Changes in population cholesterol concentrations and other cardiovascular risk factor levels after five years of the non-communicable disease intervention programme in Mauritius

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See p 1251, 1260

Abstract

***Objective*—To study changes in the prevalence of risk factors for cardiovascular disease after a five year population-wide intervention programme promoting a healthy lifestyle in a developing country.**

***Design*—Cross sectional cluster surveys in 1987 and 1992. Methodology included a two hour 75 g oral glucose tolerance test, measurement of body mass index, waist:hip ratio, basal lipid concentrations, and blood pressure; and a lifestyle questionnaire.**

***Setting*—Mauritius, in the Indian Ocean.**

***Subjects*—All adults aged 25-74 years residing in geographically defined clusters.**

***Main outcome measures*—Age standardised prevalence of categorical disease and risk factor conditions and mean levels and frequency distributions of continuous variables.**

***Results*—Response rates were 86·2% (5080/5892) in 1987 and 89·5% (5162/5770) in 1992. Significant decreases were found in the prevalence of hypertension (15·0% to 12·1% in men and 12·4% to 10·9% in women); cigarette smoking (58·2% to 47·2% and 6·9% to 3·7% respectively); and heavy alcohol consumption (38·2% to 14·4% and 2·6% to 0·6% respectively). Moderate leisure physical activity increased from 16·9% to 22·1% in men and from 1·3% to 2·7% in women. Mean population serum total cholesterol concentration fell appreciably from 5·5 mmol/l to 4·7 mmol/l ($P<0·001$). The prevalence of overweight or obesity increased, and the rates of glucose intolerance changed little. The population frequency distributions of blood pressure, serum lipid concentration, and a composite risk factor score shifted advantageously.**

***Conclusions*—Lifestyle intervention projects can be implemented and have positive effects in developing countries. A pronounced improvement in the population lipid profile in Mauritius was probably related to a change in the saturated fat content of a widely used cooking oil.**

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Introduction

The multiethnic island nation of Mauritius in the Indian Ocean has experienced rapid industrialisation and general improvement in living standards over the past two decades, and its gross national product per head of US$2410 (£1607) in 1991 is at the upper end of the range for developing countries.[1] Its mortality, however, both for coronary heart disease and for diabetes mellitus exceeds that of most Western countries.[2]

Alarmed by its country's high and increasing rates of cardiovascular disease, the government of Mauritius instituted a national non-communicable disease intervention programme in 1987, after a baseline survey of the distribution of disease and risk factors, which confirmed that the prevalence of non-insulin dependent diabetes mellitus, hypertension, and coronary heart disease was indeed high.[3-6] A dedicated non-communicable disease unit was created within the Ministry of Health, and since 1988 this unit has coordinated an intensive national programme aimed at modifying levels of risk factors related to lifestyle, including glucose intolerance, hypertension, hyperlipidaemia, obesity, cigarette smoking, alcohol misuse, and physical inactivity.

Primary prevention components of the programme have included extensive use of the mass media; fiscal and legislative measures; and widespread community, school, and workplace health education activities. All these components have promoted healthy nutrition, increased exercise, smoking cessation, and reduction in alcohol intake. The Mauritian programme is a demonstration project within the framework of the World Health Organisation's "Interhealth" initiative.[7]

Mortality from cardiovascular disease has decreased in several Western countries over the past 30 years, and at least some of the decline has been ascribed to reductions in risk factor levels.[8-10] The Finnish North Karelia project showed that population interventions can favourably influence cardiovascular risk factor levels and disease outcomes,[11] but there are no comparable data from less developed countries. In 1992, five years after the start of the Mauritius programme, we performed a follow up study to evaluate the effects of the lifestyle intervention programme.

Subjects and methods

SAMPLING AND RESPONSE

The eligible population for the 1987 survey comprised all adults aged 25-74 years living in 10 randomly selected population clusters, plus an 11th area, which we deliberately selected for its geographic concentration of the minority Chinese community.[3] The overall response rate was 86·2% (5080/58932. These eligibility criteria also applied for the 1992 survey (response rate 86·6% (2366/2732) in men and 92·0% (2796/3038) in women).

