Lessons for prevention from a coronary heart disease epidemiological study in western India

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Coronary heart disease, a major health problem in India and many other developing countries, is more prevalent in urban than in rural areas. To determine causes for this urban–rural difference in prevalence, we performed studies in the western Indian state of Rajasthan. Coronary heart disease prevalence was more in urban than in the rural Rajasthan (men 6.0% vs 3.4%; women 10.5% vs 3.7%, $P < 0.01$). Risk factor comparison showed that smoking/tobacco consumption was more in rural than in urban men (51% vs 39%), but more in urban women (19% vs 5%). In urban men compared to rural men, the prevalence of a history of diabetes mellitus (1.1% vs 0.2%), hypertension (30% vs 24%), obesity (11% vs 5%), and truncal obesity (25% vs 4%) was significantly more ($P < 0.01$). Likewise, in urban women (compared to rural women) the prevalence of a history of diabetes mellitus (1.0% vs 0.1%), hypertension (33% vs 17%), obesity (11% vs 6%) and truncal obesity (17% vs 5%) was greater ($P < 0.01$). Prevalence of regular moderate-grade leisure-time physical activity was low among both urban and rural populations; lower in urban men. In urban men (compared to rural men), mean levels of total cholesterol (175.8 ± 43 vs 165.2 ± 37 mg/dl) and LDL-cholesterol (107.6 ± 39 vs 96.8 ± 33 mg/dl) were significantly greater ($P < 0.01$). Serum levels of HDL-cholesterol and triglycerides in urban and rural men were similar. Higher prevalence of coronary risk factors such as hypertension, diabetes mellitus, obesity, truncal obesity and higher total and LDL-cholesterol in urban subjects indicates that efforts should be directed towards controlling these risk factors in the urban population for coronary heart disease prevention in India.

CARDIOVASCULAR diseases, especially atherosclerotic coronary heart disease, are responsible for major disability in both the developed and developing countries. World Health Organization has predicted that by A.D. 2020 up to three quarters of deaths in developing countries would result from non-communicable diseases and that coronary heart disease will top the list of killers[1]. Data also indicate that epidemiological transition, which is characterized by ageing and changing lifestyles which culminate in an epidemic of hypertension and coronary heart disease, is rapidly occurring in the developing countries[1,2].

Epidemiological studies over a period of the last 30 years have identified risk factors which predispose an individual to coronary atherosclerosis[3]. These studies have also shown that bulk of coronary heart disease is preventable or at least its occurrence can be postponed. The Framingham study was a milestone because it confirmed the clinical evidence that smoking, hypertension and elevated cholesterol were important risk factors contributing to the development of coronary heart disease[4]. The study also identified the origin of coronary disease in unhealthy lifestyles characterized by diets rich in saturated fats, use of tobacco, excessive use of alcohol and lack of physical activity. Although limited in scope, case control and prospective studies in India have shown the importance of these risk factors in the pathogenesis of coronary heart disease[5]. Studies among immigrant Indians, who have one of the highest coronary heart disease mortalities in the world, have also shown that apart from major coronary risk factors, other genetically-determined as well as acquired coronary risk factors are important[6,7]. Genetic risk factors are: increased insulin resistance, decreased pancreatic beta-cell function, higher prevalence of diabetes, increased lipoprotein (a), increased plasminogen activator inhibitor activity and decreased tissue plasminogen activity[7]. Many of these are potentiated by factors acquired by westernization such as decreased physical activity, central obesity, elevated levels of low density lipoprotein (LDL)-cholesterol and triglycerides and reduced levels of high density lipoprotein (HDL)-cholesterol.

Coronary heart disease prevalence is very low in rural population of India and is significantly more in urban Indians. A meta-analysis showed that coronary heart disease prevalence in urban populations increased from 3.42% in the 1960s to 3.62% in the 1970s and to 9.45% in the 1990s (χ^2 for trend = 5.63, $P = 0.018$). In rural areas the prevalence increased from 2.06% in 1970s to 4.15% in the 1990s ($\chi^2 = 2.94$, $P = 0.086$) (ref. 8). These urban–rural differences suggest that risk factors

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which are more common in urban subjects may be important[9]. To examine risk factor differences in urban as compared to rural populations, we performed studies in the western Indian state of Rajasthan. Randomly selected individuals in rural and urban populations were evaluated using similar epidemiological tools. This article highlights the implications for preventive strategies as revealed by our study.

