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Cardiovascular diseases in Chinese, Malays, and Indians in Singapore. II. Differences in risk factor levels

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Abstract

***Study objective*—The aim of the study was to examine cardiovascular risk factors to see how these might explain differences in cardiovascular disease mortality among Chinese, Malays, and Indians in the Republic of Singapore.**

***Design*—The study was a population based cross sectional survey. Stratified systematic sampling of census districts, reticulated units, and houses was used. The proportions of Malay and Indian households were increased to improve statistical efficiency, since about 75% of the population is Chinese.**

***Setting*—Subjects were recruited from all parts of the Republic of Singapore.**

***Subjects*—2143 subjects aged 18 to 69 years were recruited (representing 60·3% of persons approached). There were no differences in response rate between the sexes and ethnic groups.**

***Measurements and main results*—Data on cardiovascular risk factors were collected by questionnaire. Measurements were made of blood pressure, serum cholesterol, low and high density lipoprotein cholesterol, fasting triglycerides and plasma glucose. In males the age adjusted cigarette smoking rate was higher in Malays (53·3%) than in Chinese (37·4%) or Indians (44·5%). In both sexes, Malays had higher age adjusted mean systolic blood pressure: males 124·6 mm Hg *v* 121·2 mm Hg (Chinese) and 121·2 mm Hg (Indians); females 122·8 mm Hg *v* 117·3 mm Hg (Chinese) and 118·4 mm Hg (Indians). Serum cholesterol, low density lipoprotein cholesterol and triglyceride showed no ethnic differences. Mean high density lipoprotein cholesterol in males (age adjusted) was lower in Indians (0·69 mmol/litre) than in Chinese (0·87 mmol/litre) and Malays (0·82 mmol/litre); in females the mean value of 0·95 mmol/litre in Indians was lower than in Chinese (1·05 mmol/litre) and Malays (1·03 mmol/litre). Rank prevalence of diabetes for males was Indians (highest), Malays and then Chinese; for females it was Malays, Indians, Chinese.**

***Conclusions*—The higher mortality from ischaemic heart disease found in Indians in Singapore cannot be explained by the major risk factors of cigarette smoking, blood pressure and serum cholesterol; lower high density lipoprotein cholesterol and higher rates of diabetes may be part of the explanation. The higher systolic blood pressures in Malays may explain their higher hypertensive disease mortality.**

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In the accompanying paper,[1] mortality from cardiovascular diseases has been compared among the three major ethnic groups in Singapore. The main findings were that Indians had higher mortality from ischaemic heart disease than Chinese and Malays, while Malays had higher mortality from hypertensive disease, with little differences for cerebrovascular disease. We have carried out a population based cross sectional survey (as part of the Singapore Thyroid and Heart Study) to measure and compare cardiovascular risk factors in the ethnic groups and we report the results of this study here.

Methods

SAMPLE

There was a four stage sampling design. The first three stages of census districts, reticulated units, and houses, used stratified systematic sampling. The proportions of Malay and Indian households were increased to 25% and 15% respectively to increase statistical efficiency. For the fourth stage, field officers visited the selected houses and listed persons aged 18 years and over, after which a random selection of these persons was made using a sampling fraction of between 0·5 and 0·67. Two attempts were made to persuade the persons to attend the clinic at Singapore General Hospital between 1982 and 1985. A final response of 2143 (60·3%) in persons aged 18 to 69 years was obtained, with the response rates by ethnic group and sex being: Chinese males 64·6%, females 60·2%; Malay males 52·4%, females 52·1%; and Indian males 66·0%, females 64·3%. Comparisons were made between the respondents, the sample, and the sampling frame, and no major discrepancies were found by age, sex, and ethnic group; the youngest age group had slightly lower response rates than the older ones.

PROCEDURES

All clinics were held on Saturday mornings between 0900 and 1200 hours and the subjects were asked to fast from 2100 hours the previous evening. A questionnaire was administered by a field investigator (a nurse trained in interview techniques) and personal details including ethnic group (derivation previously described),[1] present and past occupations, medical history, drug usage, diet, and family medical history were obtained. Questions were asked on alcohol intake (including frequency, type and quantity, similar to those used in the British Regional Heart Study[2] based on the UK General Household Survey 1972–73),[3] smoking (same questionnaire as used in MONICA project of WHO),[4] and chest pain. (Copies of questionnaire available on request.)

Various tests were carried out and an examination and final assessment were made by a doctor.