We also studied age stratified samples from three independent population clusters in 1992. We selected each cluster deliberately to represent one of the main ethnic communities in Mauritius. Response in the independent sample was 81·9% (605/739) in men and 93·3% (696/746) in women. Unless otherwise stated, data from the original 11 clusters only are reported.

The ethnic breakdown of the random sample was close to national estimates (table I). The inclusion of the 11th area (Chinatown) led to a deliberate over-inclusion of Chinese subjects. This had little effect on overall results for either 1987 or 1992, and comparisons reported here are for the 11 survey areas. The 1992 sample underrepresented the age group 25-34 years (table I), and hence age specific or age standardised estimates are reported.

SURVEY PROCEDURE

We performed the follow up study in April and May 1992. Methods were standardised to those in 1987, and

in many instances the same staff took part. For each location we invited subjects to a central survey site where a fasting blood sample was collected: all except diabetic subjects receiving treatment had a two hour 75 g oral glucose tolerance test.[3,4] Other procedures undertaken in both 1987 and 1992 included measurement of height, weight, waist and hip circumferences, and blood pressure; and administration of a short questionnaire.[4-6]

Blood pressure was measured twice in the right arm of seated subjects with cuffs and bladder size 40-42 cm×12-14 cm.[5] There were five principal blood pressure observers in 1987, and four in 1992, three of whom also participated in 1987. Observers were trained by using videotapes and double headed stethoscopes. Hypertension was defined according to the WHO criteria as mean systolic pressure ≥160 mm Hg or diastolic (phase V) pressure ≥95 mm Hg, or both, or self reported current use of antihypertensive drugs. Borderline hypertension was systolic pressure >140 mm Hg but <160 mm Hg, or diastolic pressure >90 mm Hg but <95 mm Hg.[12]

We calculated body mass index as weight(kg)/(height(m))^2. We measured waist and hip circumferences twice and used the means to calculate the waist:hip ratio.[4] Trained interviewers graded physical activity during leisure on a four point scale (1=sedentary, 2=light, 3=moderate, 4=heavy) as described previously.[4,13] In these analyses we have combined the moderate and heavy categories.

LABORATORY METHODS

We measured plasma glucose concentrations immediately after the collection of blood at the survey site in both 1987 and 1992 (YSI glucose analysers, Yellow Springs Instruments). Concentrations of total and high density lipoprotein cholesterol, fasting triglycerides, and uric acid were measured at the Central Laboratory, Mauritius, in fresh heparin plasma (1987) and serum (1992). External quality assurance on every 10th sample was undertaken in Newcastle upon Tyne. Methods remained constant at the Newcastle reference laboratory, which is a member of the Wellcome quality assurance scheme. In 1987 the Mauritius laboratory used manual enzymatic methods, but in 1992 it used a Chemistry Profile Analyser Model LS (Coultronics). On the basis of the external quality assurance data, Mauritian values for concentrations of both total cholesterol (1987) and triglycerides (1987 and 1992) were adjusted downwards by using calculated regression equations.

STATISTICAL ANALYSIS

Prevalence was age standardised by the direct method, and 95% confidence limits for the difference in prevalence were calculated,[14] with the 1986 Mauritius population as the standard. A categorical risk factor score was computed which included components for glucose intolerance (0=normal, 1=impaired glucose tolerance or diabetes); blood pressure (0=normal, 1=borderline or hypertension); cigarette smoking (0=non-smoker or former smokers, 1=current smoker); and total cholesterol concentration (0=values <5·2 mmol/l, 1=values ≥5·2 mmol/l). Component values were added, giving a score which ranged from 0 (low risk) to 4 (high risk).