Methods

Details of survey methods and diagnostic criteria have been reported earlier[10,11]. In summary, we studied urban populations in randomly selected locations in Jaipur city and rural populations in three villages of central Rajasthan 150 km away from Jaipur in western India. Voters' lists were used for the identification of suitable persons. Men and women over the age of 20 years were eligible for the present investigation. We could examine 1415 of 1609 eligible men (87.9%) and 797 of 1391 eligible women (57.3%) in the urban area and 1982 of 2188 eligible men (90.6%) and 1166 of 1968 eligible women (59.2%) in rural areas. A physician-administered questionnaire, physical examination and a 12-lead electrocardiogram (ECG) were performed in all persons. Waist–hip ratio was measured in randomly selected 20% of the subjects and fasting blood samples for blood lipid estimation were collected from 10% of the study population.

Coronary heart disease was diagnosed on the basis of documented history, positive response to Rose questionnaire or ECG changes (Minnesota codes 1-1, 1-2, 4-1, 4-2, 5-1, 5-2 or 9-2). Current smokers, past smokers and users of all forms of tobacco were pooled together as smokers. Hypertension was diagnosed on the basis of United States Fifth Joint National Committee recommendations as blood pressure of or more than 140 mm Hg systolic or 90 mm Hg diastolic. Those on treatment for hypertension were also classified as hypertensives. Obesity was diagnosed when body-mass index was 27 kg/m^2 or more, and truncal obesity was diagnosed when waist–hip ratio was more than 0.95. Hypercholesterolaemia and low high density lipoprotein cholesterol levels were determined according to definitions of United States National Cholesterol Education Program. High serum total cholesterol was taken as $\geq$ 200 mg/dl, high LDL-cholesterol was taken as $\geq$130 mg/dl and low HDL-cholesterol was taken as $<$ 35 mg/dl. Diabetes mellitus and leisure time physical activity were determined on the basis of medical history.

Statistical analysis. The prevalence rates are given in percentage. Significance of urban–rural differences has been tested by χ^2 test, Fisher's exact test or unpaired t test as appropriate. Two-tailed P values less than 0.05 were considered significant.

Results

Coronary heart disease prevalence was more in urban than in the rural subjects (men 6.0 vs 3.4%, $P < 0.001$; women 10.5 vs 3.7%, $P < 0.001$; Table 1). Prevalence of ECG changes alone was also more in urban population (men 3.5 vs 2.8%, $P = 0.156$; women 8.4 vs 3.3%, $P < 0.001$). In urban men, as compared to rural men, the relative prevalence of coronary heart disease diagnosed by clinical and ECG criteria was 1.73 (95% confidence interval 1.25 to 2.40) and by ECG criteria alone as 1.25 (0.85 to 1.85). In urban women the relative prevalence of coronary heart disease was 2.86 (1.94 to 4.15) and 2.58 (1.69 to 3.83), respectively.

A comparison of risk factors (Table 2) shows that smoking or tobacco consumption was more in rural than in urban men. Among women, tobacco use was more in the urban areas. The prevalence of regular moderate grade leisure time physical activity was low among both urban and rural populations, but was higher in the rural population. Prevalence of a history of diabetes mellitus, hypertension, obesity, and truncal obesity was more in urban men and women. Blood samples were obtained in random samples of 199 (14.1%) urban and 202 (10.2%) rural men, and 98 (8.4%) rural women. Response was very low in urban women (5 of 111 women agreed to phlebotomy) and samples from them were not analysed further. In urban men as compared with rural, the mean levels of total cholesterol (175.8 ± 43 vs 165.2 ± 37 mg/dl) and LDL-cholesterol (107.6 ± 39 vs 96.8 ± 33 mg/dl) were significantly greater ($P < 0.01$). The levels of HDL-cholesterol (43.1 ± 12 vs 44.0 ± 13 mg/dl) and triglycerides (126.1 ± 55 vs 122.0 ± 46 mg/dl) were not significantly different between urban and rural men (Table 2). Comparison of χ^2 values shows that in urban men, prevalence of truncal obesity, obesity, hypertension, diabetes and sedentary lifestyle is significantly more. In urban women there is a higher prevalence of tobacco use, hypertension, obesity, truncal obesity and diabetes.

