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COMMODITY CONSUMPTION AND ISCHEMIC HEART DISEASE MORTALITY, WITH SPECIAL REFERENCE TO DIETARY PRACTICES*

B. K. ARMSTRONG, J. I. MANN, A. M. ADELSTEIN and F. ESKIN

Department of the Regius Professor of Medicine,
University of Oxford, and the Office of Population Censuses and Surveys, London

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MANY attempts have been made to relate death rates from ischemic heart disease (I.H.D.) to certain environmental factors. In most studies, international I.H.D. death rates have been related to dietary patterns of the different countries. Many of these are methodologically unsatisfactory: mortality statistics have usually been derived from the B listing (B26) of the 7th Revision of the International Classification of Diseases (ICD), which includes certain groups of conditions not necessarily associated with atherosclerosis of the coronary arteries; where other than narrow age specific rates have been used, age standardization has not been applied; and countries with unreliable mortality statistics (15 per cent or more of deaths attributed to senility and ill-defined causes) have been included. Within country temporal associations have not been studied in any detail, and female mortality statistics have not usually been investigated. Statistical analysis has often been limited to calculation of simple correlation coefficients.

We have attempted to examine the validity of the methods used by investigating the temporal changes in male and female I.H.D. mortality and commodity consumption in England and Wales and comparing the results with a cross-sectional correlation study in nine regions of England, Wales and Scotland and in 30 countries where mortality statistics were considered to be reliable.

METHODS

The years 1950–1967 were chosen to study correlation between temporal changes in I.H.D. mortality and commodity consumption in England and Wales. During this period the 6th and 7th Revisions of the ICD were in use. Rubrics 420 and 422.1 were selected as being most likely to include deaths from I.H.D. and age-standardized mortality rates for men and women aged 35–64 yr calculated using quinquennial age specific rates and the population of England and Wales in 1960 as a standard [1].

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Earlier mortality data were not used in the analyses because of the difficulty in isolating I.H.D. deaths in the previous classifications. The short list rubric B28 of the 8th Revision was used to calculate age-standardized mortality rates from I.H.D. in 1969 in men and women aged 35–64 yr in the nine regions of England, Wales and Scotland shown in Fig. 1 [1].

FIG. 1. Map of England, Wales and Scotland identifying the nine regions. (Key: S-Scotland; N-Northern Region; NW-North Western Region; Y-Yorkshire and Humberside; W-Wales; WM-West Midlands; EM-East Midlands; SW-South Western Region; SE-South Eastern Region).

TABLE 1. 30 COUNTRIES OVER WHICH CROSS-SECTIONAL CORRELATION ANALYSIS WAS PERFORMED AND YEAR IN WHICH INTERNATIONAL CLASSIFICATION OF DISEASES 8TH REVISION DATA WERE FIRST AVAILABLE

Country	Year	Country	Year
Canada	1969	Greece	1968
Chile	1968	Hungary	1969
USA	1968	Ireland	1968
Hong Kong	1969	Italy	1968
Israel	1969	Malta	1968
Japan	1968	Netherlands	1969
Austria	1969	Norway	1969
Belgium	1968	Poland	1969
Bulgaria	1968	Romania	1969
Czechoslovakia	1968	Spain	1969
Denmark	1969	Sweden	1969
Finland	1969	Switzerland	1969
France	1968	United Kingdom	1968
German Democratic Republic	1969	Australia	1968
Federal German Republic	1969	New Zealand	1968

For the international comparisons, rubrics A83 or B28 of the 8th Revision were taken for either 1968 or 1969 [2]. Age-standardized rates for men and women aged 35–64 were calculated using the world population of Segi as a standard [3]. The 30 countries used are listed in Table 1 and were all those for which the proportion of all deaths attributed to senility or unknown causes (ICD 8th Revision A136 and A137) was less than 15 per cent.

Figures for per capita consumption of food in England, Wales and Scotland were derived from statistical data produced by the Central Statistical Office [4]. Subsequent to 1950, consumption figures have been obtained from publications based on the National Food Survey [5]. Cigarette consumption was taken from Tobacco Research Council figures [6].

International per capita commodity consumption and other data were derived from various sources [7–12]. Saturated fat consumption was taken from estimates published by Masironi [13] and expressed as calories/day rather than percentage of total calories as saturated fat. Data for certain commodities were not available in some countries: tea (available for 29 countries); coffee (1965—22 countries); saturated fat (24 countries).