Data were analysed with the Statistical Package for the Social Sciences (SPSS),[15] Changes between 1987 and 1992 in categorical conditions were assessed with saturated log-linear models,[15] which included survey year, ethnic group (Indian, Creole, Chinese), and age (25-34, 35-54, 55-74) main effects, plus interaction terms. The importance of year in determining variation in mean levels of continuous variables was investigated with *t* tests and analysis of variance, with ethnic group and age group (10 year strata) being controlled for.

TABLE I—*Ethnic group and age distribution of 1992 survey population (ages 25-74 years) compared with estimate for Mauritius. Values are numbers (percentages) of persons*

	Estimated breakdown for Mauritius*	Random sample: Eligible to respond (n=5324)	Random sample: Respondents (n=4798)	Full sample†: Eligible to respond (n=5770)	Full sample†: Respondents (n=5162)
Ethnic group:					
Hindu Indian	555 742 (53·6)	2880 (54·1)	2647 (55·2)	2880 (49·9)	2647 (51·3)
Muslim Indian	170 041 (16·4)	807 (15·1)	722 (15·2)	807 (14·0)	732 (14·2)
Creole	289 276 (27·9)	1574 (29·6)	1363 (28·4)	1574 (27·3)	1363 (26·4)
Chinese	21 774 (2·1)	63 (1·2)	56 (1·2)	509 (8·8)	420 (8·1)
Age group (years):					
25-34	195 161 (37·6)	1501 (28·2)	1294 (27·0)	1568 (27·2)	1344 (26·0)
35-44	138 585 (26·7)	1661 (31·2)	1505 (31·4)	1772 (30·7)	1589 (30·8)
45-54	84 604 (16·3)	935 (17·6)	863 (18·0)	1062 (18·4)	974 (18·9)
55-64	62 285 (12·0)	759 (14·3)	702 (14·6)	852 (14·8)	780 (15·1)
65-74	38 409 (7·4)	468 (8·8)	434 (9·0)	516 (8·9)	475 (9·2)

*As on 30 June 1990. Population: all ages, 1 036 833; ages 25-74, 519 044. †Includes Chinatown.

Results

GLUCOSE INTOLERANCE AND HYPERTENSION

Small, non-significant increases occurred in the prevalence of diabetes in both men and women, and the prevalence of impaired glucose tolerance declined in women. The changes between the two studies in the frequency of glucose intolerance were not independently important in log-linear models (table II). The prevalence of hypertension decreased by 19·3% in men and by 12·1% in women. Borderline hypertension also declined in both men and women, and the changes in the prevalence of hypertension were significant after age and ethnic group were controlled for (table II). The decrease in hypertension was population-wide and occurred in all ethnic groups and most age groups. The distributions of both systolic (P<0·001) and diastolic (P=0·001) blood pressures shifted towards the left in both men and women (fig 1).

OBESITY AND LIFESTYLE

The prevalence of obesity or overweight, or both,

TABLE II—*Age standardised prevalence of non-communicable diseases and risk factors in Mauritians and difference in prevalence, 1987-92*

	% Prevalence: Men 1987 (n=2361)	Men 1992 (n=2363)	Men Difference (95% confidence interval)	Women 1987 (n=2715)	Women 1992 (n=2797)	Women Difference (95% confidence interval)	Significance*: Men	Significance*: Women
Disease or risk factor								
Diabetes	12·1	13·9	1·8 (0·0 to 3·6)	11·7	12·6	0·9 (−0·7 to 2·5)	NS	NS
Impaired glucose tolerance	13·5	14·0	0·5 (−1·4 to 2·4)	19·7	17·2	−2·5 (−4·6 to −0·4)		
Hypertension	15·0	12·1	−2·9 (−4·7 to −1·1)	12·4	10·9	−1·5 (−3·0 to 0·0)	P<0·001	P<0·001
Borderline hypertension	11·0	8·3	−2·7 (−4·4 to −1·0)	8·7	6·6	−2·1 (−3·4 to 0·8)		
Obesity (BMI>30 kg/m^2)	3·4	5·3	1·9 (0·7 to 3·1)	10·4	15·2	4·8 (3·0 to 6·6)	P<0·001	P<0·001
Overweight (BMI 25-30 kg/m^2)	22·8	30·4	7·6 (5·1 to 10·1)	27·6	32·9	5·3 (2·9 to 7·7)		
Cholesterol ≥6·5 mmol/l	24·5	5·6	−18·9 (−21·0 to −16·8)	22·0	4·5	−17·5 (−19·2 to −15·8)	P<0·001	P<0·001
Triglycerides ≥2·0 mmol/l	28·2	25·4	−2·8 (−5·4 to −0·2)	13·1	9·7	−3·4 (−5·0 to −1·8)	P<0·05	P<0·001

