Centre for Agricultural Strategy

AGRICULTURE AND HUMAN HEALTH

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Institute of Agricultural Medicine and Rehabilitation

B 6 Diseases of the circulatory system

M WOOLAWAY

The principle diseases of the heart and the blood vessels are:-

(i) Coronary Heart Disease (CHD)

This includes the syndromes of:

i) Angina pectoris
ii) Myocardial infarction
iii) Sudden death from CHD

(ii) Cerebrovascular Disease or Stroke

This includes:

i) Cerebral thrombosis
ii) Cerebral haemorrhage
iii) Cerebral embolism
iv) Sub-arachnoid haemorrhage

(iii) Peripheral Vascular Disease

This includes:

i) Intermittent claudication
ii) Gangrene

High blood pressure, which is an important risk factor in the development of the foregoing diseases, will not be considered separately as a cause of mortality.

These three groups of diseases arise in different parts of the circulation but the underlying disease process accounting for most heart, brain and peripheral vessel disease is the same. That is atherosclerosis of the medium sized arteries.

THE IMPORTANCE OF CIRCULATORY DISEASES

Coronary heart disease

CHD is the leading cause of death in middle and old age in the UK (Table 1). In 1978 in the UK some 184,819 deaths were attributed to CHD. That represented 32% of all male deaths and some 24% of all female deaths.

However, the real toll is in years of lost life due to premature death. In 1978 almost 34,000 men died of CHD before the age of 65. The corresponding figure for women was 9,300 (Table 2). Treatment costs of CHD alone have been estimated to amount to £195 million in 1981 (Table 3).

There are large international variations in the incidence of CHD. It is essentially a disease of the developed western countries but amongst countries of comparable affluence there are marked differences (Figure 1). There are also marked regional variations between countries. In the UK, Scotland and the North West have higher rates than the South East (Table 4). There is also a social class gradient, a higher mortality being observed in the lower socio-economic groups.

Trends

The prevalence of CHD began to increase gradually in the 1920's and the trend in the UK has shown a marked increase for all ages and sexes over the last three decades. Over the last 10 years, some countries have experienced a substantial fall in CHD rates (eg. USA rates have fallen by over 20% in the last decade). However the UK rates have remained high, although there is some evidence of a slight recent decline (Figure 2).

Cerebrovascular disease (strokes)

Strokes occur predominantly in the elderly. In 1977 of some total 73,000 deaths attributed to stroke, 88% occurred in people aged 65 or over and 62% in people aged at least 75 years. Stroke mortality rises exponentially with age, is higher in males than females and shows a social class gradient, unskilled labourers suffering the higher rates. USA data shows that stroke mortality rates are higher in blacks. In the UK over the last 30 years there has been a steady overall decline in the incidence of stroke.

The principle risk factor is hypertension. However the other factors implicated in the development of atheroma and CHD are undoubtedly important.

Table 1

Major causes of death from 15-64 years in England and Wales, 1977

	Per cent of total deaths	
	Males	Females
Ischaemic heart disease	23	10
Hypertension and other heart diseases	3	5
Cerebrovascular disease	4	6
	30	21
Cancer	22	35
Pneumonia and chronic respiratory diseases	7	7
Injuries (excluding suicide and homicide)	17	9
Other	23	28
	69	79
Totals*	100	100

Source:- James et al. (1981)

* Excluding congenital and perinatal causes.
Calculations based on years of life lost.

Table 2

Deaths from coronary heart disease in the UK by age group and sex, 1978

Age group (years)	No. of CHD deaths		CHD deaths as % of all deaths in age group	
	Males	Females	Males	Females
25-34	222	59	6	3
35-44	2 017	360	29	8
45-54	9 212	1 799	41	13
55-64	22 427	7 099	39	21
65-74	37 859	21 187	34	28
All ages	105 999	78 820	32	24

Source: Adapted from DHSS (1981)

