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The Ecological Relationship between Fish Intake and Standardized Mortality Ratios of Stroke and Ischemic Heart Disease.

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ABSTRACT

The nutritional surveys were made during the same season (July−August; from 1976 to 1984) in 11 towns of Tokushima Prefecture, east south of Shikoku, Japan. These surveys were made by 24-hour recall interview method. The daily consumption of fish per person was 3 to 4 times higher in the sea coast regions than in the mountainous regions. The relationships between the food variables and standardized mortality ratios (SMR) on town basis for vascular diseases were analyzed. Significant inverse relationships were observed between the fish intake in summer per cm of body height and SMR of cerebral haemorrhage, and incidence of borderline hypertension plus hypertension. No significant relationships were found between SMR of cerebral haemorrhage and intake of sodium chloride or ratio of sodium to potassium. Dietary protein had a significant negative association with the SMR of cerebral haemorrhage. Significant inverse relation was seen between SMR of ischemic heart disease (IHD) and the fish intake per cm of body height, at least up to the value of 0.7 of fish intake per cm of body height. Whereas a positive correlation was seen between them, in the value of greater than 0.7 of fish intake per cm of body height. These findings indicate that more consumption of fish in summer than average level might be preventive value both for cerebral haemorrhage and IHD. But diatary habbit with the larger proportion of fish, seems to have upward influence upon the SMR of IHD.

INTRODUCTION

Recongnition that fish is important in the prevention of heart disease has increased, since Dynerberg had reported low incidence of coronary heart disease in Greenland Eskimos whose predominant food had been seal and fish (1−3). In 1985 the mortality from ischemic heart disease (IHD) has been more frequent than that of stroke among Japanese (4). This inversion is thought to be due to the steady upward tendency of the animal protein and fat intake, as shown by National Nutrition Survey in Japan (5). In the Zutphen study (6), it is recommended to eat more fish, for the prevention of IHD. However the average fish intake of the Zutphen man was only 20g per day, whereas in Japan it is about 90g (5). Kimura *et al.* (7), reported that the intake of higher fish protein prevented the death from cerebral haemorrhage in Ushibuka, although the incidence of hypertension and intake of sodium chloride were higher at fishing village of Ushibuka than at farming village of Tanushimaru in Fukuoka Prefecture.

Komachi (8), found the inverse relationship between the concentration of cholesterol in serum and the incidence of death from cerebral haemorrhage in Japan. He concluded that a diet which induced too low serum cholesterol was a risk factor for stroke. On the other hand, fish oils lowered the concentration of plasma cholesterol in normal subjects (9), and also in patients with hypertriglyceridemia (10). Therefore, the more specific studies are needed to determine whether high fish consumption really prevents the IHD or the cerebrovascular diseases in Japan. To examine the relationships between the fish intake and standardized mortality ratios (SMR) from vascular diseases on town basis (11), we have conducted nutritional surveys of middle-aged adults living in different environments such as sea coast, plain and mountainous area in Tokushima. The present paper reports the relationships between fish intake per day per person and SMRs of vascular diseases among Japanese in Tokushima Prefecure, then discusses its roles in prevention of cerebral haemorrhage and IHD.

Figure 1: Maps of Japan and Tokushima Prefecture. Shadows in the maps show the places surveyed in the present study. 1:Mugi, 2:Ichiba, 3:Kamiita, 4:Ikeda, 5:Handa, 6:Yuki, 7:Yamashiro, 8:Sadamitu, 9:Wajiki, 10:Kamojima, 11:Hanoura.

Materials and Methods

1) Subjects of nutritional surveys;

The nutritional surveys were made during the same seson (July–August), in 11 towns in Tokushima Prefecture, east south of Shikoku, Japan (Fig 1), beginning from 1976 to 1984. The subjects were selected from the members of agricultural or fishing association. Their age ranged from 30 to 59 years. The study population, totally consisted of 689 men and 957 women whose average ages were 48.0 ±7.5 in male and 47.2 ± 7.2 in femals (Mean ± SD). Table 1 shows the characteristics of subjects in each town surveyed.