*P value from log-linear model for change between surveys in prevalence, after age group, ethnicity, and interactions were controlled for. For glucose tolerance, blood pressure, and body mass index, three-level disease/risk factor variables (for example, obesity, overweight, normal) were modelled.

TABLE III—*Age standardised prevalence of behavioural risk factors for non-communicable diseases in Mauritians and difference in prevalence, 1987-92*

Risk factor	% Prevalence: Men 1987 (n=2361)	Men 1992 (n=2363)	Men Difference (95% confidence interval)	Women 1987 (n=2715)	Women 1992 (n=2797)	Women Difference (95% confidence interval)	Significance*: Men	Significance*: Women
Current smoker	58·2	47·2	−11·0 (−13·9 to −8·1)	6·9	3·7	−3·2 (−4·4 to −2·0)	P<0·001	P<0·001
Moderate leisure activity	16·9	22·1	5·2 (2·9 to 7·5)	1·3	2·7	1·4 (0·6 to 2·2)	P<0·001	P<0·001
Frequent alcohol consumption†	18·2	14·4	−3·8 (−6·4 to −1·2)	2·1	1·6	−0·5 (−1·2 to 0·2)	P<0·001	NS
Heavy alcohol consumption	38·2	14·4	−23·8 (−25·9 to −21·7)	2·6	0·6	−2·0 (−2·7 to −1·3)	P<0·001	P<0·001

*P value from log-linear model for change between surveys in prevalence after age group, ethnicity, and interactions were controlled for. †Men ≥4 days/week; women ≥2 days/week.

increased in men and women, and the year effect was independently important (table II). Increases were seen in all ethnic groups and age groups. Similarly, mean waist:hip ratio and mean body mass index increased in all subgroups, and in analysis of variance the changes between the two surveys were independent of age and ethnic group ($P<0·001$) in both sexes. There were shifts to the right in the cumulative frequency distributions of body mass index and waist: hip ratio (fig 1).