Blood pressure—The standard mercury sphygmomanometer was used (12·5 × 22·5 cm cuff) and all measurements done by one medically qualified person (KH) so as to remove interobserver variation, which can be serious.[5] The protocol of the MONICA project[4] was followed to reduce intraobserver variation. The mean of two readings was used and phases 1 and 5 recorded to the nearest 2 mm Hg above. All blood pressures were measured in the morning between 0900 and 1000 hours so there is no problem of diurnal variation, and in the clinic the temperature (which can influence blood pressure[6]) was kept uniform at 21°C by central air conditioning.

Height and weight—Height was measured without shoes to the nearest 0·5 cm. Standing weight was taken in light clothing and without shoes, using a beam balance to the nearest 0·1 kg.

Blood samples—These were obtained between 0900 and 1000 from the antecubital vein with the subject in a sitting position and with minimum venostasis using the venoject vacuum container.

Serum lipids—About 10 ml of blood was collected from each subject, allowed to clot, refrigerated, and serum obtained by centrifugation at 6000 *g*. Aliquots were used for total cholesterol and triglyceride determinations. An aliquot of fresh serum was reacted with heparin-manganese reagent and the supernatant used for high density lipoprotein cholesterol determination; difficult samples were clarified with a Millex 0·45 μ filter. A further aliquot of fresh serum was ultracentrifuged in a cellulose tube in a Ti 50·3 Beckman rotor at a non-protein solvent density of 1·006 g/litre, at 100 000 *g* for 18 hours at 10°C and the bottom fraction used for determination of low and high density lipoprotein cholesterol. The cholesterol[7] and triglyceride[8] measurements were carried out using the Roche Cobas Bio Automated System (Enzymatic). Total cholesterol, high density lipoprotein (HDL) cholesterol, and triglyceride were measured directly, while low density lipoprotein (LDL) cholesterol was computed from LDL + HDL cholesterol minus HDL cholesterol.

External quality control was achieved using the rules of the World Health Organization Prague Lipid Reference Centre with standardisation provided by analysing freeze dried control samples from the Centre.[9] The overall coefficients of variation for each batch were satisfactorily low for both cholesterol (averaging 3·4%) and triglyceride (averaging 3·9%) indicating good reproducibility (precision). There was little variation in the biases (differences between the mean of the batch and the reference value) with the average values indicating that our laboratory was measuring cholesterol 5·0% and triglyceride 6·0% lower than the reference laboratory. Blood samples were obtained between 0900 and 1000 and so there is no problem with the diurnal variation that occurs for serum triglyceride and high density lipoprotein cholesterol.[10]

Plasma glucose and diabetes—A further 3 ml of venous blood was drawn with fluoride oxalate as the anticoagulant. The specimen was centrifuged and plasma glucose measured within 2 h of blood collection using the Beckman Glucose Analyzer 2 (glucose oxidase method). There was ongoing quality control by running through the standard sample five or six times. Both the coefficient of variation and the bias were checked and if either was more than 3% then recalibration was carried out. Persons with a previous diagnosis of diabetes and receiving treatment were classified as diabetic. For the remaining subjects, all those with a fasting plasma glucose ⩾6 mmol/litre were recalled for a 75 g oral glucose tolerance test after an overnight fast of at least 10 h (response rate 81·8%). Subjects were classified as having diabetes (plasma glucose: fasting ⩾7·8 mmol/litre and/or 2 h after the glucose load ⩾11·1 mmol/litre), or impaired glucose tolerance (plasma glucose: fasting <7·8 mmol/litre and 2 h after the glucose load 7·8–11·1 mmol/litre) according to WHO recommendations.[11] Subjects not fulfilling these criteria were considered to be normal, as were subjects with an original fasting plasma glucose of <6 mmol/litre.

ANALYSIS

The data were processed using the SPSS statistical package. Qualitative variables were age adjusted by direct standardisation with significance testing (Z test) using a microcomputer program written in BASIC,[12] based on the statistical method of Mosteller and Tukey.[13] Quantitative variables were adjusted by analysis of covariance using the SAS statistical package, with means and standard deviations calculated in the usual way and the *t* test used for significance testing; adjustments were made for age alone and also for age and body mass index, since obesity is not only associated with plasma glucose but also with blood pressure[14] and serum lipids (positively with total cholesterol and triglyceride and negatively with high density lipoprotein cholesterol).[10]

Results

BODY MASS INDEX

One male and four females failed to have their height and weight recorded and 19 pregnant females were also excluded. The frequency distributions of body mass index (weight in kilograms divided by height in metres squared) were unimodal with skewing to the right, with Malay and Indian females showing a more kurtotic pattern because of a greater proportion with higher values. Mean values are shown in table I. For males the ethnic differences were small though in the older age groups Malays had somewhat higher values; in the 18–69 age group age adjustment showed that the only difference (0·8) was between Malays and Chinese (p=0·017). However for females, Malays and Indians were on average more obese than Chinese in all age groups (except for Indians in the 50–69 age group where numbers were small). The age adjusted means in the 18–69 age group show that the differences for Malays over Chinese (3·0) and Indians over Chinese (2·4) are both very highly significant (p<0·001).