Product moment simple, and first and second order partial correlation coefficients between I.H.D. mortality and commodity consumption were calculated and stepwise multiple regression analyses carried out using SPSS package programs [14] on the Oxford University ICL 1906A computer. Countries with missing data were deleted only from computation of correlation coefficients involving the missing variable.

RESULTS

The results of correlation analysis of the longitudinal data from England and Wales are shown in Tables 2 and 3. The partial correlation coefficients (r_1 and r_2) are measures of the association between the commodity variables and mortality rates independent of their association with the controlled variables. The variables controlled were those selected by stepwise multiple regression.

TABLE 2. ZERO (r_0) AND FIRST AND SECOND ORDER PARTIAL (r_1 AND r_2) PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ISCHEMIC HEART DISEASE MORTALITY (1950–1967) AND COMMODITY CONSUMPTION IN ENGLAND AND WALES IN THE SAME YEAR

Commodity	Men			Women		
Controlled Variable	r_0 None	r_1 Flour	r_2 Flour Coffee	r_0 None	r_1 Flour	r_2 Flour Coffee
Flour	−0.93*	—	—	−0.92*	—	—
Margarine	−0.92*	−0.41	−0.05	−0.93*	−0.53*	−0.08
Eggs	0.90*	0.34	0.24	0.89*	0.29	0.16
Coffee	0.90*	0.65*	—	0.95*	0.86*	—
Milk	−0.85*	0.35	−0.14	−0.81*	0.49*	−0.22
Butter	0.83*	0.15	−0.06	0.84*	0.23	−0.07
Meat	0.68*	−0.45	−0.11	0.66*	−0.47	0.08
Sugar	0.60*	−0.45	0.15	0.54*	−0.61*	0.27
Cheese	0.54*	0.16	−0.15	0.56*	0.23	−0.27
Fish	−0.31	0.39	−0.01	−0.25	0.55*	0.06
Cigarettes†	0.28	−0.30	0.15	0.95*	0.66*	0.14

*Correlation coefficient significant $P<0.05$.
†Separate data for men and women.

In Table 3, the correlation coefficients were calculated with each yearly mortality rate from 1950–1967 paired with the commodity consumption data recorded nine years previously, i.e. in the appropriate year in the range 1941–1958. In the absence of *a priori* grounds for choosing a latent period for the possible effect of changing commodity consumption on I.H.D. mortality, periods of 3, 6, 9, 12 and 15 yr were examined. It was found that the changes in the simple correlation coefficients which

occurred with increasing latent periods stabilized at 9 yr and so this period was chosen for detailed study. The use of a longer period would have required the use of commodity consumption data recorded before the Second World War; these are known to be less reliable than those recorded during and subsequent to the War.

TABLE 3. ZERO (r_0) AND FIRST AND SECOND ORDER PARTIAL (r_1 AND r_2) PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ISCHEMIC HEART DISEASE MORTALITY (1950–1967) AND COMMODITY CONSUMPTION IN ENGLAND AND WALES NINE YEARS PREVIOUSLY

Commodity	Men				Women		
Controlled Variable	r_0 None	r_1 Sugar	r_2 Sugar Milk	r_2 Sugar Flour	r_0 None	r_1 Flour	r_2 Flour Sugar
Flour	−0.92*	−0.47	−0.52*	—	−0.96*	—	—
Margarine	0.00	0.50*	0.49	0.55*	−0.06	0.35	0.59*
Eggs	0.52*	0.16	−0.12	0.24	0.45	0.12	−0.12
Coffee	0.59*	0.46	0.33	0.33	0.57*	0.01	0.20
Milk	0.58*	0.54*	—	0.58*	0.50*	0.38	0.40
Butter	0.81*	0.33	0.21	0.19	0.81*	0.17	0.08
Meat	0.67*	−0.20	0.04	−0.43	0.72*	−0.23	−0.50
Sugar	0.93*	—	—	—	0.96*	0.69*	—
Cheese	−0.28	−0.03	0.14	−0.28	−0.26	−0.56*	−0.37
Fish	0.09	0.08	−0.39	0.33	0.04	0.43	0.25
Cigarettes†	−0.33	−0.26	−0.07	−0.23	0.81*	0.05	−0.34

*Correlation coefficient significant $P < 0.05$.

†Separate data for men and women.