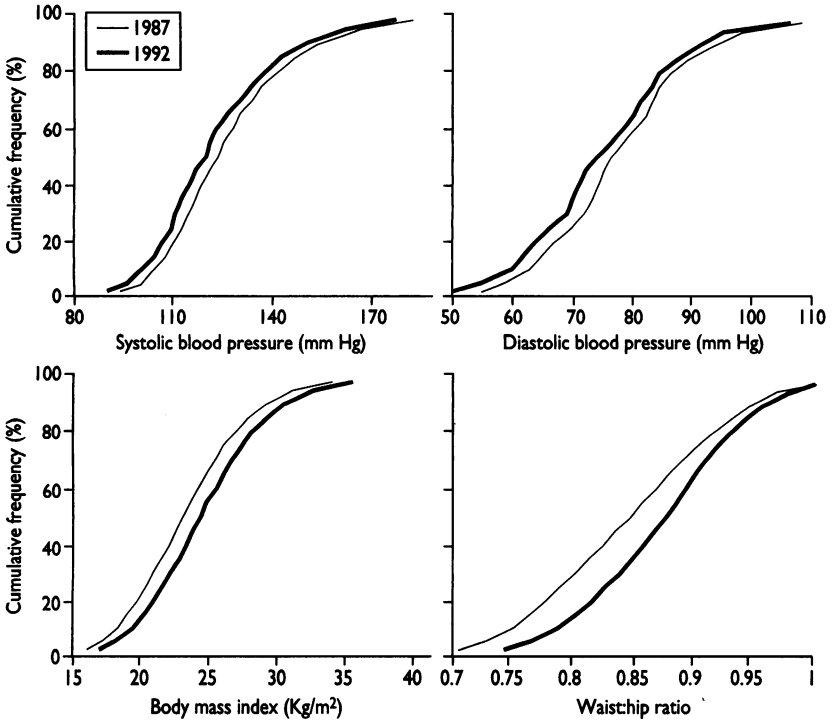

FIG 1—*Cumulative frequency distributions for systolic and diastolic blood pressure, body mass index and waist:hip ratio in Mauritians, 1987 and 1992*

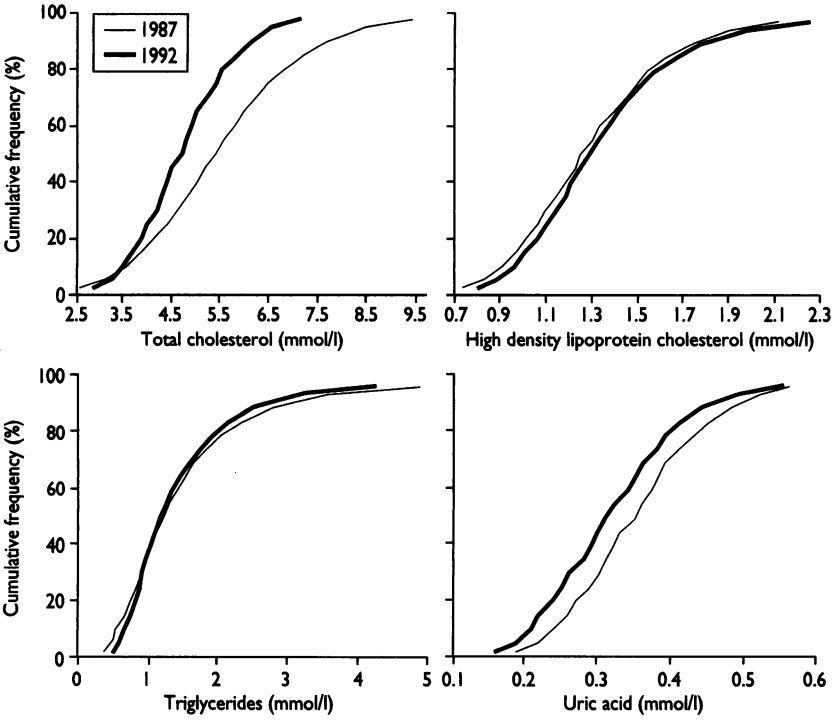

FIG 2—*Cumulative frequency distributions for total and high density lipoprotein cholesterol, fasting triglycerides, and uric acid in Mauritians, 1987 and 1992*

The prevalence of cigarette smoking decreased in both men and women (table III). These reductions occurred in all age groups. The proportion of Mauritians undertaking moderate or heavy leisure physical activity (aerobic activity lasting 30 minutes or more at least one day a week) increased from 16·9% to 22·1% in men, and from 1·3% to a still low 2·7% in women (table III). The increases were seen in all age groups.

Frequent alcohol consumption decreased in men from 18·2% to 14·4%, and this pattern was evident across all age groups and ethnic groups except Muslim Indian men. Alcohol consumption remained uncommon in women. Similarly, the prevalence of heavy drinking (average ≥3 standard drinks a day) decreased in both men and women (table III).