CIGARETTE SMOKING

Table II shows that in males Malays have the highest proportion of current regular (at least one cigarette/day) smokers in all age groups, the age adjusted rate for the 18–69 age group showing a difference of 15·8% (p<0·001) with Chinese and 8·8% (NS) with Indians. However there was little difference in the mean number of cigarettes consumed by these smokers per day by ethnic group. Smoking is uncommon and unimportant in females (overall rate 3·0%).

BLOOD PRESSURE

Two females did not have their blood pressure taken. The frequency distributions for all six sex/ethnic groups were continuously unimodal with skewing to the right more pronounced for systolic than diastolic pressure. Table III shows that in both sexes, Malays tended to have higher mean systolic blood pressures than the other two ethnic groups, with Chinese and Indians much the same; the higher levels in Malays were more pronounced in the oldest age group (50–69 years). For the 18–69 age group the age adjusted difference in males between Malays and Chinese was 3·3 mm Hg (p=0·012), as it was between Malays and Indians (p=0·063). For females the difference between Malays and Chinese was 5·5 mm Hg (p<0·001) and between Malays and Indians 4·4 mm Hg (p=0·014). Adjusting for body mass index as well as for age reduced but did not remove the differences. In males the difference between Malays and Chinese (2·5 mm Hg) was almost significant at the 5% level (p=0·053), though that between Malays and Indians (2·7 mm Hg) was not significant (p=0·111). In females the difference between Malays and Chinese was 2·2 mm Hg (p=0·087) and between Malays and Indians 3·9 mm Hg (p=0·026).

Diastolic blood pressures were less different, though again Malays had the highest values in the oldest age group (50–69 years) for both sexes. For the age adjusted mean in the 18–69 age group, the differences in males were small and not significant; however for females Malays had higher values than Chinese (3·4 mm Hg, p<0·001) and Indians (2·5 mm Hg, p=0·023). Adjustment for body mass index largely removed the differences so that in males the mean values were virtually the same, though in females the values in Malays were still significantly higher than in Indians (2·1 mm Hg, p=0·046) but not Chinese.

The prevalence of definite hypertension (persons on antihypertensive therapy or with systolic pressure ≥160 mm Hg or diastolic pressure ≥95 mm Hg), together with the

Table I Mean body mass indices (BMI) by age group.

Age group (years)	Chinese n	Chinese Mean (SD)	Malay n	Malay Mean (SD)	Indian n	Indian Mean (SD)
			Males			
18–29	237	21·5 (3·9)	102	21·9 (3·5)	64	21·2 (3·3)
30–49	337	22·8 (3·9)	66	23·8 (4·1)	54	24·2 (3·5)
50–69	129	23·0 (3·4)	47	24·3 (3·6)	39	22·8 (3·4)
18–69	703	22·4 (3·9)	215	23·0 (3·8)	157	22·6 (3·6)
18–69*	703	22·3 (0·2)	215	23·1 (0·3)	157	22·5 (0·3)
			Females			
18–29	222	20·3 (3·3)	88	22·4 (4·6)	61	22·4 (5·0)
30–49	348	22·8 (3·6)	90	26·5 (4·7)	68	26·2 (5·0)
50–69	111	24·0 (4·9)	42	27·8 (5·4)	14	22·8 (7·6)
18–69	681	22·2 (4·0)	220	25·1 (5·3)	143	24·2 (5·6)
18–69*	681	22·2 (0·2)	220	25·1 (0·3)	143	24·6 (0·3)

*Mean (SE) age adjusted by analysis of covariance

Table II Proportion of males who are current regular cigarette smokers with the mean daily number smoked, by age group.*

Age group (years)	Chinese n	Chinese Smokers % (n)	Chinese Cigarettes/day Mean (SD)	Malay n	Malay Smokers % (n)	Malay Cigarettes/day Mean (SD)	Indian n	Indian Smokers % (n)	Indian Cigarettes/day Mean (SD)
18–29	237	30·4 (72)	16·3 (10·1)	102	55·9 (57)	16·9 (13·0)	64	48·4 (31)	12·1 (6·2)
30–49	338	39·1 (132)	20·8 (12·7)	66	47·0 (31)	20·4 (10·0)	54	46·3 (25)	17·4 (9·9)
50–69	129	47·3 (61)	18·7 (9·5)	47	61·7 (29)	15·2 (9·5)	39	33·3 (13)	14·8 (8·3)
18–69	704	37·6 (265)	19·1 (11·5)	215	54·4 (117)	17·4 (11·5)	157	43·9 (69)	14·5 (8·3)
18–69†	704	37·4		215	53·3		157	44·5	

*At least one cigarette/day
†Age adjusted by direct standardisation to total male study population

Table III Mean blood pressure (mm Hg) by age group.