Table 3

The impact of some chronic diseases with possible diet-related aetiologies

ICD categories and disease		Years of life lost before age 65 yr.	Cost of treatment (£ m/yr)	Cost of sickness absence from work (£ m/yr)
410-4	Ischaemic heart disease	339 000	195	425
430-8	Cerebrovascular disease	93 000	367	86
174	Breast cancer	70 000	39	2
153	Colon cancer	27 000	28	2
151	Stomach cancer	26 000	18	2
400-4	Hypertensive disease	15 000	111	182
250	Diabetes	14 000	83	61
521	Dental caries	0	388	11

Source: Adapted from Laing (1981)

Table 4

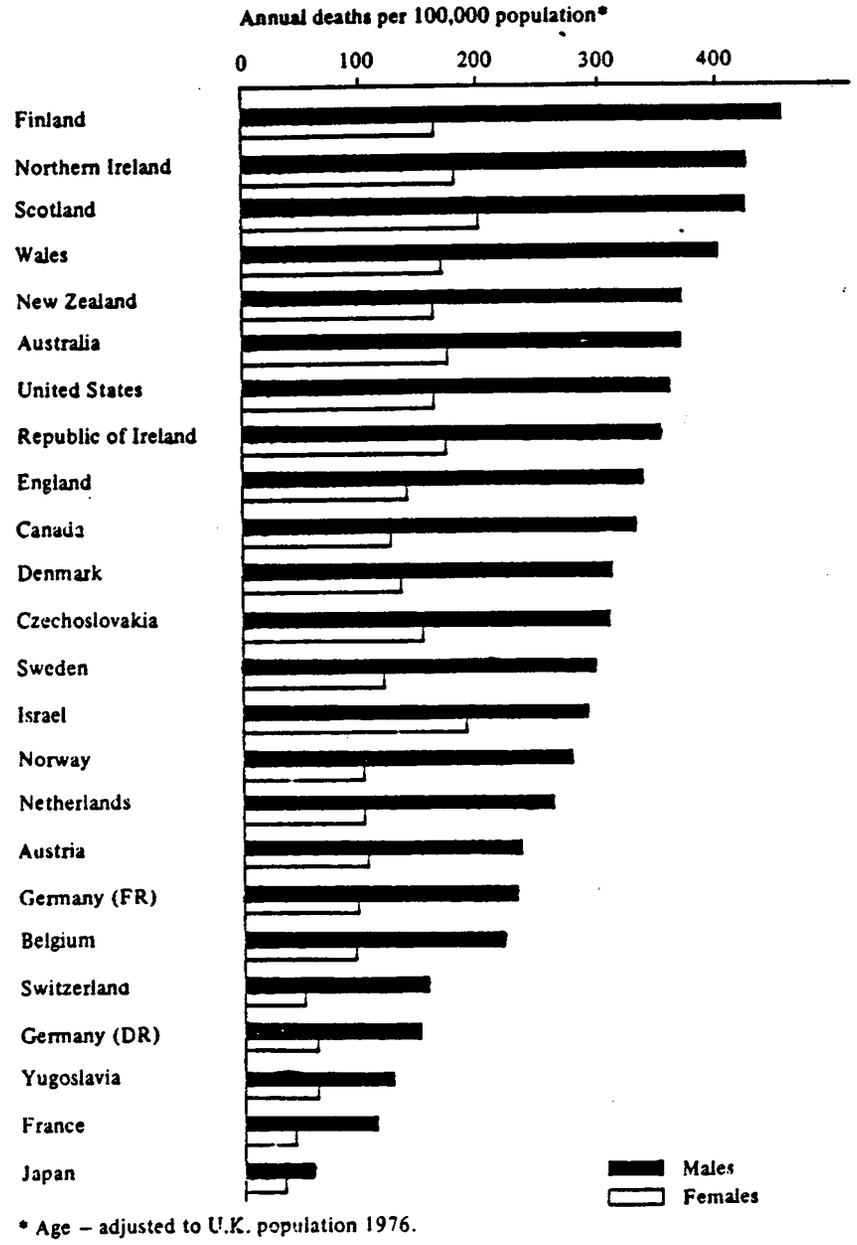
Regional variation in mortality from IHD in men aged 55-64. SMR's (England and Wales = 100)

