total	2451	868	35.4	2243	1113	49.6	2861	378	13.2
P-value[a]		< 0.001			< 0.001			< 0.001	

[a]*Chi-squared, the significance of the differences of percentage of hypercholesterolaemia, hypertriglyceridaemia and hyperglycaemia among the regions*

TC = total serum cholesterol

TG = triglycerides

FBS = fasting blood sugar

Table 3 **Prevalence of obesity (%) (BMI ≥ 30 kg/m²) by age and sex in the different regions**

Region	Age (years)										P-value for all ages
	18–<21		21–<31		31–<40		≥ 40		All ages		
	M	F	M	F	M	F	M	F	M	F	M vs F
Al-Qassim	14.2	13.3	11.5	.25.4	27.7	36.7	34.5[a]	66.7[a]	23.5	29.7	< 0.01
Riyadh	5.4	15.0	9.9	23.3	16.3	42.8	25.5[a]	47.5[a]	15.7	28.2	< 0.001
Hail	21.3	24.3	17.4	38.0	27.6	39.9	28.1[b]	61.2[a]	22.9	41.4	<0.001
Tabouk	11.1	5.8	14.3	24.4	31.0	38.1	32.2[b]	29.3[b]	24.8	26.8	NS
Al-Sharqia[a]	8.6	19.9	21.3	21.5	32.5	43.2	29.4[b]	44.0[b]	25.7	30.3	NS
Jizan	9.5	7.7	3.2	10.7	7.4	22.6	12.1[a]	32.3[a]	7.7	16.2	< 0.001
Asir	4.8	2.7	6.6	15.1	26.2	31.6	20.3[a]	29.5[a]	12.9	19.5	< 0.001
Medina[a]	3.6	6.4	6.6	16.6	14.2	24.6	20.0[a]	33.2[a]	10.5	20.3	< 0.001
Al-Taif	2.7	10.3	5.9	23.0	17.4	46.2	28.9[a]	68.3[a]	14.1	32.5	< 0.001
Mecca[a]	9.4	10.3	13.7	16.5	14.8	30.8	23.8[a]	41.5[a]	14.9	22.7	< 0.05
Jeddah	14.3	11.1	17.1	11.4	13.0	25.2	13.0[b]	34.1[a]	15.5	19.0	NS
Farasan	0	0	0	30.7	11.1	28.5	25.0[b]	25.0[b]	9.0	25.6	< 0.02
All regions	9.0	16.5	10.4	22.1	20.7	32.7	20.8[a]	33.2[a]	15.6	24.9	< 0.001

[a]Significant increase with age within the same sex (P < 0.001)
[b]No significant difference within the same sex
M = males F = females
NS = not significant

Table 4 **Pearson correlation coefficient (*r*) of BMI with TC, TG, SBP, DBP and FBS**

	BMI ≥ 30 kg/m²	TC ≥ 200 mg/dL	TG ≥ 150 mg/dL	SBP ≥ 140 mmHg	DBP ≥ 90 mmHg	FBS ≥ 126 mg/dL
BMI	1					
TC	0.210*	1				
TG	0.196**	0.376**	1			
SBPH	0.216**	0.184**	0.169*	1		
DBPH	0.235**	0.165**	0.156*	0.693**	1	
FBS	0.214**	0.255*	0.218*	0.231[a]	0.212[a]	1

**P < 0.001* ***P < 0.0001*
[a]Not significant
BMI = body mass index *TC = serum total cholesterol*
TG = triglycerides *SBP = systolic blood pressure*
DBP = diastolic blood pressure *FBS = fasting blood sugar*

hypercholesterolaemia and hypertriglyceridaemia. It also shows that the prevalence of obesity increased significantly with age in males in seven regions and in females in nine regions, with females more affected. Diabetes mellitus followed the same pattern as obesity. This is in agreement with Kaplan, who noted that obesity leads to glucose intolerance and hyperinsulinaemia, which in turn precipitate hypertension and dyslipidaemia [*28*]. However, Reaven noted that increases in both plasma catecholamines and renal tubular reabsorption of sodium and water can be seen in response to hyperinsulinaemia and that either may lead to an increase in blood pressure [*29*]. Al-Nozha et al. reported a high dietary sodium intake among Saudis [*2*]. This may also predispose to hypertension among those sensitive to sodium.