SERUM CONCENTRATIONS OF LIPIDS AND URIC ACID

Dramatic reductions occurred in the prevalence of hypercholesterolaemia and hypertriglyceridaemia in both sexes (table II); these changes were observed in all ethnic groups (not shown). The frequency distributions of concentrations of total cholesterol, fasting triglycerides, and uric acid each shifted towards the left, while high density lipoprotein cholesterol shifted towards the right (fig 2). Reductions occurred in the mean concentrations of fasting triglycerides (1·52 *v* 1·45 mmol/l), total cholesterol (5·52 *v* 4·75 mmol/l), and uric acid (351 *v* 319 μmol/l), and high density lipoprotein cholesterol increased (1·29 *v* 1·33 mmol/l) ($P<0·001$ for each comparison). Figures 3 and 4 show age specific data: the change between the two surveys was independently associated with mean concentrations of each variable except triglycerides in both men and women. Concentrations in the independent sample were similar to those seen in the main study areas, confirming that changes to these variables were population-wide.

Discussion

These data show predominantly favourable trends in risk factor levels for cardiovascular disease in Mauritius from 1987 to 1992, including a shift to the left in the frequency distribution of a composite risk factor score (table IV).

GLUCOSE INTOLERANCE AND HYPERTENSION

The increase in the prevalence of diabetes is not surprising given the high prevalence of impaired glucose tolerance observed in the baseline survey[3] and the well documented risk of progression to diabetes from impaired glucose tolerance.[16] We had no data to enable us to assess whether improvements occurred in survival that may have contributed to the increase in prevalence. In any case, the overall prevalence

of glucose intolerance remains alarmingly high. The increasing prevalence of diabetes reflects similar trends observed recently in other developing[17 18] and developed[19] populations.

The decline in prevalence of hypertension is encouraging. It seems likely that a change in community lifestyle (for example, diet) and improved case finding and medical care together play a part in the decline. Certainly, the increase in leisure physical activity, the decline in alcohol consumption, and the beneficial changes in serum concentration of lipids may have favourably influenced blood pressure. Longitudinal data on salt consumption are not available, but the healthy lifestyle campaign also highlighted the need to reduce salt intake.

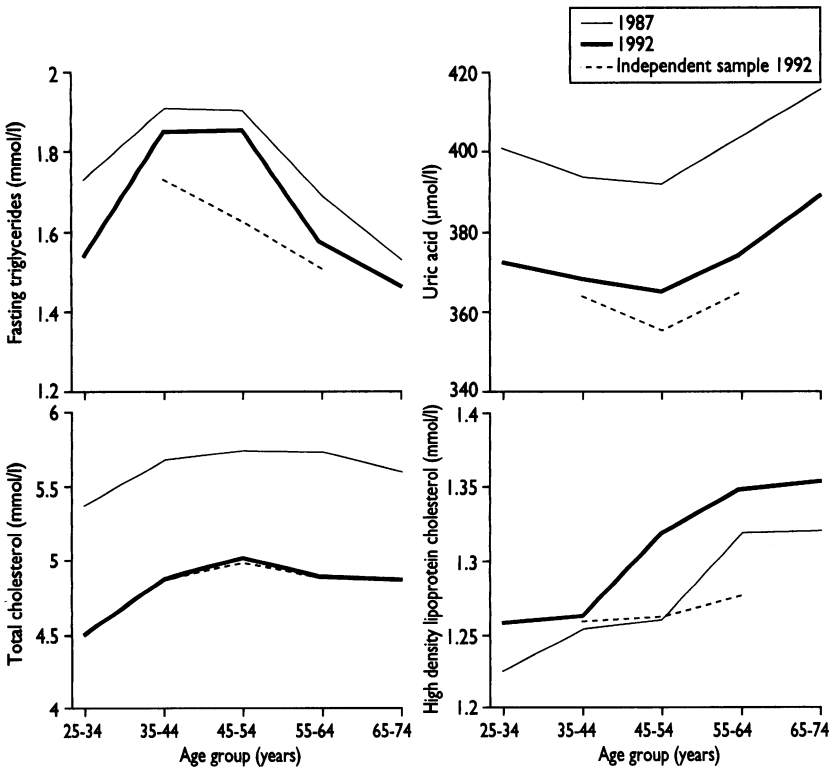

FIG 3—*Mean total and high density lipoprotein cholesterol, fasting triglycerides, and uric acid by age group in Mauritian men, 1987 and 1992. Significance levels from analysis of variance for change between two surveys in mean concentration of each variable, after age group, ethnicity, and interactions were controlled for were: total cholesterol, P<0·001; high density lipoprotein cholesterol, P<0·001; triglycerides, P>0·05; and uric acid, P<0·001*