Region or city	SMR for IHD
Northern Scotland & Isles	117
Southern Scotland	123
City of Glasgow	126
Northern region	111
North west	109
Yorks and Humberside	106
West Midlands	95
East Midlands	97
East Anglia	76
South west	93
South east	86
Greater London	91
Wales	109
Northern Ireland	121

Source: Adapted from Marmot et al. (1981)

Figure 1

Death rate of males and females from CHD at ages 15-74 years in 24 countries, 1974-76

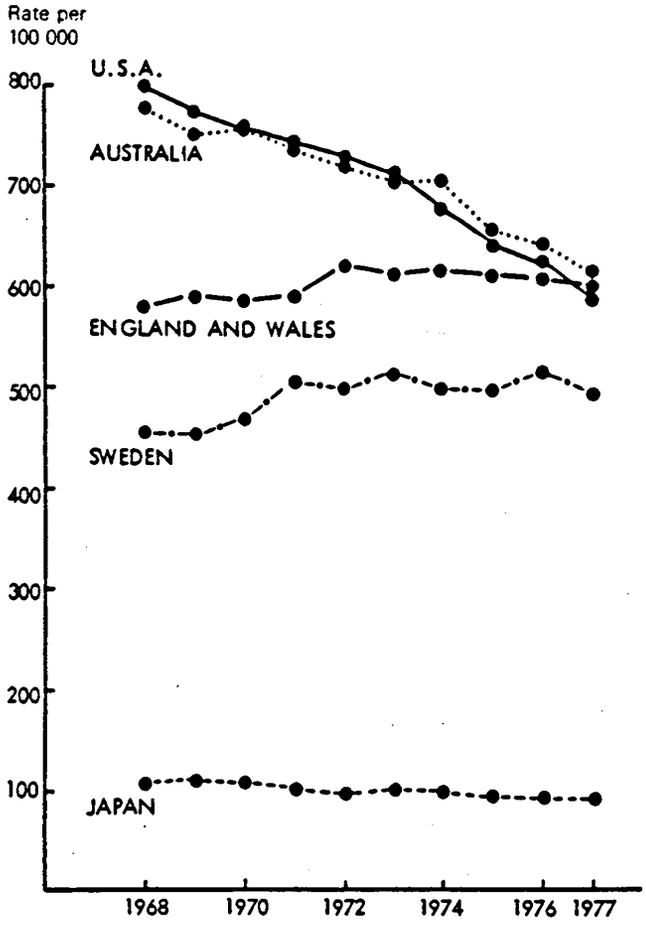


* Age – adjusted to U.K. population 1976.

Source: DHSS (1982)

Figure 2

IHD mortality 1968-77 in USA, Australia, England and Wales, Sweden and Japan. Males 35-74 years. Age-adjusted rates per 100 000 population