Almost 50% of the population in our study had hypertriglyceridaemia. Al-Kanhal and Osman showed that fat consumption among Saudis had increased from 40 g per capita per day in 1971 to 121 g per capita per day in 1992, providing 39.6% of the total energy intake [*30*]. Miller suggested that dietary fat might influence both the atherosclerotic and thrombogenic components of coronary heart disease [*31*]. Factor VII coagulant activity (VIIC) is a risk factor for coronary heart disease and it is positively associated with dietary fat intake suggesting that fat-rich diets are accompanied by hypercoagulable state. However, he showed that reduction in total fat consumption is followed by a decrease in VIIC within 24 hours. Serum TC is an indicator of low-density lipoprotein cholesterol (LDL-C). Growing evidence suggests that oxidative modification of LDL may be of particular importance in atherogenesis as oxidized LDL has been shown to be cytotoxic. Therefore inhibiting LDL oxidation will ultimately inhibit the atherosclerotic process. One such approach is to enhance the endogenous antioxidant defence system within the LDL particle with lipophilic antioxidants such as vitamin E and beta-carotene or supplementing the aqueous phase antioxidant capacity with ascorbic acid [*32*]. It is well established that nutrition plays an important role in the prevention of conventional atherogenic risk factors such as obesity, diabetes mellitus and hyperlipidaemia.

The national nutrition survey [*3*] showed that the daily energy intake in Jizan was 3174 kcal per capita with 36.4% derived from fat. In Al-Qassim it was 2782 kcal and 35.4% respectively. In spite of the similar fat contributions to total daily energy intake, the prevalence of obesity and hypertriglyceridaemia was lowest in Jizan compared with all other regions. Al-Qassim residents are primarily engaged in trade and government administrative jobs, while fishing and farming are the two most common occupations in Jizan. Fish and vegetable consumption is very frequent in the latter while very rare in Al-Qassim [*3*].

Bainton et al. [*33*] showed that plasma TG concentration predicted major ischaemic events after adjustment was made for TC and high-density lipoprotein cholesterol and other risk factors. Fish oil has a lowering effect on TG and this is generally accepted to be associated with hepatic output of very-low-density lipoproteins in humans [*34*] and consequently a low plasma level of low-density lipoproteins. This might explain the lower prevalence of hypertriglyceridaemia in Jizan.

Conclusion

Lifestyle, particularly eating habits, seems to be the main underlying cause of the CAD risk factors we investigated. Therefore, a comprehensive understanding of the pathogenesis of CAD risk factors in the regions as well as the mechanisms of nutrients interaction and energy expenditure are essential prerequisites for planning successful nutrition intervention strategies for primordial and primary prevention and control of CAD.

Acknowledgements

This survey was supported by research grants from King Abdul Aziz City for Science and Technology (KACST), Riyadh, Saudi Arabia. The help of Tariq Hameed in preparing the tables and typing the manuscript is greatly appreciated.

References

1. Yano K et al. Dietary intake and the risk of coronary heart disease in Japanese men living in Hawaii. *American journal of clinical nutrition*, 1978, 31:1270–9.
2. Al-Nozha M, Ali MS, Osman A. A community-based epidemiological study of hypertension in Riyadh region. *Journal of the Saudi Heart Association*, 1993, 5(1): 25–30.
3. *Evaluation of the nutritional status of the people of the Kingdom of Saudi Arabia.* Riyadh, King Abdul Aziz City for Science and Technology (KACST), 1994.
4. Al-Balla SR et al. Causes of morbidity in the elderly population of Saudi Arabia. *Tropical medicine and hygiene*, 1993, 96:157–62.
5. Awada A et al. Nontraumatic cerebral hemorrhage in Saudi Arabs: a hospital-based study of 243 cases. *Journal of neurological sciences*, 1996, 144:198–203.
6. Al-Balla SR et al. Pattern of adult ad-mission to medical wards of King Khalid University Hospital, Riyadh (1985–1990). *Saudi medical journal*. 1993. 13(1):8–13.
7. Awada A. Stroke in Saudi Arabian young adults: a study of 120 cases. *Acta neurologica scandinavica*, 1994, 89(5):323–8.
8. Al-Rajeh S et al. A community survey of neurological disorders in Saudi Arabia: the Thugbah study. *Neurological epidemiology*, 1993, 12(3):164–78.
9. Al-Rajeh S et al. Stroke in a Saudi Arabian national guard community: Analysis of 500 consecutive cases from a population-based hospital. *Stroke*, 1993, 24(11):1635–9.
10. Alwan A. Cardiovascular diseases in the Eastern Mediterranean Region. *World health statistics quarterly*, 1993, 46(2): 97–100.
11. El-Hazmi MAF, Warsy AS. Prevalence of obesity in the Saudi population. *Annals of Saudi medicine*. 1997. 17(3):302–6.
12. Al-Shammary SA et al. Blood lipid concentration and other cardiovascular risk factors among Saudis. *Family practice*, 1994, 11(2):153–8.
13. Binhemd T, Larbi EB, Absood G. Obesity in primary health centre: retrospective study. *Annals of Saudi medicine*, 1991, 11:163–6.
14. El-Hazmi MAF et al. Diabetes mellitus, impaired glucose tolerance in Saudi Arabia. *Annals of Saudi medicine*, 1996, 16:381–5.
15. Al-Nozha M, Ali MS, Osman AK. Arterial hypertension in Saudi Arabia. *Annals of Saudi medicine*, 1997, 17:170–4.
16. Musaiger AO, Al-Roomi KA. Prevalence of risk factors for cardiovascular disease