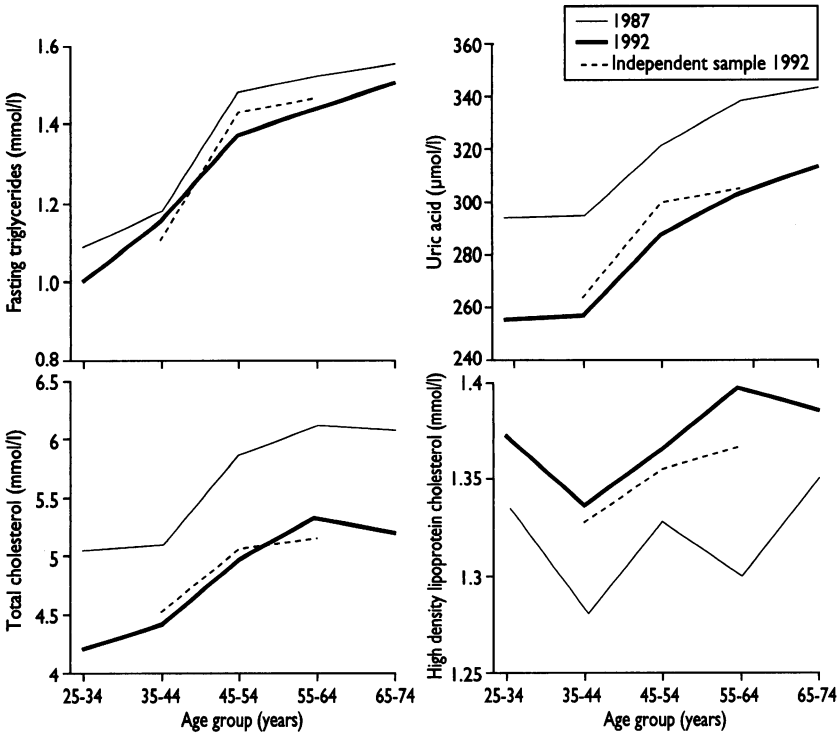

FIG 4—*Mean total and high density lipoprotein cholesterol, fasting triglycerides, and uric acid by age group in Mauritian women, 1987 and 1992. Significance levels from analysis of variance for change between two surveys in mean concentration of each variable, after age group, ethnicity, and interactions were controlled for: total cholesterol, P<0·001; high density lipoprotein cholesterol, P<0·001; triglycerides, P>0·05; and uric acid, P<0·001*

TABLE IV—*Distribution of values for risk factor score in Mauritians, 1987 and 1992. * Figures are numbers (percentages) of respondents in each score category*

Score	1987	1992
Men:	2291	2349
0	231 (10·1)	506 (21·5)
1	771 (33·7)	905 (38·5)
2	853 (37·2)	625 (26·6)
3 and 4 combined	436 (19·0)	313 (13·3)
Women:	2647	2752
0	756 (28·6)	1217 (44·2)
1	1020 (38·5)	877 (31·9)
2	597 (22·6)	465 (16·9)
3 and 4 combined	274 (10·4)	193 (7·0)

*Change between surveys in risk factor score, after age group, ethnicity, and interactions were controlled for, was P<0·001 both in men and in women.

Reductions in blood pressure have been observed in other population intervention programmes.[11 20 21] That decreases are also often observed in control cohorts[21 22] suggests that part of the effect may be due to familiarity with the measurement procedure. Nevertheless, studies with independent samples at successive time points have also documented decreases in blood pressure both in the context of interventions[20 21] and in whole populations,[23 24] showing that there are true secular decreases, as well as intervention effects. In Mauritius the prevalence of hypertension in first time survey attenders in 1992 was similar to that in the 3751 cohort subjects seen in both 1987 and 1992, showing that a real decrease occurred in the population.