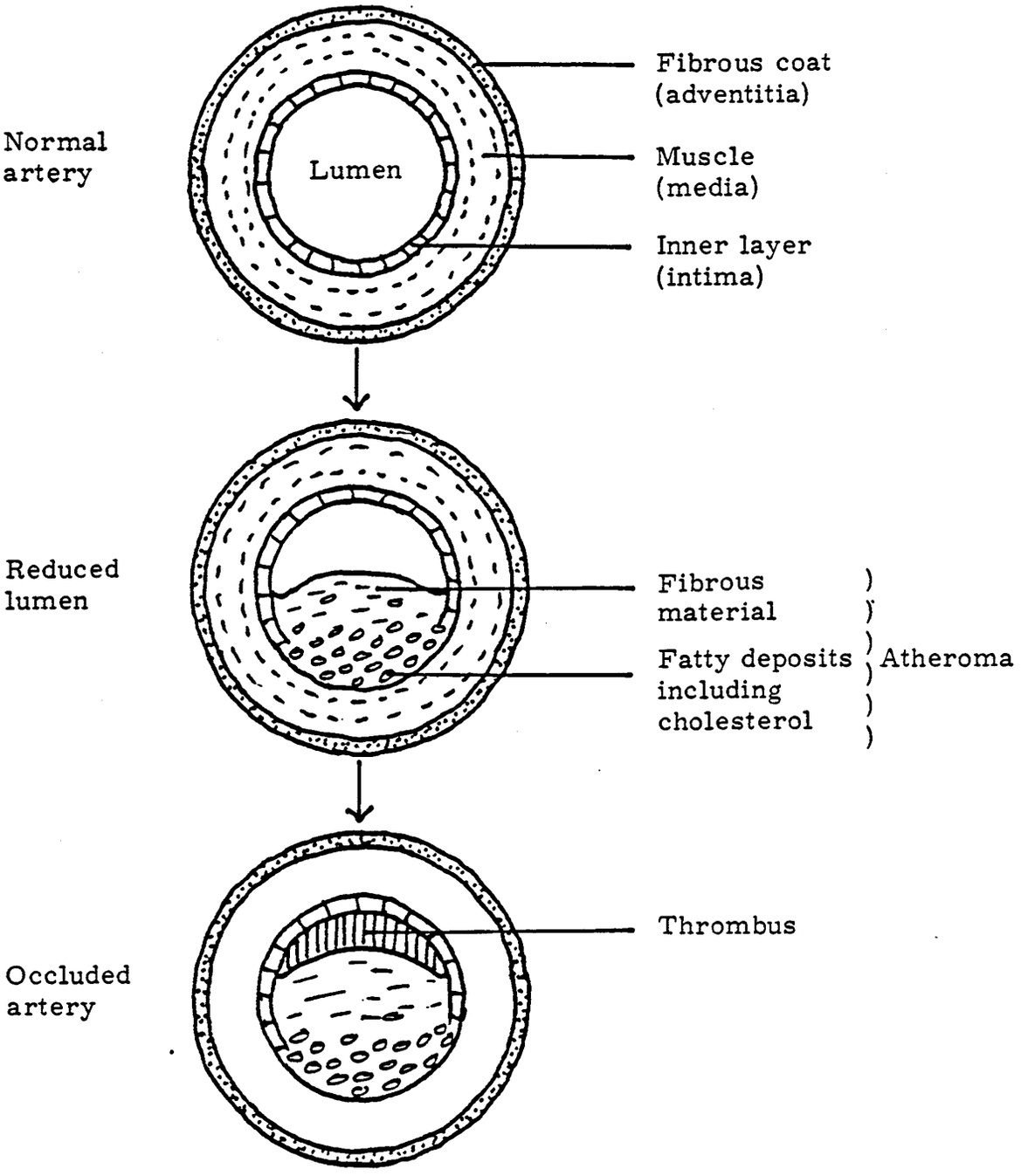
Source: Marmot et al. (1981)

Figure 3

The stages of coronary heart disease

Mechanisms involve:-

(i) Atheroma of wall of coronary artery
(ii) Thrombus formation on mural atheroma
(iii) Coronary artery spasm



Peripheral vascular disease

Extensive atheromatous disease of the arteries of the lower limbs can lead to intermittent leg pain on walking (claudication) and gangrene of the extremities. However atheromatous disease of the limb vessels is principally a cause of chronic ill health rather than death, patients tending to die of CHD which usually co-exists as part of a generalised degenerative arterial process. Cigarette smoking is the dominant predisposing factor.

THE UNDERLYING DISEASE PROCESS IN RELATION TO CHD

Atheroma of the medium sized arteries is usually a generalised condition, the vessels of the heart, brain and periphery usually being simultaneously affected to varying degrees.

The following account relates to the process of coronary heart disease.

The heart receives its blood supply through the coronary arteries. The fundamental problem in CHD is that as a result of an inadequate blood flow to the heart muscle, due to reduced patency in the coronary vessels, death of muscle or an abnormal rhythm occurs, leading to loss of pumping function.

There are three principal mechanisms contributing to loss of patency of coronary arteries (Figure 3).

(i) Atheromatous deposits in the vessel wall leads to loss of lumen and elasticity. (These mural lesions consist of lipids, including cholesterol and scar tissue.) The so-called 'plaques' of atheroma take decades to form and are a potential surface for thrombosis.

