Sugar Intake and Myocardial Infarction*

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In 1957, Yudkin showed that the mortality from arteriosclerotic heart disease in different countries was more closely related to sugar consumption than to fat consumption, and he subsequently suggested that the consumption of sugar might be a cause of the disease (1963). He tested this hypothesis by comparing the dietary histories of patients with myocardial infarction or peripheral vascular disease with those of other patients or healthy subjects interviewed at home or at work (Yudkin and Roddy, 1964; Yudkin and Morland, 1967). In two separate studies the men with myocardial infarction were found to have habitually eaten about twice as much sugar as the other men. Other investigators have failed to confirm Yudkin's findings in patients (Little *et al.*, 1965; Papp, Padilla, and Johnson, 1965); but it should be noted that they recorded the patients' dietary histories several months after the infarct had occurred, when food intake might have been modified. We have, therefore, sought to reproduce Yudkin's results by adhering as closely as possible to his method and interviewing patients while they were still in hospital.

METHOD

Men under 65 years of age were studied who were admitted to the Central Middlesex Hospital during specified periods between October 1965 and February 1968 with a diagnosis of a first myocardial infarct.

The diagnosis was accepted only if there was: (i) a history of pain at rest accompanied by Q wave changes

in the electrocardiogram; or (ii) a history of at least one hour's pain at rest accompanied by S-T changes in the electrocardiogram and ancillary evidence of an infarct: that is, one or more of the following, (a) a white blood cell count of over 11,000/cu.mm.; (b) an ESR of over 20 mm./hour; (c) a temperature of 48 hours' duration, rising to at least 37.8°C. (100°F.); or (d) a serum aspartate aminotransferase (SGOT) over 40 units/100 ml. (Reitman and Frankel, 1957) or a serum hydroxybutyric dehydrogenase over 140 units/100 ml. (Rosalki, 1962).

For comparison, other men were also studied who were admitted to the general medical or surgical wards of the same hospital, who were under 65 years of age, and who provided no evidence of overt arterial disease (for example, did not have, or give a history of having had, angina pectoris, myocardial infarction, intermittent claudication, or a cerebrovascular accident). Two such men were chosen to match each infarct patient, by being in hospital at or about the same time and within 2½ years of the same age.

Bias due to national differences and the effect of disease was reduced by excluding patients from both groups if they: (i) were born outside Great Britain, or (ii) had had diabetes mellitus, a hospital diagnosis of peptic ulcer, or treatment for hypertension. Patients were not excluded if they had dieted for other purposes before admission, but the type of diet and its duration were recorded.

All patients were seen in hospital, when the medical history and diagnosis were checked, the blood pressure recorded, and the weight and height measured. Dietary histories were taken, while the patients were still in hospital, by an experienced interviewer trained as a medical social worker. A standard questionnaire was used which paid special attention to sugar consumption, but which also included questions about other relevant personal characteristics. No attempt was made to obtain a complete dietary history which would enable an estimate to be made of the calorie value of the diet or the total consumption of fat, carbohydrate, or protein. Patients were told that the object of the inquiry was to find out if there was any connexion between items of diet and disease.

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TABLE I
PRINCIPAL DIAGNOSES IN CONTROL
PATIENTS

Diagnosis	No. of patients
Cancer of bronchus	12
Cancer of large bowel	8
Other malignant disease	6
Varicose veins	7
Other cardiovascular disease	6
Chronic bronchitis	12
Asthma	6
Other respiratory disease	7
Hernia	19
Appendicitis	5
Gall-bladder disease	7
Other gastro-intestinal disease	9
Prolapsed disc	5
Disease of joints	11
Trauma	14
Other disease	26
All diagnoses	160

SUBJECTS

Altogether 80 infarct and 160 control patients were studied. The principal conditions for which the control patients were admitted are shown in Table I. The comparability of the two groups of patients is shown in Tables II (age distribution), III (social class distribution), and IV (marriage status). It is evident that the groups are comparable with regard to age—as indeed was ensured by the design of the study—but that the infarct patients included a higher proportion in social classes I, II, and III, and a higher proportion who were married. This latter difference may be an artefact due to the choice of hospital patients as controls. Patients who are unmarried (whether bachelors, widowed, or separated) tend to stay in hospital longer than married patients, and are, consequently, more readily available for interview.