In an attempt to distinguish the relative importance of this plethora of highly correlated variables, stepwise multiple regression to three steps was performed (Table 4). In this procedure, at each step the commodity variable is selected which is most highly correlated with the mortality rate controlling for the variables selected in previous steps. The multiple correlation coefficient (R) at each step is a measure of the correlation between the commodity variables selected so far and the mortality rate. The mean square ratio (F) indicates whether inclusion of the commodity variable at that step makes a significant reduction in the residual variance. The value $R^2 \times 100$ is a measure of the percentage of the total variation explained by the variables so far included in the regression equation; this value is not shown in the table but can be derived from the values of R which are given. In men, the negative association with flour, and the positive association with coffee consumption in the same year accounted for 93 per cent of the variation, whereas in women, cigarettes and coffee accounted for 95.8 per cent. However, when flour was forced in as first variable in the regression equation in women, flour and coffee together accounted for 96.1 per cent of the variation. No other variable made a further significant reduction in the residual sum of squares.

The situation is less clear when commodity consumption 9 yr previously is considered. In men, sugar, milk and flour consumption together accounted for 93 per cent of the variation and in women, flour, sugar and margarine for 97 per cent.

The I.H.D. mortality data for England and Wales with some of the commodity data are represented graphically in Fig. 2.

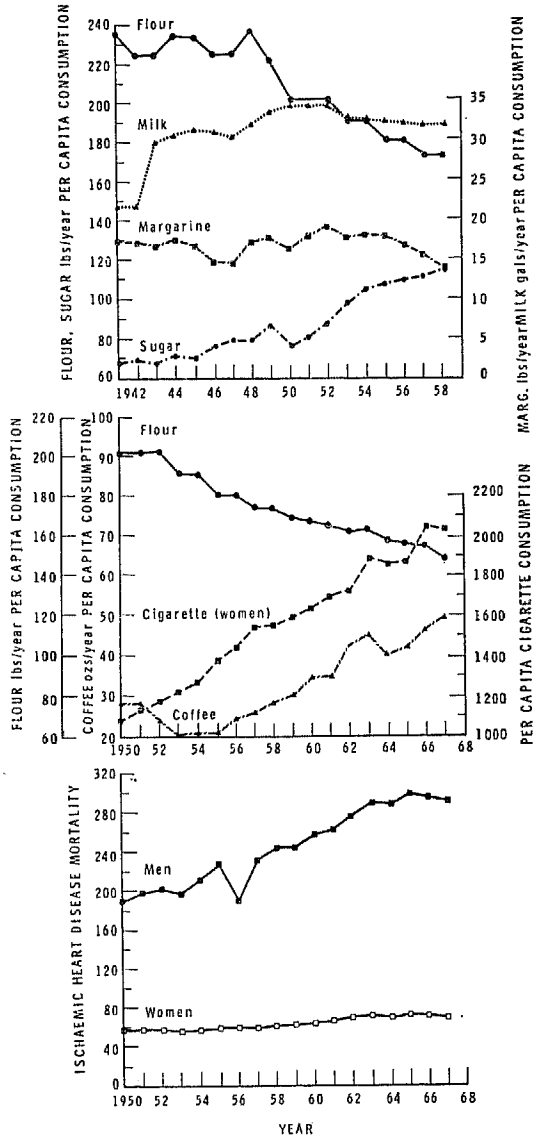

FIG. 2. Age standardized ischemic heart disease mortality in men and women aged 35–64 yr in England and Wales (1950–1967) and consumption of highly correlated commodities in the same year and nine years previously.

Only a few of the correlation coefficients between I.H.D. mortality and commodity consumption in the nine regions of England, Wales and Scotland were statistically significant (Table 5). From stepwise multiple regression analysis, total fresh green vegetable consumption emerged as the dominant associated variable, with total cereal also contributing significantly in women (Table 6). These associations are plotted in Fig. 3.

Correlation coefficients between the commodity variables available and I.H.D. mortality in the 30 countries are given in Table 7. Stepwise multiple regression analysis showed that sugar consumption accounted for 58 per cent of the variation in men, and sugar and cigarette consumption for 68 per cent in women. Addition of other variables did not make a further significant reduction in the total sum of squares (Table 8).