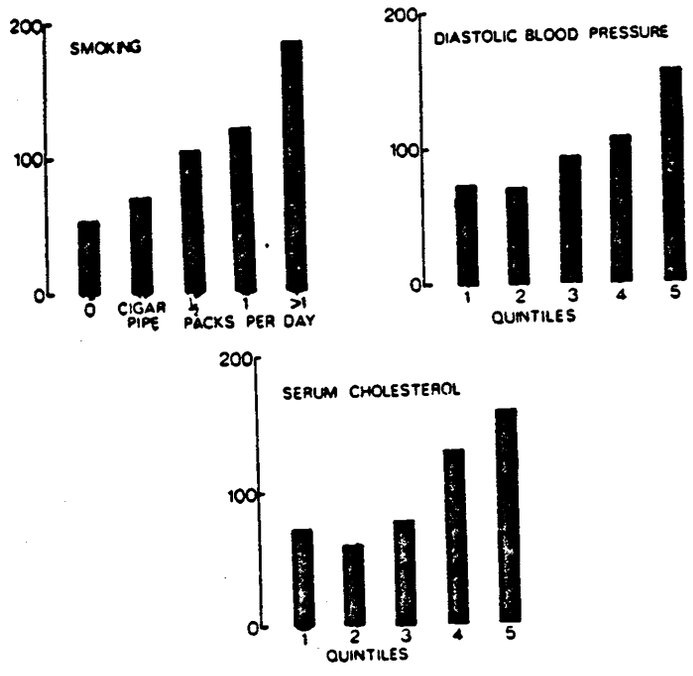
(ii) Thrombus formation on the atheromatous plaques leads to occlusion of the lumen of the artery. This process is relatively rapid being measured in minutes or hours.

(iii) Coronary artery spasm occurring as a rapid abnormal response to external or endogenous stimuli.

Which of the foregoing mechanisms is paramount in the causal explanation of CHD is to some extent contentious. However, it does seem that even though mural atheroma alone cannot explain lumen occlusion in many cases, it is a pre-requisite of a fatal thrombotic occlusion that the lumen of the vessel must be reduced to one quarter or less of its cross-sectional area. Further, the inner lining of the artery must be the seat of severe atheroma or thickened by previous mural thrombus.

Figure 4

Risk factors for first major coronary event



Source: James et al (1981)

THE PRINCIPAL RISK FACTORS FOR CHD

Of the several factors implicated in CHD (Table 5) three major factors predominate. They are:-

(i) high blood pressure (Hypertension),
(ii) serum cholesterol,
(iii) cigarette consumption.

These three factors are of approximately equal and independent predictive power. In each case the gradient of risk between those in the top and bottom fifths of the population distribution is about 2.5 : 1 (Figure 4). Several of the biological risk factors such as age, sex and heredity are of academic interest only, as these cannot be changed. However preventive measures are feasible with all three of the major established risk factors (ie. hypertension, serum cholesterol and smoking) as well as some of the less powerful ones (eg. obesity and physical exercise).

The relationship of coronary risk factors to diet

Diet is important in the natural history of two of the established coronary risk factors and clearly important with respect to obesity.

(i) Serum cholesterol is influenced by:

- Dietary saturated fat - Dietary cholesterol - Obesity (re excess calorie intake)	All raise serum cholesterol
- Dietary polyunsaturated fat - and possibly dietary fibre	Lower serum cholesterol

(ii) Hypertension is influenced by:

- Excess dietary salt	Raises blood pressure
- Increased potassium - Low total fat or high poly-unsaturated/saturated (P/S) ratio - Dietary fibre	May lower blood pressure (case not well established)

(iii) Obesity

Foods high in dietary fibre may help to prevent excess calorie intake by increasing satiety but this is not well proven.