TABLE II
AGE DISTRIBUTION OF PATIENTS

Disease group	No. of patients aged (yr.):				Mean age (yr.)
	35 to 44	45 to 54	55 to 64	All ages	
Myocardial infarct	8	30	42	80	54.4
Other	12	59	89	160	55.1
All groups	20	89	131	240	—

$$\chi^2 = 0.501, n = 2, 0.3 < p < 0.5$$

TABLE III
SOCIAL CLASS DISTRIBUTION IN PATIENTS

Disease group	No. of patients in social class:			Total
	I and II	III	IV and V	
Myocardial infarct	18	50	12	80
Other	25	87	48	160
All groups	43	137	60	240

$$\chi^2 = 6.824, n = 2, p = 0.03$$

TABLE IV
MARITAL STATUS DISTRIBUTION OF PATIENTS

Disease group	No. of patients			Total
	Married	Widowed, separated, or divorced	Never married	
Myocardial infarct	73	4	3	80
Other	125	12	23	160
All groups	198	16	26	240

$$\chi^2 = 7.171, n = 2, p = 0.03$$

RESULTS

Three measures have been used to assess the amount of sugar consumed: (i) the amount taken per cup of hot drink, (ii) the total amount taken in hot drinks per day, and (iii) the total amount of refined sugar consumed per day in the whole diet. To obtain these measures, items of diet were converted to grams of refined sugar by using the following conversion factors (Table V).

The distinction between heaped and level teaspoons and between large and small lumps was made in an attempt to attain greater accuracy. It is possible, however, that the attempt may have defeated itself, by increasing the amount of random variation. A simple estimate of the number of teaspoons of sugar (equating one lump of sugar with one teaspoon) may provide a better indication of the subject's taste for sugar and hence of his likely total consumption. We have, therefore, also expressed the first two measures in terms of "teaspoons" of sugar as well as in grams.

The results of the analysis show that patients admitted to hospital with a myocardial infarct took, on average, slightly more sugar in their tea and coffee than the control patients. The mean amounts were 1.40 and 1.24 teaspoons per cup, respectively ($t = 1.60, n = 238, 0.1 < p < 0.2$). The numbers of

TABLE V
CONVERSION FACTORS USED IN DIETARY
ASSESSMENT

Item	Refined sugar (g.)
1 level teaspoon of sugar	4.0
1 heaped teaspoon of sugar	6.0
1 small lump of sugar	3.5
1 large lump of sugar	7.0
1 oz. boiled sweets, toffees or chocolates	24.0
1 oz. block chocolate	15.0
3 oz. helping of pudding	17.0
1 cake or 1 slice (1½ oz.) of cake	12.0
1 sweet or semi-sweet biscuit	1.5
1 teaspoonful of jam or marmalade	5.0
1 teaspoonful of honey or syrup	6.0
1 glass of non-alcoholic drink, squash	10.0
1 glass of non-alcoholic drink, ribena (bottled "fizzy" drinks ignored)	17.0
1 teaspoonful of powdered Ovaltine, etc.	2.0
1 teaspoonful of sweetened condensed milk	2.0

TABLE VI
NUMBER OF PATIENTS TAKING DIFFERENT
AMOUNTS OF SUGAR PER CUP OF HOT DRINK

Disease group	No. of men					All amounts
	Number of teaspoonsful per cup					
	0	< 1	1, < 2	2, < 3	3 or more	
Myocardial infarct	7	5	33	33	2	80
Other	16	14	79	49	2	160
All groups	23	19	112	82	4	240

$\chi^2 = 3.524$, $n = 4$, $0.3 < p < 0.4$
 χ^2 for trend = 1.023, $n = 1$, $0.3 < p < 0.5$

patients who took different amounts are shown in Table VI. Relatively more of the infarct patients than of the control patients took two or more teaspoons per cup and relatively fewer took less than one teaspoon. A statistical test showed, however, that this trend could well be due to chance ($p > 0.3$).

When the amounts were converted into grams, and a distinction was made between heaped and level teaspoons and large and small lumps, the difference between the groups was reduced. The means were then calculated to be 7.07 g. and 6.49 g. per cup, respectively ($t = 1.03$, $n = 238$, $0.3 < p < 0.4$).