TABLE 4. STEPWISE MULTIPLE REGRESSION OF ISCHEMIC HEART DISEASE MORTALITY (1950–1967) ON COMMODITY CONSUMPTION IN ENGLAND AND WALES FOR THE SAME YEAR AND NINE YEARS PREVIOUSLY

Commodity	Multiple correlation coefficient (R)	Mean square ratio (F)	Significance of F
Same year			
Men aged 35–64 yr			
Flour	0.93	109.2	$P<0.001$
Coffee	0.96	10.9	$P<0.01$
Eggs	0.96	0.9	$P>0.05$
Women aged 35–64 yr			
Cigarettes	0.95	165.6	$P<0.001$
Coffee	0.98	16.9	$P<0.01$
Milk	0.98	1.8	$P>0.05$
*Flour	0.92	90.4	$P<0.001$
Coffee	0.98	43.3	$P<0.001$
Cheese	0.98	1.1	$P>0.05$
Nine years previously			
Men aged 35–64 yr			
Sugar	0.93	105.4	$P<0.001$
Milk	0.95	6.1	$P<0.05$
Flour	0.96	5.2	$P<0.05$
Women aged 35–64 yr			
Flour	0.96	182.2	$P<0.001$
Sugar	0.98	13.5	$P<0.01$
Margarine	0.99	7.3	$P<0.05$

*Flour selected for first step in multiple regression.

TABLE 5. ZERO (r_0) AND FIRST AND SECOND ORDER PARTIAL (r_1 AND r_2) PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ISCHEMIC HEART DISEASE MORTALITY (1969) AND COMMODITY CONSUMPTION IN NINE REGIONS OF ENGLAND, WALES AND SCOTLAND IN 1969

Commodity	Men		Women		
	r_0	r_1	r_0	r_1	r_2
Controlled Variable	None	Total fresh green vegetables	None	Total fresh green vegetables	Total fresh green vegetables/ total cereals
Milk	−0.17	0.42	−0.47	−0.15	−0.12
Cheese	−0.51	0.46	−0.72*	0.02	−0.06
Meat	−0.53	−0.12	−0.54	−0.05	−0.36
Fish	−0.05	−0.24	0.06	−0.07	0.21
Eggs	0.27	0.02	0.43	0.36	0.26
Fat	−0.44	−0.37	−0.01	0.63	0.22
Butter	−0.39	−0.07	−0.11	0.74*	0.31
Margarine	0.62	0.16	0.50	−0.37	−0.00
Sugar	−0.16	0.00	0.12	0.73*	0.19
Potatoes	0.22	−0.27	0.57	0.47	−0.29
Total fresh green vegetables	−0.83*	—	−0.91*	—	—
Total other vegetables	0.12	−0.54	0.44	0.03	−0.02
Total fresh fruit	−0.53	0.46	−0.78*	−0.14	0.67
Flour	−0.30	−0.37	−0.10	0.00	0.14
Total cereals	0.59	−0.03	0.91*	0.86*	—
Coffee	−0.27	0.37	−0.76*	−0.77*	−0.30
Tea	−0.57	−0.38	−0.27	0.41	0.02

*Correlation coefficient significant $P<0.05$.