The principal link between diet and CHD is that connecting dietary saturated fat and serum cholesterol. (Dietary cholesterol has only a

Table 5

Risk factors for coronary heart disease

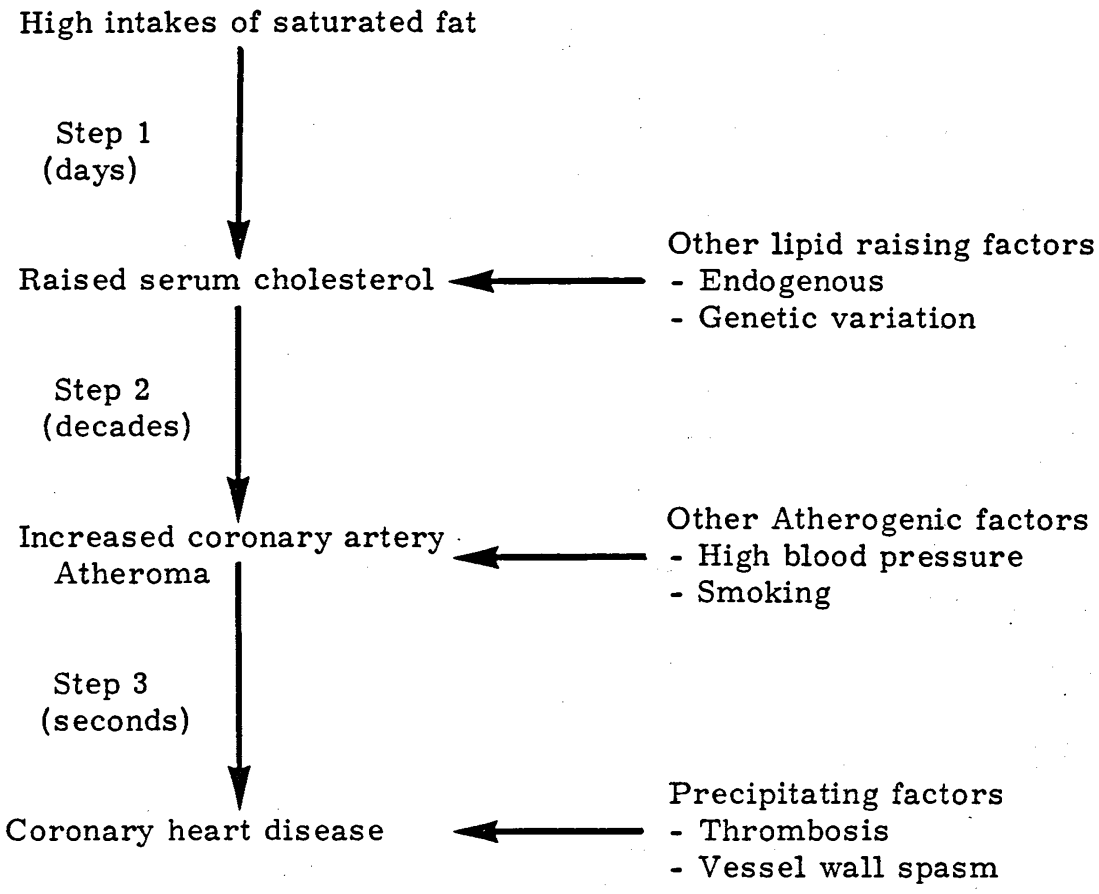
	Characteristic	Effect on the risk of coronary heart disease
Principal risk factors	Smoking (cigarettes)	The greater the amount smoked currently, the greater the risk
	Blood pressure	The higher the pressure the greater the risk
	Blood cholesterol	The greater the concentration the greater the risk
	Diabetes	People with diabetes have a higher risk
	Family history	The longer parents live, the less the risk for their children
	Obesity	Being overweight may increase the risk (unproven)
	Stress	Stress may increase the risk (unproven)
	Personality	Some types may be more prone than others (unproven)
	Physical activity	The less exercise customarily taken, the greater may be the risk (unproven)
	Hardness of tap water	The softer the tap water the greater may be the risk (unproven)

Note:- In most cases of coronary heart disease it is likely that more than one factor is present. Only the first three characteristics given above have been shown to operate as risk factors independently of others. A combination of factors is likely to increase the risk.