Age group	Chinese n	Chinese Systolic Mean (SD)	Chinese Diastolic Mean (SD)	Malay n	Malay Systolic Mean (SD)	Malay Diastolic Mean (SD)	Indian n	Indian Systolic Mean (SD)	Indian Diastolic Mean (SD)
					Males				
18–29	237	116·4 (11·1)	69·9 (9·0)	102	116·0 (11·1)	69·5 (9·3)	64	114·4 (10·3)	69·0 (9·5)
30–49	338	119·2 (15·2)	76·2 (11·9)	66	121·7 (14·7)	77·2 (11·2)	54	122·3 (15·8)	79·9 (11·0)
50–69	129	137·8 (23·6)	82·5 (11·5)	47	144·3 (21·5)	83·4 (10·3)	39	132·1 (20·8)	79·7 (9·9)
18–69	704	121·7 (17·7)	75·3 (11·8)	215	123·9 (18·6)	74·9 (11·5)	157	121·5 (16·7)	75·3 (11·4)
18–69*	704	121·2 (0·6)	75·0 (0·4)	215	124·6 (1·2)	75·2 (0·7)	157	121·2 (1·4)	75·2 (0·8)
18–69†	703	121·8 (0·6)	75·5 (0·4)	215	124·3 (1·1)	75·0 (0·7)	157	121·5 (1·3)	75·5 (0·8)
					Females				
18–29	225	107·5 (11·4)	65·4 (9·1)	91	111·0 (11·9)	67·7 (8·8)	61	107·4 (10·1)	65·7 (7·9)
30–49	357	116·8 (17·9)	72·6 (10·8)	93	122·9 (18·2)	77·3 (11·5)	68	120·5 (25·5)	74·7 (11·7)
50–69	112	139·0 (28·5)	80·3 (13·0)	44	144·5 (27·7)	82·8 (11·2)	14	139·4 (20·0)	80·0 (10·4)
18–69	694	117·4 (21·1)	71·5 (11·8)	228	122·3 (22·0)	74·5 (12·0)	143	116·8 (22·0)	71·4 (11·3)
18–69*	694	117·3 (0·6)	71·4 (0·4)	228	122·8 (1·1)	74·8 (0·7)	143	118·4 (1·4)	72·2 (0·9)
18–69†	691	118·0 (0·6)	72·0 (0·4)	226	120·2 (1·1)	72·7 (0·8)	142	116·2 (1·4)	70·5 (0·7)

Mean (SE) adjusted by analysis of covariance for *age, †age and BMI.

Table IV Prevalence of definite hypertension and proportion on therapy by age group.

Age group (years)	Chinese n	Chinese Hypertension % (n)	Chinese On therapy % (n)	Malay n	Malay Hypertension % (n)	Malay On therapy % (n)	Indian n	Indian Hypertension % (n)	Indian On therapy % (n)
					Males				
18–29	237	2·1 (5)	40·0 (2)	102	1·0 (1)	0 (0)	64	0·0 (0)	0 (0)
30–49	338	8·3 (28)	42·9 (12)	66	16·7 (11)	54·5 (6)	54	14·8 (8)	37·5 (3)
50–69	129	33·3 (43)	51·2 (22)	47	38·3 (18)	50·0 (9)	39	28·2 (11)	54·5 (6)
18–69	704	10·8 (76)	47·4 (36)	215	14·0 (30)	50·0 (15)	157	12·1 (19)	47·4 (9)
30–69	467	15·2 (71)	47·9 (34)	113	25·7 (29)	51·7 (15)	93	20·4 (19)	47·4 (9)
30–69*	467	15·4		113	22·8		93	18·6	
					Females				
18–29	225	0·0 (0)	0 (0)	91	0·0 (0)	0 (0)	61	0 (0)	0 (0)
30–49	357	7·3 (26)	38·5 (10)	93	9·7 (9)	44·4 (4)	68	10·3 (7)	42·9 (3)
50–69	112	28·6 (32)	50·0 (16)	44	38·6 (17)	29·4 (5)	14	14·3 (2)	50·0 (1)
18–69	694	8·4 (58)	44·8 (26)	228	11·4 (26)	34·6 (9)	153	6·3 (9)	44·4 (4)
30–69	469	12·4 (58)	44·8 (26)	137	19·0 (26)	34·6 (9)	82	11·0 (9)	44·4 (4)
30–69*	469	13·3		137	17·9		82	11·4	

*Age adjusted by direct standardisation to total study population

Table V Mean serum lipid concentrations (mmol/litre) in males by age group.