The effect of differences in the social class and marital status of the patients in the disease groups is shown in Table VII. Men in social classes I and II took slightly less sugar per cup than men in social classes III, IV, and V, and married men took slightly more sugar than the unmarried. Since the infarct patients included a higher proportion of married men and of men in social classes I and II, the effects of these differences will have largely cancelled themselves out. The effects were, in any case, small, and the mean amounts for each disease group, after standardizing for social class or for

TABLE VII
MEAN NUMBER OF TEASPOONSFUL OF SUGAR
TAKEN PER CUP, BY SOCIAL CLASS AND BY
MARITAL STATUS

Category		Mean number of teaspoons among:		
		Men with myocardial infarcts	Men with other diseases	All men
Social class	I and II	1.29	1.01	1.13
	III	1.44	1.32	1.36
	IV and V	1.42	1.23	1.27
Standardized for social class		1.41	1.24	1.30
Married		1.42	1.27	1.33
	Unmarried	1.21	1.13	1.14
Standardized for marital status		1.38	1.25	1.30

TABLE VIII
NUMBER OF PATIENTS TAKING DIFFERENT
AMOUNTS OF SUGAR IN HOT DRINKS PER DAY

Disease group	No. of men					All amounts
	No. of teaspoons per day					
	< 5	5-8	9-12	13-16	17 or more	
Myocardial infarct	15	19	17	13	16	80
Other	39	43	34	26	18	160
All groups	54	62	51	39	34	240

$\chi^2 = 3.834$, $n = 4$, $0.3 < p < 0.5$
 χ^2 for trend = 3.277, $n = 1$, $p = 0.07$

marital status, were almost identical with the crude figures.

Consideration of the number of cups drunk per day also made little difference to the results. On average, patients admitted with a myocardial infarct took 11.00 teaspoons of sugar in hot drinks per day compared with 9.63 teaspoons per day for the control patients ($t = 1.18$, $n = 238$, $0.2 < p < 0.3$). The numbers of patients taking different total amounts of sugar in hot drinks are shown in Table VIII. Relatively more of the infarct patients than of the control patients took 17 or more teaspoons and relatively fewer took less than 9 teaspoons, but the trend, though somewhat more marked than when the number of teaspoons per cup was considered alone, was not quite statistically significant ($p = 0.07$).

When the amounts were converted into grams and a distinction was made between heaped and level teaspoons and large and small lumps, the difference between the groups was reduced. The means were then calculated to be 56.10 g. and 51.04 g. per day, respectively ($t = 0.71$, $n = 238$, $0.4 < p < 0.5$).

The estimated total amounts of refined sugar taken per day are shown in Table IX. The mean amounts were 100.1 g. for the men with a myo-

TABLE IX
NUMBER OF PATIENTS TAKING DIFFERENT
TOTAL AMOUNTS OF REFINED SUGAR PER DAY

Disease group	No. of men					All amounts
	Amount of sugar taken per day (g.)					
	< 30	30-59	60-89	90-119	120 or more	
Myocardial infarct	4	10	25	18	23	80
Other	11	28	43	34	44	160
All groups	15	38	68	52	67	240

$\chi^2 = 1.571$, $n = 4$, $0.8 < p < 0.9$
 χ^2 for trend = 0.676, $n = 1$, $0.3 < p < 0.5$

TABLE X
MEAN TOTAL CONSUMPTION OF REFINED SUGAR
PER DAY, BY SOCIAL CLASS

Disease group	Mean amount of sugar taken per day (g.)			Mean amount standardized for social class
	I and II	III	IV and V	
Myocardial infarct	100.7	102.2	90.8	99.1
Other	77.9	103.6	95.4	96.9
All groups	87.4	103.1	94.5	98.1

cardial infarct and 97.1 g. for the other men. The amount taken varied irregularly with social class, and standardization for social class made practically no difference to the results (Table X). Only in social classes I and II was there any appreciable difference in the total daily consumption between the affected and the control patients, but even in this subgroup the difference was not statistically significant (mean consumption, 100.7 g. and 77.9 g., $t = 1.749$, $n = 41$, $p \approx 0.1$).

Comparison of the weights of the patients is inappropriate, because some of the men in the control group were suffering from wasting disease. It may be noted, however, that about the same proportion of men in each group had attempted to control their weight by dieting (20 out of 80 infarct patients, or 25%, and 45 out of 160 controls, or 28%).

The patients' smoking habits are summarized in Table XI. Patients with lung cancer or chronic bronchitis have been omitted, because their conditions are known to be associated with smoking. The remaining results are broadly in accordance with those of many other studies (see U.S. Public Health Service, 1964, 1967) and show that a higher proportion of the infarct patients than of the control patients were current smokers before the onset of the illness that brought them into hospital.