Source: DHSS (1981)

Figure 5

The dietary fat-coronary heart disease hypothesis



small influence on serum cholesterol.) This link will now be explored in more detail.

THE DIETARY FAT-HEART DISEASE HYPOTHESIS

This hypothesis is illustrated in Figure 5. The model is simplistic and ignores increasing knowledge about the effects of the different lipid fractions (eg. the high density lipoproteins (HLD) are independently protective against CHD). However, the low density lipoproteins carry most cholesterol and approximate closely enough to total cholesterol for our purposes.

Non-epidemiological studies

It has been known for a long time that atheromatous plaques contain large amounts of cholesterol and that coronary atheroma is a general precursor to CHD (Strong et al., 1973). Studies of people who have rare disorders leading to high blood cholesterol suffer premature CHD. Animal experiments have shown that altering the fat composition of the diet can produce high blood cholesterol and certain forms of coronary artery disease. These diverse lines of evidence provide biological plausibility for the hypothesis but not proof.

OBSERVATIONAL EPIDEMIOLOGY

International comparisons

In prosperous countries the intake of fat is high and a major prorportion is of animal origin. There is a strong correlation between the saturated fat and cholesterol composition of habitual diets of populations and their average total serum cholesterol (TC) or low density lipoprotein (LDL) level (Keys, 1970) and also their CHD incidence rates (Kannel et al., 1979).

Long term trends

Similarly secular changes in national diets are accompanied by changes in average population TC and possible CHD rates (Stern, 1979).

Individual studies

Many prospective studies have shown an increased risk of developing CHD in relation to raised pre-existing serum cholesterol levels (Dayton et al., 1970).

The foregoing epidemiological evidence is reasonably strong in view of:

(i) the strength of the demonstrated associations
(ii) its dose/response characteristics
and (iii) its consistency.

However the diet - blood cholesterol - CHD story has some important limitations. Firstly in homogeneous groups of men it has not usually been possible to demonstrate that dietary habits correlate to plasma cholesterol. The failure to demonstrate this association within populations has been attributed to (i) a low precision and accuracy of techniques for assessing dietary habits and (ii) genetic differences between individuals in their cholesterol metabolism masking the differences which might be observed due to diet.

In the Framingham and other prospective studies the development of CHD could not be related to any dietary factor.

Clinical CHD depends not only on atheroma but on thrombotic mechanisms and the state of the heart muscle. It has been argued that the secular changes in CHD rates are not accompanied by parallel changes in the extent of atheromatous vessel disease and that the rapid changes observed (eg. a fall in CHD rates during the years of the second world war) are more likely to be explained by factors influencing the rapid thrombotic or vessel spasm mechanisms. Much work is currently underway on the role of the polyunsaturated fats in the diet and their effect on blood platelet activity and thrombosis.

The evidence in support of the dietary fat - heart disease hypothesis remains circumstantial. Intervention studies by means of controlled clinical trials provide a means of revealing direct rather than circumstantial evidence for inferring causal connections.

INTERVENTION: TRIALS OF PREVENTION

Trials have been made of the effect of diets low in saturated fat and with increased amounts of polyunsaturated fats, on the subsequent incidence of CHD. These have been carried out on men who have already evidence of CHD and also on apparently healthy men (primary prevention).

These trials have shown the feasibility of reducing serum cholesterol levels by dietary means but the effects on morbidity and mortality have been to some extent equivocal. However both the single factor intervention trials examining the effect of diet alone showed a reduction of CHD mortality. (Dayton et al., 1969; Miettinen et al., 1972) Most subsequent trials have attempted to intervene with several risk factors simultaneously. The results have been inconsistent and in general disappointing. Perhaps this is not too surprising. Middle aged men entering the trials must already have varying degrees of atheroma. The ability to ensure compliance to treatment regimes and prevent intervention measures by the control groups is clearly a problem.