Age group (years)	Chinese n	Chinese Mean (SD)	Malay n	Malay Mean (SD)	Indian n	Indian Mean (SD)
			Total cholesterol			
18–29	236	5·13 (1·18)	102	5·22 (1·20)	64	5·09 (1·10)
30–49	329	5·97 (1·24)	65	6·16 (1·33)	54	6·28 (1·34)
50–69	127	6·26 (1·20)	45	6·32 (1·29)	39	6·09 (1·22)
18–69	692	5·74 (1·29)	212	5·74 (1·36)	157	5·75 (1·33)
18–69*	692	5·72 (0·05)	212	5·78 (0·08)	157	5·74 (0·10)
18–69†	691	5·74 (0·05)	212	5·77 (0·08)	157	5·75 (0·09)
			LDL cholesterol			
18–29	235	3·79 (1·06)	102	3·90 (1·12)	63	3·85 (1·07)
30–49	328	4·39 (1·14)	63	4·60 (1·36)	54	4·74 (1·12)
50–69	127	4·56 (1·19)	45	4·63 (1·06)	39	4·54 (1·21)
18–69	690	4·22 (1·16)	210	4·27 (1·23)	156	4·33 (1·19)
18–69*	690	4·20 (0·04)	210	4·30 (0·08)	156	4·32 (0·09)
18–69†	689	4·22 (0·04)	210	4·29 (0·08)	156	4·33 (0·09)
			HDL cholesterol			
18–29	235	0·84 (0·33)	102	0·78 (0·29)	63	0·66 (0·25)
30–49	328	0·87 (0·34)	63	0·84 (0·33)	54	0·64 (0·25)
50–69	127	0·93 (0·36)	45	0·86 (0·27)	39	0·80 (0·38)
18–69	690	0·87 (0·34)	210	0·82 (0·30)	156	0·69 (0·29)
18–69*	690	0·87 (0·01)	210	0·82 (0·02)	156	0·69 (0·03)
18–69†	689	0·85 (0·01)	210	0·82 (0·02)	156	0·69 (0·03)
			Fasting triglyceride			
18–29	218	1·02 (0·56)	93	1·10 (0·54)	55	1·13 (0·49)
30–49	309	1·51 (1·08)	61	1·46 (0·60)	49	1·62 (0·78)
50–69	118	1·59 (0·97)	42	1·76 (0·86)	35	1·55 (0·55)
18–69	645	1·36 (0·95)	196	1·36 (0·69)	139	1·40 (0·66)
18–69*	645	1·35 (0·03)	196	1·37 (0·05)	139	1·40 (0·06)
18–69†	644	1·37 (0·03)	196	1·36 (0·05)	139	1·42 (0·06)

Mean (SE) adjusted by analysis of covariance for *age, †age and BMI. LDL=low density lipoprotein; HDL=high density lipoprotein.

Table VI Mean serum lipid concentrations (mmol/litre) in females by age group.

Age group (years)	Chinese n	Chinese Mean (SD)	Malay n	Malay Mean (SD)	Indian n	Indian Mean (SD)
			Total cholesterol			
18–29	215	5·37 (1·04)	80	5·48 (1·00)	61	5·26 (0·97)
30–49	333	5·93 (1·24)	75	6·25 (1·23)	67	5·83 (1·41)
50–69	109	6·86 (1·52)	43	6·39 (0·91)	14	6·80 (1·09)
18–69	657	5·90 (1·32)	198	5·97 (1·15)	142	5·68 (1·29)
18–69*	657	5·89 (0·05)	198	5·97 (0·08)	142	5·76 (0·10)
18–69†	654	5·91 (0·05)	198	5·88 (0·09)	141	5·68 (0·10)
			LDL cholesterol			
18–29	214	3·90 (1·01)	80	4·00 (0·96)	60	3·86 (0·94)
30–49	331	4·40 (1·16)	73	4·60 (1·11)	67	4·27 (1·22)
50–69	108	5·11 (1·46)	43	4·62 (0·86)	14	5·22 (1·04)
18–69	653	4·35 (1·24)	196	4·36 (1·04)	141	4·19 (1·15)
18–69*	653	4·34 (0·04)	196	4·36 (0·08)	141	4·25 (0·09)
18–69†	650	4·37 (0·04)	196	4·27 (0·08)	140	4·18 (0·09)
			HDL cholesterol			
18–29	214	1·08 (0·40)	80	1·09 (0·33)	60	0·96 (0·33)
30–49	331	1·01 (0·36)	73	0·99 (0·41)	67	0·94 (0·37)
50–69	108	1·12 (0·45)	43	1·01 (0·29)	14	0·88 (0·34)
18–69	653	1·05 (0·39)	196	1·04 (0·36)	141	0·94 (0·35)
18–69*	653	1·05 (0·01)	196	1·03 (0·03)	141	0·95 (0·03)
18–69†	650	1·04 (0·01)	196	1·09 (0·02)	140	0·99 (0·03)
			Fasting triglyceride			
18–29	209	0·84 (0·42)	75	0·91 (0·51)	57	0·85 (0·35)
30–49	319	1·12 (0·68)	73	1·30 (0·67)	63	1·28 (0·75)
50–69	104	1·39 (0·72)	41	1·52 (0·87)	13	1·58 (0·85)
18–69	632	1·07 (0·63)	189	1·19 (0·71)	133	1·13 (0·67)
18–69*	632	1·07 (0·03)	189	1·20 (0·05)	133	1·17 (0·06)
18–69†	629	1·09 (0·03)	189	1·06 (0·05)	132	1·08 (0·06)