among men and women in an Arab Gulf community. *Nutrition health*, 1977, 11(3):149–57.

17. El-Mugamer IT et al. Diabetes, obesity and hypertension in urban and rural people of Bedouin origin in United Arab Emirates. *Journal of tropical medicine and hygiene*, 1995, 98(6):407–15.
18. Kohli KL, Al-Omain M. Mortality level, trends and differentials in Kuwait, 1957–1982. *Population bulletin of ESCWA*, 1986, 28:91–123.
19. Garrow JS, Webster J. Quetelet's index (W/H2) as a measure of fatness. *International journal of obesity*, 1985, 9:147–53.
20. Allian CC et al. Enzymatic determination of total serum cholesterol. *Clinical chemistry*, 1974, 20:470–5.
21. Fossati P, Precipe L. Serum triglyceride determination colorimetrically with an enzyme that produces hydrogen peroxide. *Clinical chemistry*, 1982, 28:2077–80.
22. Report of the Expert Committee on Diagnosis and Classification of Diabetes Mellitus. *Diabetes care*, 1997, 20:1183–97.
23. Alberti K, Zimmer P. Definitions, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus; provisional report of a World Health Organization consultation. *Diabetic medicine*, 1998, 15:539–53.
24. Al-Nozha M, Osman AK. The prevalence of hypertension in different regions of Saudi Arabia. *Annals of Saudi medicine*, 1998, 18(5):401–7.
25. Stamler R et al. Weight and blood pressure: findings in the hypertension screening of one million Americans. *Journal of the American Medical Association*, 1978, 240:1607–10.
26. The WHO/MONICA Project. Geographical variation in the major risk factors of coronary heart disease in men and women aged 35–64 years. *World health statistics quarterly*, 1988, 41:115–40.
27. El-Hazmi MAF. Haemoglinopathies, thalassaemias and enzymopathies in Saudi Arabia: the present status. *Acta haematologica*, 1987, 78:130–4.
28. Kaplan MM. The deadly quartet: upper body obesity, glucose intolerance, hypertriglyceridemia and hypertension. *Archives of internal medicine*, 1989, 149:1514–20.
29. Reaven GM. Role of insulin resistance in human disease. *Diabetes*, 1988, 37: 1595–607.
30. Al-Kanhal MA, Osman Ali K. *Changing food consumption pattern and health in Saudi Arabia*. Paper presented at the Symposium on Epidemiologic Transition/ Transaction and Health in Developing Countries, College of Medicine, King Saud University, Riyadh, 27–29 November, 1994.
31. Miller GJ. Dietary fatty acids and blood coagulation. *Prostaglandins leukotrienes and essential fatty acids*, 1997, 57(4–5):389–94.
32. Odeh RM, Cornish LA. Natural antioxidants for prevention of atherosclerosis. *Pharmacotherapy*, 1995, 15(5):648–59.
33. Bainton D et al. Plasma triglycerides and high-density lipoprotein cholesterol as predictors of ischaemic heart disease in British men. The Caerphilly and Speedwell collaborative heart disease studies. *British heart journal*, 1992, 68:60–6.
34. Nestel PJ et al. Suppression by diets rich in fish oil of very-low-density lipoprotein production in man. *Journal of clinical investigation*, 1984, 74:82–9.