Table 1. Characteristics of subject groups in the study

Town		Sex	Number	Age	Height	Weight	Obesity Index*	Population
Hanoura	(1984)	M	38	49.1±1.3	164.2±0.9	59.3±1.4	104.4±2.2	5,430
		F	89	50.2±0.7	151.9±0.5	51.9±0.7	105.6±1.3	5,910
Kamojima	(1983)	M	84	49.6±0.7	161.8±0.7	57.9±0.8	104.6±1.3	12,444
		F	68	47.6±0.8	151.4±0.5	52.3±1.0	106.9±1.8	13,662
Wajiki	(1982)	M	79	46.9±0.8	163.4±0.6	60.3±0.8	107.0±1.3	1,650
		F	94	48.3±0.7	153.2±0.6	53.4±0.7	107.1±1.2	1,867
Sadamitu	(1981)	M	76	48.8±0.8	162.0±0.6	58.6±0.8	105.6±1.2	3,785
		F	92	48.9±0.7	150.8±0.5	51.9±0.8	106.9±1.5	4,228
Yamashiro	(1980)	M	91	47.6±0.8	161.2±0.6	56.8±0.8	103.2±1.2	3,708
		F	88	46.8±0.7	149.9±0.5	51.1±0.7	106.4±1.4	4,013
Yuki	(1980)	F	76	44.3±0.8	151.9±0.6	54.7±1.0	111.0±1.8	2,525
Handa	(1980)	F	67	48.6±1.0	150.6±0.7	54.1±1.1	111.2±1.9	4,097
Ikeda	(1979)	M	70	50.5±0.8	162.1±0.8	58.2±1.0	104.6±1.5	10,050
		F	108	48.1±0.5	150.7±0.5	51.4±0.7	105.7±1.3	11,242
Kamiita	(1978)	M	87	46.5±0.9	163.2±0.6	59.4±0.9	105.5±1.3	5,853
		F	87	45.4±0.9	152.2±0.5	51.9±0.8	105.2±1.5	6,221
Ichiba	(1977)	M	82	46.6±0.9	162.7±0.5	57.8±0.8	103.5±1.2	5,950
		F	105	46.3±0.6	151.0±0.5	51.6±0.8	106.1±1.5	6,404
Mugi	(1976)	M	69	47.2±1.0	163.4±0.6	60.5±1.0	107.5±1.6	3,621
		F	76	44.6±1.0	151.8±0.6	53.0±0.9	108.0±1.8	4,073

Values are means ± SEM. * Obesity Index ; Weight/Standard Weight × 100.

Standard Weight (Male) : $75.588 \times \text{Height}^3 \times 10^{-7} + 23.226$

Standard Weight (Female) : $79.463 \times \text{Height}^3 \times 10^{-7} + 21.233$

2) Method of nutritional surveys

We used the 24-hour recall interview method (12) for the nutritional surveys. This method was conducted by trained nutritionists and University students majoring in Nutrition, showing food models and serving utensils to determine the type and size of food portions consumed. Method of food preparation, with paticular emphasis on the types of fats and oils were identified. The daily intakes of nutrients were calculated by a FACOM–M-360 Computer (Computer Center in Tokushima University), referring to the Standard

Table of Food Composition in Japan, 4th revised edition (Committee on Food Composition 1983) (13). All food items were classified into 19 food groups in a manner found in the Food Composition Table mentioned above. After 24-hour recall interview, systolic and diastolic blood pressure were measured with a mercury spygmomanometer. Hypertention and borderline hypertention were classified according to the criteria of WHO Expert Committie on Arterial Hypertention in 1978 (14).

3) Calculations of the correlation coefficients between SMRs of vascular deseases or parameters related to blood pressure, and nutritional intakes per day per person

Regional SMRs of vascular diseases were obtained from the report of major disease mortalities for cities, towns and village in Japan (Edited by the Research Committee on Geographical Distribution of Diseases) (11). Relationships between SMRs of vascular diseases or parameters related to blood pressure, and nutritional intakes or food group intaken to body height were analyzed with simple linear correlation. Two-tailed probabilities were used for testing statistical significance of the correlation coefficients.

Table 2. The average intakes of food variables and nutrients per day per person (Male)