OBESITY AND LIFESTYLE

The interview data showed reductions in cigarette smoking and alcohol consumption, and increased leisure physical activity over the intervention period. National data on the sales of cigarettes and alcohol per head of population for 1986-92 support the survey findings (unpublished data). Decreased frequency of smoking has been observed in many developed countries over recent decades,[9 10 24] but generally smoking is common and increasing in the developing world. The Mauritian results are encouraging as they show that a comprehensive anti-tobacco campaign using the mass media, advertising bans, and increased taxation can be effective in a developing country. Of particular interest is that the uptake of smoking by Mauritian women has not increased.

The increase in overweight and obesity contrasts with trends in other risk factors and is also at variance with the decreased prevalence of hypertension. Other studies have also noted either little change[22] or increasing obesity[25] despite favourable changes in other risk factors. Changing diet, the reduction in smoking,[26] and declining occupational activity may play a part in the increase in obesity. Differing relative changes in specific dietary components might explain the opposing trends in obesity, hypertension, and cholesterol concentrations. An increasing prevalence of obesity has been documented in both developing[27] and developed[24] countries, and the trend in Mauritius is of concern.

CONCENTRATIONS OF SERUM LIPIDS

The improvement in the serum lipid profile was pronounced, particularly given the increase in obesity. The consistency of the changes across age groups, ethnic groups, and the 1992 independent sample suggests a population-wide phenomenon that cannot

Key messages

- Rates of cardiovascular disease and non-insulin dependent diabetes mellitus are increasing throughout the developing world, with little evidence that trends can be reversed
- A national healthy lifestyle intervention programme in Mauritius included extensive use of the mass media, fiscal and legislative measures, and community health promotion activities
- After five years there were reductions in population blood pressure and serum lipid concentrations, increased leisure exercise, and decreased smoking and alcohol consumption
- A regulated change in the saturated fat content of a widely used cooking oil may have contributed importantly to the dramatic fall in serum cholesterol concentrations
- Lifestyle intervention programmes can be implemented and have positive effects in developing countries

be explained by chance or regression to the mean. External quality assurance data confirm that the changes are real. Intervention studies in Finland,[11 28] South Africa,[22] and the United States[29] showed reductions in total cholesterol concentration, although it was not clear whether changes in the intervention groups exceeded underlying secular trends. Certainly, evidence exists that population cholesterol concentrations are declining in several developed countries.[24 28]

Reductions in cholesterol concentrations and rates of coronary heart disease have been associated with declining consumption of animal fats.[9-11 24 29] A dramatic alteration in the average Mauritian diet would seem to be necessary for such clear changes in cholesterol concentrations to have occurred over five years. A sufficient change, however, seems possible. In 1987 most Mauritians used "ration oil" for cooking, which was inexpensive, sold in bulk, and comprised predominantly palm oil. Palm oil is high in saturated palmitic acid (16:0) and has been associated with high concentrations of total and low density lipoprotein cholesterol relative to polyunsaturated and monounsaturated oils.[30 31] After the baseline survey, the Mauritian Ministry of Health ordered a change in the formulation of the ration oil to almost 100% soybean oil. This change may have had an important effect on fatty acid intake and serum lipid concentrations.

CONCLUSION

It was not feasible to have a reference area in the small island state of Mauritius, and hence it is not clear to what extent the changes documented represent true intervention effects versus underlying secular trends. At the start of the intervention programme the Mauritian public had little knowledge of non-communicable diseases and their risk factors, but preliminary analyses show that their knowledge on health had improved substantially by 1992. The beneficial changes were probably in large part due to the healthy lifestyle intervention programme. These results show that lifestyle intervention projects can be implemented and have positive effects in rapidly developing countries. A pronounced improvement in the population lipid profile in Mauritius may have resulted from a change in the saturated fat content of a common cooking oil.

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Conflict of interest: None.

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