Discussion

Our analysis of differences in coronary risk factors between urban and rural populations shows that coronary heart disease is more in urban subjects and is associated with a greater prevalence of coronary risk factors, i.e. hypertension, diabetes mellitus, obesity, truncal obesity and higher total and LDL-cholesterol.

In hospital-based studies, a higher prevalence of coronary heart disease in urban Indians was initially reported in 1950s (refs 8, 12). Epidemiological studies in Agra, Delhi and Chandigarh in 1960s confirmed the high prevalence of coronary heart disease in urban subjects[8]. Gupta *et al.* compared coronary heart disease and risk

Table 1. Coronary heart disease prevalence (%) in urban and rural populations in Rajasthan

Age group (years)	Urban No.	Urban Clinical + ECG	Urban ECG only	Rural No.	Rural Clinical + ECG	Rural ECG only
		Men (Urban = 1415, rural = 1982)				
20–29	526	18 (3.4)	12 (2.3)	571	10 (1.8)	9 (1.6)
30–39	374	20 (5.3)	12 (3.2)	495	13 (2.6)	10 (2.0)
40–49	183	6 (3.3)	5 (2.7)	366	12 (3.3)	11 (3.0)
50–59	211	24 (11.4)	12 (5.7)	268	11 (4.5)	8 (3.0)
60 +	121	16 (13.2)	8 (6.6)	282	22 (7.8)	17 (6.0)
Total	1415	84 (6.0)*	49 (3.5)	1982	68 (3.4)	55 (2.8)
		Women (Urban = 797, rural = 1166)				
20–29	136	8 (5.9)	7 (5.2)	382	5 (1.3)	4 (1.0)
30–39	157	12 (7.6)	12 (7.6)	342	9 (2.6)	8 (2.3)
40–49	211	24 (11.4)	18 (8.5)	212	11 (5.2)	8 (3.8)
50–59	151	18 (11.9)	12 (7.9)	127	11 (8.7)	11 (8.7)
60 +	142	22 (15.5)	18 (12.7)	103	7 (6.8)	7 (6.8)
Total	797	84 (10.5)*	67 (8.4)*	1166	43 (3.7)	38 (3.3)

*$P < 0.05$ on urban–rural comparison, ECG = electrocardiogram.

Table 2. Urban–rural differences in coronary risk factor prevalence (%) in Rajasthan

	Urban	Rural	χ^2 (P-value)
	Men (urban = 1415, rural = 1982)		
Smoking and tobacco use	548 (38.7)	1006 (50.8)	47.65 (<0.001)
Leisure time activity	202 (14.3)	363 (18.3)	9.43 (0.002)
Diabetes history	15 (1.1)	4 (0.2)	9.44 (0.002)
Hypertension ≥140/90 mm Hg	417 (29.5)	470 (23.7)	13.88 (<0.001)
Hypertension ≥160/95 mm Hg	146 (10.3)	150 (7.6)	7.51 (0.006)
Obesity BMI ≥ 27 kg/m^2	161 (11.4)	104 (5.2)	42.30 (<0.001)
Truncal obesity >0.95	64/252 (25.4)	17/399 (4.3)	61.41 (<0.001)
Cholesterol ≥200 mg/dl	52/199 (26.1)	45/202 (22.3)	0.62 (0.433)
HDL-cholesterol <35 mg/dl	47/199 (23.6)	49/202 (24.2)	0.01 (0.97)
	Women (urban = 797, rural = 1166)		
Smoking and tobacco use	149 (18.7)	54 (4.6)	99.48 (<0.001)
Leisure time activity	64 (8.0)	88 (7.5)	0.09 (0.76)
Diabetes history	8 (1.0)	2 (0.1)	4.93 (0.026)
Hypertension ≥140/90 mm Hg	267 (33.5)	197 (16.9)	71.40 (<0.001)
Hypertension ≥160/95 mm Hg	97 (12.2)	72 (6.2)	20.87 (<0.001)
Obesity BMI ≥ 27 kg/m^2	87 (10.9)	74 (6.4)	12.53 (<0.001)
Truncal obesity >0.95	33/193 (17.1)	5/104 (4.8)	8.08 (0.001)
Cholesterol ≥200 mg/dl	–	22/98 (22.5)	–
HDL-cholesterol < 35 mg/dl	–	40/98 (40.8)	–