	Hanoura	Kamojima	Wajiki	Sadamistu	Yamashiro	Ikeda	Kamiita	Ichiba	Mugi
Wheat, Bread (g)	30 ± 6	78 ± 8	38 ± 7	99 ± 14	101 ± 10	81 ± 12	69 ± 9	79 ± 10	65 ± 11**
Cooked rice (g)	804 ± 37	666 ± 23	858 ± 26	738 ± 27	702 ± 25	784 ± 37	670 ± 25	760 ± 28	953 ± 39
Fishes (g)	137 ± 16	79 ± 7	110 ± 8	50 ± 6	69 ± 7	79 ± 7	71 ± 6	67 ± 8	233 ± 27
Meats (g)	39 ± 8	60 ± 7	54 ± 7	51 ± 7	52 ± 6	51 ± 6	77 ± 9	88 ± 10	34 ± 5
Green vegetable (g)	146 ± 24	192 ± 19	197 ± 21	265 ± 37	194 ± 24	173 ± 30	121 ± 15	140 ± 19	139 ± 23
Other vegetable (g)	210 ± 17	192 ± 14	191 ± 15	236 ± 16	245 ± 23	201 ± 17	157 ± 10	241 ± 16	176 ± 14
Energy (kcal)	2,728 ± 107	2,466 ± 63	2,616 ± 59	2,554 ± 75	2,386 ± 67	2,547 ± 87	2,553 ± 70	2,701 ± 75	2,868 ± 93
Protein (g)	92 ± 4	83 ± 3	87 ± 3	78 ± 3	76 ± 3	82 ± 3	87 ± 3	90 ± 33	113 ± 6
Fat (g)	52 ± 3	52 ± 2	50 ± 2	53 ± 3	48 ± 2	50 ± 3	59 ± 3	59 ± 3	50 ± 2
Carbohydrate (g)	416 ± 16	371 ± 10	406 ± 10	408 ± 13	360 ± 10	387 ± 15	383 ± 13	415 ± 13	428 ± 15
Ca (mg)	603 ± 42	575 ± 33	534 ± 30	626 ± 108	446 ± 26	560 ± 41	720 ± 89	732 ± 107	468 ± 26
NaCl (g)	13 ± 1	12 ± 0	12 ± 1	13 ± 0	12 ± 1	13 ± 1	14 ± 1	16 ± 2	12 ± 1
Na/K	1.9 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.9 ± 0.1	2.2 ± 0.1	2.4 ± 0.1	2.0 ± 0.1	1.9 ± 0.1	1.7 ± 0.1
Cholesterol (mg)	431 ± 42	342 ± 28	360 ± 28	294 ± 19	329 ± 24	402 ± 30	379 ± 28	354 ± 27	458 ± 39

** Values are means ± SEM.

Table 3. The average intakes of food variables and nutrients per day per person (Female)

	Hanoura	Kamojima	Wajiki	Sadamistu	Yamashiro	Yuki	Handa	Ikeda	Kamiita	Ichiba	Mugi
Wheat, Bread(g)	27 ± 4	74 ± 11	37 ± 5	92 ± 9	103 ± 11	92 ± 8	86 ± 9	92 ± 10	62 ± 9	63 ± 7	78 ± 10**
Cooked rice(g)	557 ± 18	458 ± 17	612 ± 19	584 ± 20	559 ± 20	448 ± 22	464 ± 19	546 ± 16	520 ± 18	546 ± 17	670 ± 27
Fishes (g)	107 ± 8	62 ± 6	95 ± 7	50 ± 5	43 ± 5	139 ± 24	58 ± 6	56 ± 4	72 ± 8	73 ± 7	142 ± 13
Meats (g)	42 ± 4	59 ± 6	40 ± 5	50 ± 7	36 ± 5	49 ± 6	42 ± 6	44 ± 4	63 ± 6	61 ± 6	35 ± 5
Green vegetable	147 ± 17	198 ± 20	200 ± 16	265 ± 28	308 ± 28	165 ± 20	186 ± 24	166 ± 16	142 ± 15	127 ± 14	150 ± 20
Other vegetable	226 ± 14	229 ± 21	201 ± 10	260 ± 17	224 ± 15	191 ± 13	188 ± 13	220 ± 14	165 ± 9	231 ± 13	186 ± 14
Energy (kcal)	2,123 ± 50	2,026 ± 59	2,054 ± 45	2,267 ± 55	1,921 ± 46	2,006 ± 61	1,884 ± 53	2,020 ± 47	2,125 ± 60	2,194 ± 49	2,127 ± 58
Protein (g)	78 ± 2	72 ± 2	74 ± 2	73 ± 2	63 ± 3	80 ± 5	66 ± 2	68 ± 2	77 ± 3	77 ± 3	81 ± 3
Fat (g)	47 ± 2	51 ± 3	44 ± 2	53 ± 2	39 ± 2	54 ± 3	41 ± 2	45 ± 2	55 ± 3	53 ± 2	42 ± 3
Carbohydrate(g)	339 ± 8	310 ± 10	328 ± 8	362 ± 9	322 ± 9	289 ± 9	300 ± 9	322 ± 9	325 ± 10	342 ± 8	343 ± 9
Ca (mg)	621 ± 36	534 ± 28	528 ± 31	507 ± 22	475 ± 74	573 ± 39	521 ± 36	497 ± 28	643 ± 57	546 ± 28	417 ± 22
NaCl (g)	12 ± 0	11 ± 0	12 ± 0	12 ± 0	12 ± 1	12 ± 1	12 ± 0	11 ± 0	12 ± 1	11 ± 0	11 ± 1
Na/K	1.8 ± 0.1	1.6 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.8 ± 0.1	1.9 ± 0.1	2.2 ± 0.1	2.0 ± 0.1	1.9 ± 0.1	1.8 ± 0.1	1.8 ± 0.1
Cholesterol(mg)	345 ± 20	377 ± 23	320 ± 22	337 ± 23	252 ± 16	343 ± 25	288 ± 22	306 ± 16	333 ± 21	371 ± 26	315 ± 22