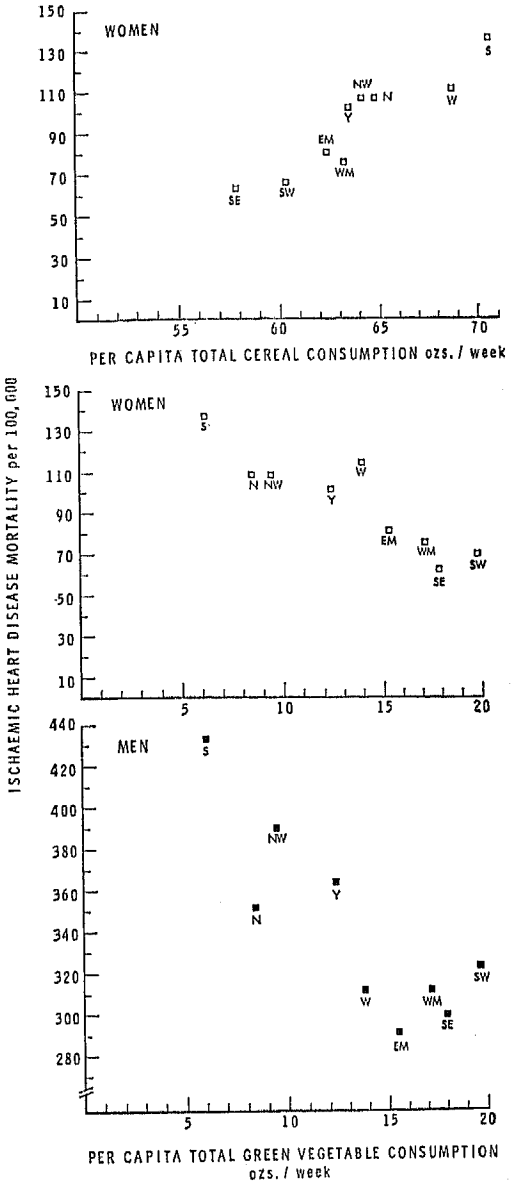

FIG. 3. Male ischemic heart disease mortality plotted against total fresh green vegetable consumption and female ischemic heart disease mortality plotted against total fresh green vegetable and total cereal consumption in nine regions of England, Wales and Scotland.

I.H.D. mortality is plotted against sugar consumption in 30 countries in Fig. 4.

The multiple regression analyses presented in Tables 4, 6 and 8 have identified the commodity variables most likely to be independently associated with ischemic heart disease in each data set. In an endeavor to identify other commodities which might explain these observations, first and second order partial correlation coefficients were calculated between these variables and ischemic heart disease mortality, controlling for the other commodities. All commodities and pairs of commodities were controlled except in the data from 30 countries where only the commodities significantly ($P < 0.05$) correlated with ischemic heart disease mortality were controlled. The minimum coefficients obtained with each key commodity are presented in Table 9.

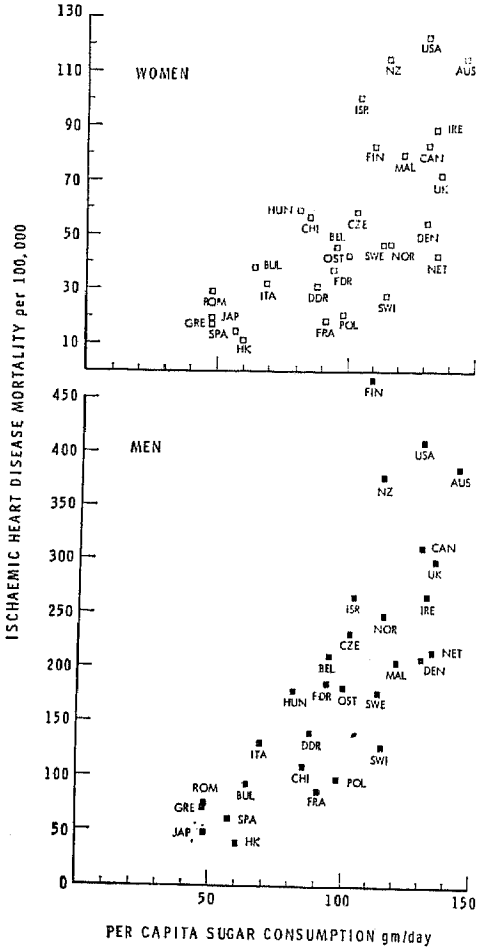

FIG. 4. Male and female ischemic heart disease mortality plotted against sugar consumption in 30 countries.

TABLE 6. STEPWISE MULTIPLE REGRESSION OF ISCHEMIC HEART DISEASE MORTALITY (1969) ON COMMODITY CONSUMPTION IN NINE REGIONS OF ENGLAND, WALES AND SCOTLAND IN 1969

	Commodity	Multiple correlation coefficient (R)	Mean square ratio (F)	Significance of F
Men	Total fresh green vegetables	0.83	15.4	$P<0.001$
	Total other vegetables	0.91	2.5	$P>0.05$
Women	Total fresh green vegetables	0.91	33.8	$P<0.001$
	Total cereals	0.98	17.1	$P<0.001$
	Total fresh fruit	0.99	4.5	$P>0.05$

TABLE 7. ZERO (r_0) AND FIRST AND SECOND ORDER PARTIAL (r_1 AND r_2) PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ISCHEMIC HEART DISEASE MORTALITY (1968 OR 1969) AND COMMODITY CONSUMPTION IN 30 COUNTRIES IN THE YEARS 1963–1965 UNLESS SPECIFIED OTHERWISE