HDL, high density lipoprotein.

factor prevalence in urban and rural populations of Haryana using similar epidemiological tools[13]. Coronary heart disease prevalence in urban subjects was twice that in the rural subjects. The present study has shown similar findings. The studies in Haryana showed higher prevalence of hypertension, obesity and sedentary lifestyle in urban subjects. Our study shows that, in addition, factors such as diabetes, truncal obesity and cholesterol levels are also more in the urban subjects. The greater prevalence of truncal obesity, hypertension and diabetes mellitus in urban subjects is suggestive of insulin-resistant state. A sedentary lifestyle can worsen insulin resistance while low-grade or intermittent physical activity present in rural subjects may be protective. Total and LDL-cholesterol values are more in urban as compared to rural subjects. A higher consumption of saturated fats in urban subjects may be a potential cause. Psychosocial risk factors involved in rapid urbanization and migration may also be important. We reported that certain protective social factors such as joint family are more common in rural areas[14]. A detailed study of biochemical and social factors among Indian urban subjects is needed.

Preventive implications

The effective prevention of cardiovascular diseases through the correction of modifiable risk factors has been widely demonstrated in a number of studies[4]. They call for correction of lipid disorders, lowering of blood pressure, smoking cessation, improving eating habits, more physical exercise and attention to psychosocial factors. Our studies show that the coronary risk factors which are more prevalent in urban subjects (compared to rural subjects) are hypertension, diabetes mellitus, obesity, truncal obesity and elevated levels of total and LDL cholesterol. These factors need to be modified to decrease the prevalence of coronary heart disease in India.

Rose initially suggested that a population-based approach to disease prevention is important[15]. He identified that population means reflect the presence of deviant individuals. The higher the mean level of a risk factor, the greater would be the prevalence of that risk factor in the population. Thus, mean blood pressure of a population accurately predicts the number of hypertensive individuals, mean body weight predicts the number of obese subjects and average consumption of alcohol is indicative of the prevalence of heavy drinking. He also identified that the prevalence of high-risk state (hypercholesterolaemia, hypertension, obesity, excessive consumption of alcohol) is largely a reflection of the lifestyles and attitudes of the masses. A population-based approach would correct the underlying cause of the coronary heart disease epidemic and is safer, cheaper and more cost-effective than the high-risk approach.

We have identified many traditional coronary risk factors as important in the present study. Most of these can be changed by adopting healthier lifestyles[15]. Control of hypertension can be achieved by reduction of dietary salt, alcohol and calorie intake, increased physical exercise, stress management, and a greater intake of calcium, potassium, magnesium and fibre[16]. Control of hypercholesterolaemia and decrease in mean LDL-cholesterol levels can be achieved by reducing the dietary intake of saturated fats, meat and dairy products and a greater intake of polyunsaturated fats and fibre[17]. HDL-cholesterol levels can be influenced by greater intake of monounsaturated fats, fruits and green vegetables, and by exercise[17]. Truncal obesity can be reduced by regular exercise[7]. Peripheral insulin resistance can also be improved by regular physical activity.

In summary, coronary heart disease in India can be prevented by controlling intake of tobacco, salt, saturated fats, alcohol and calories, by increasing both work-related and leisure-time physical activity, increasing consumption of 'heart-healthy' foods such as fruits and vegetables, high fibre cereals, oils containing balanced amounts of polyunsaturated and monounsaturated fats[18] (e.g. canola oil, soya bean oil), and spices and cereals with a high flavonoid content[19]. Stress management techniques, especially yoga may be important[20]. Reverting to traditional Indian social lifestyles (joint families, small families, good education) may also be important[14]. Physicians have key roles as expert advisers, opinion formers; and hopefully by setting good personal examples. Governments, the food and agriculture industries, the mass media, educators, and many other community groups and agencies could supplement the efforts of physicians in implementing the guidelines for coronary heart disease prevention[21].

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