TABLE XI
DISTRIBUTION OF SMOKING HABITS IMMEDIATELY
PRECEDING THE ILLNESS THAT CAUSED ADMISSION

Disease group	No. of men					All smoking categories
	Non-smokers	Ex-smokers	Current smokers			
			Pipe or mixed	Cigarettes per day		
				1-14	15 or more	
Myocardial infarct	6	7	12	24	31	80
Other, excluding lung cancer and chronic bronchitis	16	33	13	34	40	136

Comparison between non- and ex-smokers and current smokers, $\chi^2 = 9.629$, $n = 1$, $p < 0.01$.

TABLE XII
RELATION BETWEEN SMOKING HABITS AND SUGAR CONSUMPTION: ALL PATIENTS

No. of teaspoons of sugar in hot drinks per day	No. of men					All smoking cat- egories
	Non- smokers	Ex- smokers	Current smokers			
			Pipe or mixed	Cigarettes per day		
				1-14	15 or more	
< 5	6	15	6	8	19	54
5-8	10	20	5	15	12	62
9-12	6	7	4	17	17	51
13-16	0	5	5	13	16	39
17 or more	1	2	5	9	17	34
All amounts	23	49	25	62	81	240
Mean for all men	Daily consumption of refined sugar (g.)					
	90.6	80.8	105.4	108.2	100.7	98.1

Table XII shows that the smoking habits of the patients were, to some extent, correlated with their consumption of sugar, smokers tending to take more sugar than non-smokers or ex-smokers. For this purpose the number of teaspoons of sugar consumed in hot drinks per day was taken as the best estimate of sugar consumption, as this had provided the clearest distinction between the infarct patients and the controls. It is, therefore, important to see whether the difference in sugar consumption between the two groups could be due to an underlying difference in smoking habits, or vice versa. The results are summarized in Table XIII which shows the data separately for three categories of sugar consumption and two smoking categories. The number of infarct patients expressed as a percentage of all the patients with a given dietary and smoking history shows no trend with the amount of sugar

TABLE XIII
MYOCARDIAL INFARCT AND CONTROL PATIENTS
DIVIDED BY SMOKING HABITS AND SUGAR CONSUMPTION
(TEASPOONFUL OF SUGAR PER DAY IN HOT DRINKS)

	Smoking category	No. of teaspoons of sugar		
		< 9	9-12	13 or more
No. of patients with myocardial infarct	Non-smokers or ex-smokers	9	3	1
	Current smokers	25	14	28
No. of patients with other diseases	Non-smokers or ex-smokers	42	10	7
	Current smokers	40	24	37
No. of myocardial infarct patients expressed as percent of all patients in same category	Non-smokers or ex-smokers	18%	23%	13%
	Current smokers	38%	37%	43%

TABLE XIV

DAILY CONSUMPTION OF REFINED SUGAR, BY MEN WITH AND WITHOUT MYOCARDIAL INFARCTS: COLLECTED DATA

Country	Authors	Mean daily consumption of refined sugar (g.)		Comments
		Patients with myocardial infarcts (no. in parentheses)	Other subjects (no. in parentheses)	
U.K.	Yudkin and Roddy (1964)	132 (20)	77 (25)	Controls: 13 orthopaedic patients and 12 healthy men Orthopaedic controls
U.K.	Yudkin and Morland (1967)	148 (20)	90 (13)	
U.K.	This paper (Burns-Cox <i>et al.</i>) Marr and Heady (1964)	100 (80)	78 (20)	Healthy controls
U.K.		—	97 (160)	Controls: other in-patients
		—	109 (99)	Bank clerks
		—	118 (60)	Bus drivers
		—	123 (48)	Bus conductors
U.K.	Hollingsworth and Greaves (1967)	—	140 (—)	Estimated available supply per person
Canada*	Papp <i>et al.</i> (1965)	121 (20)	117 (20)	Controls: 19 in-patients and 1 healthy man
U.S.A.	Paul <i>et al.</i> (1968)	116 (66)	96 (85)	Controls: workers in same factory
Eire	Finegan <i>et al.</i> (1968)	66 (100)	69 (50)	Controls: surgical patients

* Data of Little *et al.* (1965) show lower mean values (58 coronary patients under 60 years, 48 g.; 52 healthy controls 55 g.), but they took account only of sucrose used in cooking or added to food and drink.

consumed within each smoking category, but it does show a substantial difference between smoking categories within each category of sugar consumption. This suggests that the slightly greater sugar intake recorded in patients with myocardial infarction may be secondary to their heavier consumption of tobacco.