General conclusion: The existing evidence although circumstantial is both extensive and coherent in support of the dietary fat-heart disease hypothesis. Overwhelming proof that CHD can be reduced by dietary means remains elusive. However the present evidence has been judged sufficient to justify the formation of nutritional guidelines by

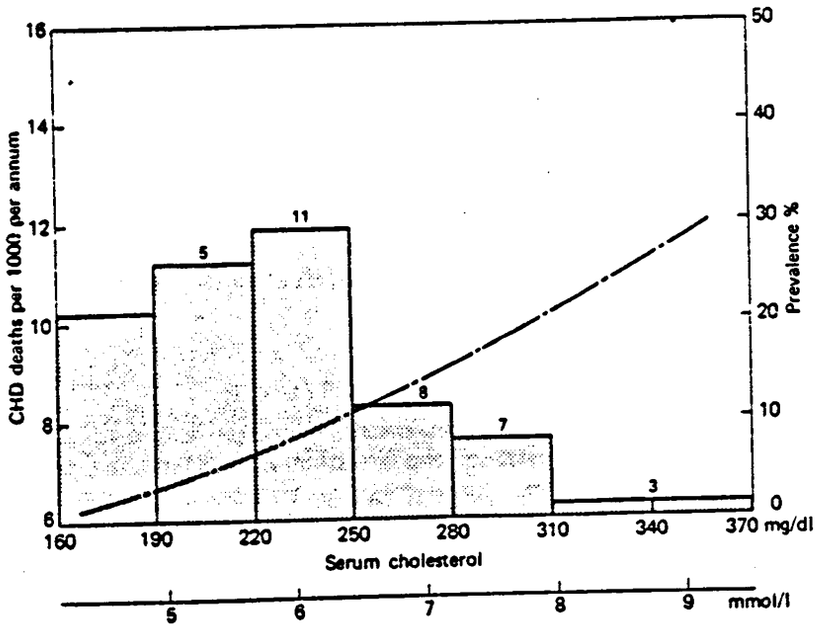
Table 6

Approximate percentages of dietary energy derived from different nutrient groups

	% of dietary energy		
	Present UK diet	Proposed UK diet	Developing countries
Protein	12	12	11
Carbohydrate-total	48	58	77
(sucrose)	16	8	7
Fat-total	40	30	12
(polyunsaturated)	5	10	-
(monounsaturated)	16	10	-
(saturated)	19	10	-

Figure 6

Prevalence distribution (histogram) of serum-cholesterol concentrations related to coronary heart disease mortality (interrupted line) in men aged 55-64 years



Source: Rose (1981)

Note: The number above each column represents an estimate of attributable deaths per 1000 population per 10-year period.

many national and international bodies which recommend reduction in the per cent of energy derived from dietary fat (Select Committee on Nutrition and Human Needs, 1977; WHO, 1982).

Table 6 broadly summarises the changes recommended in many national and international policies.

Population versus individual intervention

If an individual is at particular risk of CHD by reason of an elevated serum cholesterol, why is it not preferable to detect such an individual and treat him separately, rather than apply measures aimed at the population? Leaving aside the difficulties and costs of screening populations, there are powerful reasons for a population strategy for CHD. Even though the risk of CHD rises with a rising serum cholesterol, the greater proportion of deaths will occur in men with near normal or moderately raised levels as so many more men will occur in this group. Hence a small downward shift in the total population distribution of serum cholesterol will be much more significant than managing a few severely affected individuals (Figure 6).

SUMMARY

The role of diet in relation to diseases of the circulation has been discussed with special reference to coronary heart disease (CHD). The overwhelming importance of CHD as a cause of premature death and disability has been stressed. Of the risk factors for CHD, smoking tobacco, high blood pressure and high serum cholesterol were highlighted as the most powerful predictors of future disease.

The relation of these coronary risk factors to diet were explored. The principal link concerns the relationship between dietary fats and serum cholesterol and subsequent CHD. The categories of evidence in support of the foregoing hypothesis were examined. The evidence although still only circumstantial and in parts incomplete is both extensive and coherent in support of the hypothesis. It has been judged sufficient to justify the formation of nutritional guidelines by many national and international bodies. The residual uncertainties are unlikely to be resolved in the foreseeable future, given the difficulties entailed by the necessary intervention trials.

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