** Values are means ± SEM.

RESULTS

Table 2 and 3 show the average daily per-person consumptions of some food groups and nutrients on town basis. In these regions, a large portion of the energy comes from rice. There are some differences in the dietary habits among regions. The average daily consumption of fish per-person (Fig 2) and protein are higher in the sea coast regions

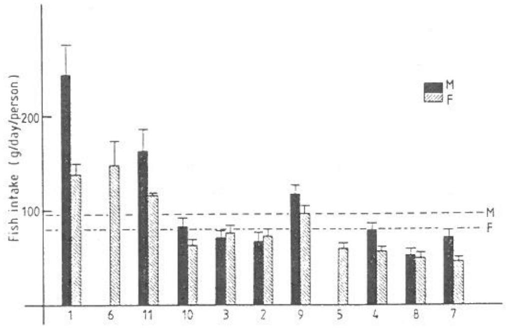

Figure 2: Regional difference of daily fish intake per-person. Black bars show the intake of fish in males (M). Shadow bars show the intake of fish in females (F). Dotted line shows the average intake of fish in total male or female. Numbers under the bars show the regions suveyed, as indicate in Fig 1.

(Mugi, Yuki) than in the mountainous regions (Sadamitu, Yamashiro). Figure 3 shows the changes in fish intake with advancing age in the sea coast (Mugi) and the mountainous (Sadamitu) regions. Three to four times of more fish were consumed by both males and females in the sea coast region than those in the mountainous region in all age groups.

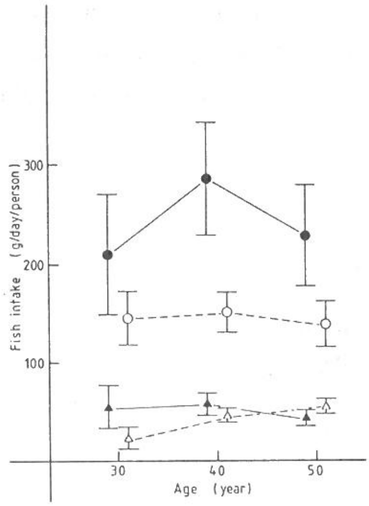

Figure 3: Aging effect on daily fish intake per-person. (●)–line shows the fish intake of male in sea coast region (Mugi). (○)–dotted line shows the fish intake of female in sea coast region (Mugi). (▲)–line shows the fish intake of male in mountanious region (Sadamitu). (△)–dotted line shows the fish intake of female in mountanious region (Sadamitu).

Table 4 shows the correlation coefficients between the SMRs of vascular diseases and major food groups and nutrients. The variables that negatively correlated at less than 1 % level of significance are energy from protein, fish intake, protein intake from fishes and fat intake from fishes with cerebral haemorrhage. The variables that positively correlated at less than 1 % level of significance are meats and total fat intake with cerebral infarction. No significant relations are found between intake of sodium chloride or ratio of sodium to potassium or level of cholesterol in serum and the SMR of cerebral haemorrhage. With the SMR of IHD, only confectionary of wheat product intake correlates positively at the 5 % level of significance.

Table 4. The correlation coefficients between the SMRs of vascular diseases and food variables or nutrients among Japanese living in Tokushima

	Ischemic heart disease	Cerebral infarction	Cerbral haemorrhage
Wheat, Bread	0.419120	− 0.254382	0.271130
Cooked rice	− 0.074800	− 0.114309	− 0.136802
Fishes	0.059316	− 0.222763	− 0.659118**
Meats	− 0.141385	0.677755**	0.165310
Green vegetable	0.032509	− 0.413383	0.459174*
Other vegetable	− 0.070559	0.042226	0.416715
Energy from protein	0.033892	− 0.097440	− 0.776085***
Energy from fat	0.013638	0.448087*	− 0.040160
Energy from carbohydrate	− 0.028770	− 0.355415	0.360856
Ca	− 0.260491	0.475258*	0.140149
Nacl	− 0.156248	0.133026	0.307404
Na/k	− 0.091554	− 0.166742	0.278105
Cholesterol	− 0.105226	− 0.012984	0.060352

* $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Figure 4 shows the inverse correlation between the SMR of cerebral haemorrhage and fish intake per cm of body height. This figure indicates that the SMR of cerebral haemorrhage is the lowest where fish intakes per cm of body height are between 1 and 1.5.