DISCUSSION

The object of our study was to see if we could reproduce Yudkin's results, by adhering as closely as possible to his method. This we have failed to do. Our data, however, do not justify a firm conclusion that sugar consumption is unrelated to the development of myocardial infarction. Retrospective studies of hospital patients may be subject to bias both in the selection of patients and in the recording of the data, and it is impossible to be sure that either our results or Yudkin's were not biased in one or other respect. In our study the infarct series consisted of groups of consecutive patients admitted to the medical wards of the hospital who survived long enough to be interviewed and who met the required criteria, with the exception only of those who were deaf or unable to speak English. The control series included similar patients with a variety of other diseases and all who were available at the time the ward was visited were interviewed. Limitation of the study to men who were born in Great Britain eliminated major national differences in dietary habits, and the exclusion of patients with a history of diabetes mellitus, peptic ulcer, treatment for hypertension, or a previous infarction eliminated the main sources of dietary differences for medical reasons. That this was effective was shown by the fact that the proportion of patients who had

attempted to control their weight by dieting was similar in both groups (25% and 28%). It is conceivable that the control series included a disproportionate number of patients with conditions associated with a high consumption of sugar, but the inclusion of such a wide variety of diseases makes this unlikely.

It was not practical to conduct the interview without knowledge of the type of disease from which the patient suffered, since the infarct patients were largely concentrated in special wards. It is, however, unlikely that this influenced the recording of the data, since the interviewer had been interviewing patients for research purposes successfully, and without the apparent introduction of bias, for 20 years. It remains possible that the patient's knowledge of the condition from which he was suffering influenced the account of his dietary habits. This could most easily have affected the relatively complex history of the individual's total sugar consumption. It is less likely to have affected the simple assessment of the number of teaspoonsful of sugar taken habitually in a cup of tea.

The various results reported in earlier publications are summarized in Table XIV. All refer to middle-aged men. For comparison, an estimate has been included of the available supply of refined sugar per person in the United Kingdom in 1964. All but two show that the patients with a myocardial infarct have consumed, on average, more refined sugar than the controls with which they were compared. The extent of the difference, however, is very variable. It is possible, as Yudkin and Morland (1967) suggest, that Papp *et al.* (1965) and Little *et al.* (1965) failed to observe any appreciable excess consumption by infarct patients be-

cause the histories were not taken until several months after the infarct had occurred, when their diet (and memory of their previous diet) might have been modified. This criticism does not apply to our results nor to those reported by Paul *et al.* (1968) or Finegan *et al.* (1968). In Paul's study, moreover, the dietary histories were taken when the patients were well and before it was known which patients were going to develop an infarct. In their study the collection of the dietary histories cannot have been biased by knowledge of the nature of the patient's illness.

Smoking histories were recorded only in Paul's study and our own, and both sets of data showed a weak positive association between smoking and the consumption of sugar. In both cases the association between myocardial infarction and smoking was stronger than that between myocardial infarction and sugar consumption. In these studies much, if not all, of the excess consumption of sugar reported by patients with a myocardial infarction could have been secondary to an association between sugar consumption and smoking. The data relating sugar consumption to smoking, however, are few, and more observations are needed before the relation can be regarded as established.

We conclude only (i) that smoking habits need to be taken into account in studies of the relation between sugar consumption and disease, and (ii) that the totality of the data now available does not suggest that the consumption of refined sugar is likely to be a major and specific factor in the production of myocardial infarction.

SUMMARY

An attempt has been made to reproduce Yudkin's finding that the dietary intake of sugar was considerably greater in patients with arterial diseases.

Comparison was made between 80 men under 65 years of age recovering from a myocardial infarction and 160 men, matched for age and country of birth, who were in hospital at about the same time with other diseases. An experienced interviewer took dietary histories from all the patients using a standard questionnaire.

The infarct patients were found to take slightly more sugar in their hot drinks, and slightly more refined sugar in total than the control patients. None of the observed differences, however, was statistically significant.

A greater proportion of the infarct patients than of the control patients were smokers, and smokers tended to take more sugar in their hot drinks than non-smokers or ex-smokers. The slightly increased sugar intake recorded for the infarct patients could be a reflection of their heavier consumption of tobacco.

Miss Keena Jones undertook the dietary surveys on which this report depends, and for this we are most grateful.

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