Mean (SE) adjusted by analysis of covariance for *age, †age and BMI. LDL=low density lipoprotein; HDL=high density lipoprotein.

proportion on therapy, is shown in table IV. It can be seen that in the 18–29 age group the prevalence rates were low but for the older groups (30–49 years and 50–69 years) Malays had the highest rates, with no consistent difference between Chinese and Indians. The age adjusted rates were clearly highest in Malays but not at a statistically significant level. The proportion of hypertensives on therapy showed little ethnic difference for males (being around half). For females the proportions were somewhat lower than for males in all ethnic groups, with Malays having a lower proportion than Chinese and Indians in the 50–69 age group, though not a significant level.

SERUM LIPIDS

The blood samples from both fasting and non-fasting subjects were used for cholesterol determinations, but only those from subjects who had fasted for at least 10 h for triglyceride. Women who were pregnant or on the contraceptive pill were removed from the analysis. The frequency distributions for all sex-ethnic groups were continuously unimodal with skewing to the right which was slight for total and low density lipoprotein cholesterol, somewhat more for high density lipoprotein cholesterol, and marked for triglyceride.

Mean concentrations are shown in table V for males and table VI for females; the numbers of subjects for low and high density lipoprotein cholesterol were slightly less than those for total cholesterol since insufficient blood was removed in these cases. For total cholesterol, low density lipoprotein cholesterol and triglyceride the ethnic differences were small, even for the overall age adjusted means, and the only significant difference was for Malay females over Chinese females for fasting triglyceride (0·13 mmol/litre, $p = 0{\cdot}028$). With adjustment for body mass index the only significant ethnic differences in the 18–69 age group were higher mean concentrations in Chinese females than Indian females for total cholesterol (0·23 mmol/litre, $p = 0{\cdot}039$) and low density lipoprotein cholesterol (0·19 mmol/litre, $p = 0{\cdot}069$).

Ethnic differences were however found for high density lipoprotein cholesterol, Indians having the lowest mean concentrations and Chinese the highest in all age groups for both sexes, the differences being greater for males than females. Age adjusted means in the male 18–69 age group showed that Indians had lower values than Chinese (0·18 mmol/litre, $p < 0{\cdot}001$) and Malays (0·13 mmol/litre, $p < 0{\cdot}001$); among the females, Indians also had lower values than Chinese (0·10 mmol/litre, $p = 0{\cdot}002$) and Malays (0·08 mmol/litre, $p = 0{\cdot}027$). The differences between Malays and Chinese are not statistically significant. Adjustment for body mass index had only a small effect; for males Indians had lower mean concentrations than Chinese (0·17 mmol/litre, $p < 0{\cdot}001$) and Malays (0·14 mmol/litre, $p < 0{\cdot}001$), and for females the differences were smaller but still present, Indians having lower values than Chinese (0·05 mmol/litre, $p = 0{\cdot}103$) and Malays (0·10 mmol/litre, $p = 0{\cdot}009$).