Commodity	Men		Women		
	r_0	r_1	r_0	r_1	r_2
Cotrolled Vnariable	None	Sugar	None	Sugar	Sugar Cigarettes (1953–55)
GNP (1965)	0.61*	0.30	0.47*	0.08	0.08
Population density (1965)	−0.29	−0.19	−0.26	−0.15	−0.30
Physician density (1965)	0.11	0.10	0.21	0.24	0.33
Total calories	0.53*	0.14	0.43*	0.03	0.04
Total animal protein	0.75*	0.39*	0.58*	0.11	0.16
Total protein	0.49*	0.36	0.45*	0.30	0.30
Est. saturated fat	0.71*	0.34	0.58*	0.13	0.24
Total fat	0.59*	0.07	0.39*	−0.24	−0.10
Cereals	−0.58*	−0.02	−0.39*	0.26	0.10
Potatoes	0.09	−0.12	−0.16	−0.44*	−0.34
Sugar	0.76*	—	0.69*	—	—
Pulses	−0.28	−0.13	−0.07	0.15	0.08
Vegetables	−0.39*	−0.05	−0.22	0.17	0.10
Fruit	0.04	0.02	0.03	0.01	0.11
Meat	0.65*	0.28	0.65*	0.34	0.30
Eggs	0.56*	0.26	0.59*	0.35	0.29
Fish	−0.19	−0.07	−0.30	−0.24	−0.15
Milk	0.72*	0.35	0.48*	−0.08	0.04
Fats	0.26	−0.11	0.01	−0.44*	−0.27
Coffee (1965)	0.22	−0.18	−0.01	−0.48*	−0.38
Coffee (1955–57)	0.38*	0.12	0.14	−0.22	−0.10
Tea (1955–57)	0.41*	0.08	0.52*	0.29	0.13
Cigarettes	0.13	0.10	0.21	0.22	−0.17
Cigarettes (1953–55)	0.41*	0.26	0.55*	0.48*	—

*Correlation coefficient significant $P < 0.05$.

TABLE 8. STEPWISE MULTIPLE REGRESSION OF ISCHEMIC HEART DISEASE MORTALITY (1968 OR 1969) ON COMMODITY CONSUMPTION IN 30 COUNTRIES IN THE YEARS 1963–1965 UNLESS SPECIFIED OTHERWISE

	Commodity	Multiple correlation coefficient (R)	Mean square ratio (F)	Significance of F
Men	Sugar	0.76	26.0	$P < 0.001$
	Animal protein	0.80	3.3	$P > 0.05$
Women	Sugar	0.69	17.6	$P < 0.001$
	Cigarettes (1953–1955)	0.77	5.3	$P < 0.05$
	Coffee (1965)	0.81	2.8	$P > 0.05$

TABLE 9. MINIMUM FIRST AND SECOND ORDER PARTIAL PRODUCT MOMENT CORRELATION COEFFICIENTS (r_1 AND r_2) BETWEEN KEY COMMODITY VARIABLES AND ISCHEMIC HEART DISEASE MORTALITY WITH OTHER COMMODITIES CONTROLLED IN TURN

	Variable commodity	Controlled commodity	r_1	Controlled commodities	r_2
England and Wales 1950–1967					
Same year					
Men	Flour	Margarine	−0.55*	Coffee Milk	−0.26
	Coffee	Margarine	0.46	Butter Margarine	0.36
Women	Flour	Cigarettes	0.17	Fish Cigarettes	−0.02
	Coffee	Margarine	0.72*	Fish Cigarettes	0.57*
	Cigarettes	Flour	0.66*	Flour Coffee	0.14
Nine years previously					
Men	Sugar	Flour	0.55*	Flour Cheese	0.42
	Flour	Sugar	−0.47	Coffee Sugar	−0.34
Women	Sugar	Flour	0.69*	Flour Cheese	0.58*
	Flour	Sugar	−0.69*	Coffee Sugar	−0.63*
Nine regions of England, Scotland and Wales					
Men	Total fresh green vegetables	Margarine	−0.71*	Potatoes Tea	−0.46
Women	Total fresh green vegetables	Total fresh fruit	−0.76*	Total fresh fruit Eggs	−0.66
	Total cereals	Total fresh fruit	0.76*	Total fresh fruit Eggs	0.60
30 Countries					
Men	Sugar	Animal protein	0.44*	Meat Milk	0.37
Women	Sugar	Meat	0.45*	Eggs Saturated fat	0.36
	Cigarettes (1953–1955)	Tea	0.40*	Eggs Tea	0.35

*Correlation coefficient significant $P < 0.05$.

DISCUSSION

Three different data sets have been used in this investigation to examine the relationship between I.H.D. mortality and dietary practices.

International comparisons

The limitations of international comparisons have been reviewed by Joliffe and Archer [15]. In our study we have included only those countries in which mortality statistics might be expected to be reliable (i.e. those countries where less than 15 per

cent of deaths were attributed to senility and ill-defined causes) and statistics have been derived from the 8th Revision of the ICD, in which I.H.D. has been much more clearly defined than in earlier revisions. Data concerning coffee and cigarette consumption have also been obtained. When considering only the simple correlation coefficients, sugar, total animal protein, milk, saturated fat, meat and GNP appeared to be most strongly related to I.H.D. mortality, though several other associations were also statistically significant. A significant negative association was present for cereals (Table 7).

Utilizing data obtained from the Balance Sheets of the FAO in 1959, Joliffe and Archer found the intake of saturated fat to be the most important factor accounting for the differences in I.H.D. death rates between countries. Animal protein intake, though of lesser importance, accounted for a large proportion of the variability in these rates [15]. Yudkin, however, using similar data, suggests a closer association between sucrose consumption and I.H.D. mortality [16, 17]. McGandy *et al.* [18] have calculated the very strong correlation (r=0.92) between consumption of sugar and saturated fat as compared with the relationship between heart disease mortality and sugar (r=0.80) and saturated fat (r=0.82). They also point out the difficulties in deciding which of the dietary changes with economic development (i.e. an increase in animal protein, total and saturated fat, and simple sugars, and a decrease in the consumption of complex carbohydrate) may account for the varying frequency of ischemic heart disease.

Actual food consumption by people in defined samples and the assessment of I.H.D. in these samples by international teams form the basis for the correlations tested by Keys and his co-workers in seven countries [19]. Recent analysis of these data [20] has shown that the association between sucrose intake and I.H.D. mortality (r=0.78) is greatly reduced when the partial correlation coefficient is computed holding the saturated fat intake constant. On the other hand, the association between saturated fat intake and I.H.D. mortality (r=0.86) is not markedly reduced when the partial correlation coefficient is calculated controlling for sucrose. Results of investigations of this kind are undoubtedly more reliable than those in which crude population consumption statistics are employed.

Other factors have been studied less intensively. Cigarette consumption was shown to have a significant positive association with I.H.D. mortality by Mulcahy, McGilvray and Hickey [21] and also by Brummer [22] who was able to find no association between I.H.D. mortality and coffee, tea, cocoa, and alcohol. The significant association between I.H.D. mortality and the number of telephones in a population, which in turn is related to dietary saturated fat, indicates the complexity of these associations and the care with which they need to be interpreted.

The most recent international comparisons have been carried out by Masironi [13], who again demonstrated a strongly positive correlation between consumption of total and saturated fat and death rates, while consumption of complex carbohydrate was found to be negatively correlated.

We carried out more extensive multiple regression and partial correlation analysis in an endeavor to identify which of the significantly correlated commodity variables was most likely to be independently related to I.H.D. mortality. In our analysis of 30 countries, sugar consumption emerged as the most strongly related commodity. The reasons why sucrose in the diet is probably not a major factor in the development of I.H.D., as was suggested by Yudkin, have been carefully reviewed by Keys [23]. It may

perhaps be mentioned here that three countries (Colombia, Cuba and Venezuela) with a high sucrose consumption and low I.H.D. mortality rates were excluded from the analysis because more than 15 per cent of deaths were attributed to senility and ill-defined causes.

In women, cigarette smoking habits 15 yr earlier also made a significant contribution, independently of sugar. This finding should be viewed cautiously as the figures refer to population cigarette consumption rather than female cigarette consumption. Saturated fat consumption was not as strongly associated as sugar in our data, but in the absence of satisfactory figures for fat composition in various countries, any estimate of saturated fat consumption must be considered unreliable.