PLASMA GLUCOSE AND DIABETES

The frequency distributions of plasma glucose in persons who had fasted for at least 10 h were continuously unimodal with skewing to the right (pregnant females were excluded). Mean concentrations are shown in table VII. For males in the older age groups Indians had the highest mean values, then Malays, and Chinese had the lowest; for the age adjusted 18–69 age group, lower values were found in Chinese than Malays (0·3 mmol/litre, $p = 0{\cdot}004$) and Indians (0·5 mmol/litre, $p < 0{\cdot}001$). Among the older females Malays and Indians had higher values than Chinese, and age adjustment in the 18–69 age group shows that Chinese had lower values than Malays (0·4 mmol/litre, $p < 0{\cdot}001$) and Indians (0·4 mmol/litre, $p = 0{\cdot}002$). Adjustment for body mass index in the 18–69 age group shows that among males Malays still had a higher mean concentration than Chinese (0·3 mmol/litre, $p = 0{\cdot}008$), as did Indians (0·5 mmol/litre, $p < 0{\cdot}001$), while among females Malays and Indians also had higher mean concentrations than Chinese, at 0·3 mmol/litre ($p = 0{\cdot}023$) and 0·4 mmol/litre ($p = 0{\cdot}008$) respectively. The higher mean concentrations in Indians than Malays (males 0·21 mmol/litre, females 0·09 mmol/litre) did not reach statistical significance.

Table VIII shows the prevalence of diabetes in the age groups 18–39 and 40–69 years. It can be seen that before the age of 40 years the condition was uncommon in all ethnic groups, though this changes in the older age group. For males the prevalence was highest in Indians, then Malays, and then Chinese with a difference of 25·8% between Indians and Chinese ($p < 0{\cdot}001$) and 13·1% between Malays and Chinese ($p = 0{\cdot}004$). For females the prevalence was similar in Indians and Malays, and higher in both than in the Chinese, though the differences are not

Table VII Mean fasting plasma glucose concentrations (mmol/litre) by age group.

Age group (years)	Chinese		Malay		Indian	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
			Males			
18–29	216	4·8 (0·5)	93	4·8 (0·6)	55	4·7 (0·8)
30–49	309	5·1 (0·9)	61	5·4 (1·9)	49	5·6 (1·4)
50–69	116	5·6 (1·5)	43	6·5 (3·4)	35	6·9 (3·2)
18–69	641	5·1 (1·0)	197	5·4 (2·0)	139	5·6 (2·0)
18–69*	641	5·1 (0·1)	197	5·4 (0·1)	139	5·6 (0·1)
18–69†	640	5·1 (0·1)	197	5·4 (0·1)	139	5·6 (0·1)
			Females			
18–29	214	4·7 (0·4)	79	4·8 (0·6)	56	4·7 (0·5)
30–49	330	5·0 (1·1)	85	5·2 (1·2)	64	5·8 (2·6)
50–69	103	5·4 (1·6)	42	6·9 (3·9)	13	5·9 (2·2)
18–69	647	5·0 (1·1)	206	5·4 (2·1)	133	5·3 (2·0)
18–69*	647	5·0 (0·1)	206	5·4 (0·1)	133	5·4 (0·1)
18–69†	644	5·0 (0·1)	206	5·3 (0·1)	132	5·4 (0·1)

Mean (SE) adjusted by analysis of covariance for *age, †age and BMI

Table VIII Prevalence of diabetes mellitus (DM) and impaired glucose tolerance (IGT) by age group.

	Chinese			Malay			Indian		
Age group (years)	n	DM % (n)	IGT % (n)	n	DM % (n)	IGT % (n)	n	DM % (n)	IGT % (n)
				Males					
18–39	434	0·7 (3)	0·5 (2)	137	0·7 (1)	0·0 (0)	104	0·0 (0)	3·8 (4)
40–69	270	10·0 (27)	1·1 (3)	78	23·1 (18)	1·3 (1)	53	35.8 (19)	3·8 (2)
				Females					
18–39	427	0·7 (3)	0·7 (3)	139	0·7 (1)	0·0 (0)	98	1·0 (1)	1·0 (1)
40–69	268	7·8 (21)	0·0 (0)	89	13·5 (12)	2·2 (2)	46	13·0 (6)	2·2 (1)

statistically significant.

Impaired glucose tolerance (also in table VIII) was uncommon before the age of 40 years in either sex, except in Indian males where the prevalence was 3·8%. After the age of 40 years, the prevalence among males was higher in Indians than in Malays and Chinese, while among females it was the same in Malays and Indians, and higher in both than it was in the Chinese.

ALCOHOL INTAKE

"Heavy" consumption was defined as more than six drinks either daily or once or twice a week, a drink being a small bottle or half pint of beer, a glass of wine, or a measure of spirit. "Moderate" consumption was defined as drinking daily or on most days but less than six drinks, and "light" consumption, once or twice a week and less than six drinks. "Occasional" consumption was defined as drinking only once or twice a month or on special occasions. Even when "heavy" and "moderate" consumption were combined the age adjusted proportions for the 18–69 age group were low, being in males: Chinese 5·5%, Malays 0·5%, Indians 3·7%; and in females: Chinese 0·3% and zero in Malays and Indians.