Within country comparisons

Antar *et al.* [24] have examined changes in the American diet over the last 70 yr with particular emphasis on fats and carbohydrates. They found the principal change to be a decreasing consumption of total carbohydrate with a greater progressive decline in the intake of complex carbohydrate from flour, cereals and potatoes and a concurrent increase in simple sugars. The increase in fat consumption was slight and due to increase of unsaturated fatty acids. The authors considered that their data did not fit the hypothesis that low ratios of polyunsaturated: saturated fatty acids had contributed to the increasing incidence of I.H.D. in the United States, but rather that changes in carbohydrate may have been a factor. The main increase in fat consumption in Great Britain appears to have occurred during the 1930's [25], after the rise in I.H.D. mortality is said to have started, but sucrose consumption in this country would hardly seem to offer an alternative explanation since the per capita use of sucrose was over 40 kg per year prior to the First World War and by the mid-60's was only slightly over 50 kg [26]. In Masironi's study, no significant relationship could be demonstrated between commodity consumption and temporal changes in death rate, but only the years 1955 and 1965 were considered [13]. As far as we are aware, there has been no investigation so far in which temporal changes in male and female I.H.D. mortality and commodity consumption have been considered in any detail.

In our examination of temporal changes in England and Wales, a wide range of not unexpected significant simple correlations emerged, but multiple regression and partial correlation analysis showed coffee and flour to be the factors most strongly related to I.H.D. mortality. The positive correlation with cigarette consumption in women, however, could explain the negative correlation with flour. When considering commodity consumption nine years previously, sugar and flour (the latter again negatively associated) emerged most strongly.

Knox has recently carried out correlation analyses between standardized mortality rates for I.H.D. in different regions of England and Wales and dietary intakes of a number of nutrients [27]. Calcium intake showed a strong negative correlation which was consistent with variations between mortalities in hard and soft water areas [28]. Fat and vitamin D intakes both showed positive associations with residual variations of the mortality rates after the effects of calcium had been excluded. However, the different nutrients also correlated with the standardized mortality ratios for several other diseases and it was suggested that the regional nutrient associations of ischemic heart disease were probably best explained as indirect effects.

A high association between sugar consumption and I.H.D. mortality has also been demonstrated in the 10 regions of Czechoslovakia [29].

Our analysis of the data for the nine regions of England, Wales and Scotland shows the strongest association to be a negative relationship with consumption of total fresh green vegetables. From Figs. 1 and 3 it is apparent that both I.H.D. mortality and total fresh green vegetable consumption show a strong North–South gradient in the United Kingdom. The correlation could therefore be confounded by any other variable showing this gradient.

Perhaps the most important conclusion which is to be drawn from these data is the caution with which the significance of the associations should be interpreted. Associations suggested by these techniques need to be tested by carefully controlled dietary studies. Such studies have, for instance, shown a very clear relationship between saturated fat intake and serum cholesterol levels [30] which in turn are related to the development of I.H.D. [31]. Sucrose consumption, on the other hand, has not been found to be related to serum lipid levels or other measurable factors known to be associated with I.H.D. [18, 32] except when it is taken in amounts in excess of the usual consumption [33].

A great deal has been written concerning the effects of fibre on bowel function, but recently it has also been suggested that fibre has hypocholesterolemic properties [34]. It may be that these properties explain the strong negative association between flour and I.H.D. mortality apparent in some of our data. Further investigation is clearly necessary. This negative association with flour need not, however, reflect a negative association with cereal fibre, since the flour consumed over the period of study would have been predominantly fiber-free [35].

An association between coffee drinking and acute myocardial infarction was also found in the Boston Collaborative Drug Surveillance Program [36] but there is as yet no conclusive evidence for the mechanism by which coffee may exert its effect. Similar direct epidemiological studies have not supported the reported association between either sugar or saturated fat intake and myocardial infarction [37, 38].

A relationship between cigarette smoking and I.H.D. has been clearly demonstrated in other types of investigation [39] and failure to show a consistent association in our data probably reflects deficiencies in the method.

Lack of consistency when examining the results of these analyses and their failure to agree with other epidemiological approaches to the problem lead us to conclude that the associations seen need not reflect causal relationships but serve principally as pointers to further research.

SUMMARY

The relationship between ischemic heart disease mortality and commodity consumption has been studied by investigating the temporal changes in England and Wales and comparing the results with a cross-sectional correlation study in nine regions of England, Wales and Scotland and in thirty countries where mortality statistics were considered to be reliable. Many statistically significant simple correlations emerged. Multiple regression and partial correlation analyses identified different commodity variables as being most likely to be independently related to I.H.D. mortality in each of the three studies. These results suggest that associations

identified in this type of investigation should be interpreted with great caution and need not necessarily reflect causal relationships but rather suggest avenues along which further research might proceed.

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