Discussion

The response rate of 60·3%, while a little disappointing, is reasonable considering the extensive nature of the survey. There are several reasons for believing this has not produced significant bias. In the first place the respondents closely resembled in age and sex distribution the sample and the sampling frame. Also the response rate was similar in the ethnic groups, so that at least interethnic comparisons are valid. To check on any possible bias a comparison was also made between mean values of risk factors in the persons who responded to the initial request (44% response) and the total response (60%) after "chasing up" the non-responders and the differences were small for all the variables with none of them reaching significance at the 5% level.

This study has shown that Indians (80% of whom have their origins in southern India and Sri Lanka) do not have higher levels than Chinese and Malays for the three major risk factors (cigarette smoking, blood pressure, and serum total cholesterol or low density lipoprotein cholesterol). In contrast in Trinidad mean low density lipoprotein cholesterol concentrations have been reported as being higher in Indians than in other ethnic groups for men but not for women[15] though it was subsequently reported that the difference could not account for ethnic differences in mortality from cardiovascular diseases.[16] Diabetes has been found to be more common in Indians, as has been found in Trinidad,[16] Fiji,[17] London,[18] and previously in Singapore,[19] and this may account for part of their higher risk of ischaemic heart disease which has been found in Singapore.[1] However the higher prevalence of diabetes in Indians found in this survey was mainly in males yet their excess mortality from ischaemic heart disease was nearly as great in females as males.[1] This survey indicates that the high prevalence of diabetes in Indian males is not explained by greater obesity. Malays have been found to have a higher prevalence of diabetes than Chinese and it is the same as for female Indians.

Indians had lower high density lipoprotein cholesterol levels than Chinese or Malays (unexplained by obesity) in both males and females, the difference being greater in males; this has also been reported in Indians of both sexes in Trinidad,[15] and in females but not males in London.[20] The role of low levels of high density lipoprotein cholesterol as a risk factor for ischaemic heart disease is controversial. It has been a feature of some studies[21 22] but not others.[23 24] The lower levels may indicate that Indians remove cholesterol less efficiently and this may explain some of their excess risk from ischaemic heart disease. Obesity does not seem part of the explanation, certainly in males, and while in females Indians have higher body mass indices than Chinese they are similar to the Malays. Alcohol consumption is low compared to Western countries[2] and on a population basis is probably not a significant risk factor in any ethnic group. The independent association of serum triglyceride concentrations and ischaemic heart disease is unclear;[25] however here again the levels are very similar amongst the ethnic groups.

Hence the higher mortality from ischaemic heart disease found in Singapore for Indians[1] cannot be explained by conventional major risk factors. The contributions of a greater prevalence of diabetes, especially in males, and lower high density lipoprotein cholesterol concentrations are unclear on present evidence. The conclusion which has been drawn in Trinidad is that the propensity of Indians for ischaemic heart disease is not explained by major coronary risk factors.[16]

The explanation for the higher mortality from ischaemic heart disease in Malays relative to Chinese[1] can be attributed at least in part to their greater cigarette consumption (in males) and higher systolic blood pressures (only partially explained by obesity differences). In the Hypertension Survey in Singapore carried out in 1974 on persons aged 20 years and above, it was found (although the differences were not statistically significant) that Malays did tend to have slightly higher mean blood pressures as well as prevalence rates of hypertension; however in this survey no history was taken of hypertension and drug therapy and there were 15 non-medical observers measuring the blood pressures.[26] The presence of these risk factor differences (cigarette smoking and blood pressure) may explain why the excess mortality from ischaemic heart disease in Malays over Chinese does not decline with age, whereas it does for the Indian excess over Malays and Chinese.[1]

Higher systolic blood pressures can also explain the Malays' higher mortality from hypertensive disease;[1] the greater excess in females than males may be due to the fact that Malay females have a lower proportion of the hypertensives on treatment in the oldest age group (50–69 years), though this is not at a statistically significant level. However it is not clear why the higher blood pressures in Malays are not reflected more in cerebrovascular disease mortality where there is little difference by ethnic group;[1] in most studies hypertension has been found to be the important risk factor for this condition, with the other risk factors for ischaemic heart disease (cigarette smoking, serum lipids) having little effect.[27]

It should be noted that persons on antihypertensive therapy were classified as having definite hypertension irrespective of their blood pressure readings in the survey and this should be considered in comparing prevalence rates with other surveys. The proportion of the hypertensives on therapy (48% in males, and 42% in females) is high compared to about 25% found in surveys in the West a few years ago.[28] The finding in this survey that Indians do not have higher blood pressures than Chinese and Malays is in keeping with the finding that their mortality from cerebrovascular disease and hypertensive disease is not higher than in the other two ethnic groups.[1]

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