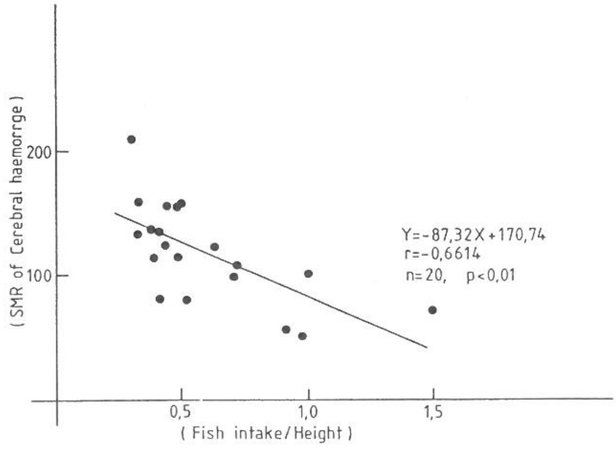

Figure 4 : Correlation between SMR of cerebral haemorrhage and fish intake per cm of body height. Abbreviation of SMR see text.

As shown in Table 4, fish intake unexpectedly had no correlation with the SMR of IHD. But the significant inverse relation is found between the SMR of IHD and fish intake per cm of body height, at least up to the value of 0.7 of fish intake per cm of body height (Fig 5). Whereas in the value greater than 0.7, a positive correlation is shown between them. Therefore the lowest SMR of IHD is seen where fish intake per cm of body height are around 0.7.

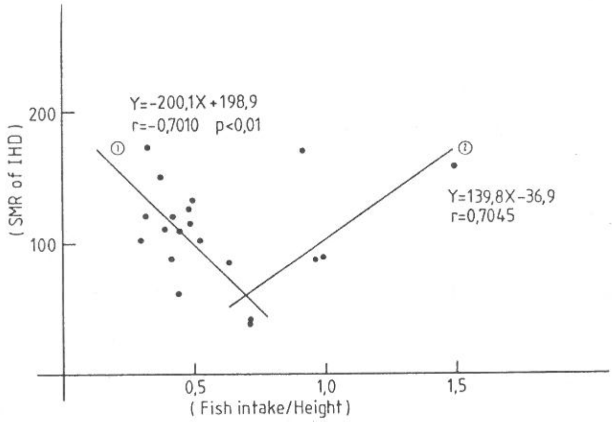

Figure 5 : Correlation between SMR of IHD and fish intake per cm of body height. Abbreviations of SMR and IHD see text.

Table 5 shows the correlation coefficients between the fish intake and the parameters related to blood pressure. Fat from fishes per cm of body height has a strong inverse correlation with the systolic blood pressure. These values suggest that dietary pattern with the larger proportion of fish, might be a favourable factor to suppress the development of hypertension. No significant relations are found between intake of sodium chloride or ratio of sodium to potassium and the parameters related to blood pressure.

Table 5. The correlation coefficients between the fish intake and the parameters related to blood pressure

	Incidence of BLH (%)	Incidence of BLH (SBP ≥ 140mmHg)(%)	Incidence of BLH (DBP ≥ 90mmHg)(%)
Fishes/Height	-0.498*	-0.531*	-0.450
Protein from fish/Height	-0.478*	-0.501*	-0.418
Fat from fish/Height	-0.547*	-0.575*	-0.452
Ca/Height	-0.306	-0.365	-0.295
NaCl/Height	-0.399	-0.247	-0.383
Na/K	0.087	0.133	-0.275

BLH: Borderline hypertension, SBP: Systolic blood pressure, DBP: Diastolic blood pressure. * $p < 0.05$.

Dissusion

The 24-hour recall method is inappropriate to assess individual dietary status but is useful for the estimation of the nutritional status of a group or various groups (15). The mortality data, for the regression analyses were obtained on town basis from the SMRs of vascular diseases, for 10-year period from 1969. No significant changes were found in the energy intakes per-person in the National Nutritional survey during the time from 1974 to 1984 (5). Thus the variations in nutritional intakes of each town found in the present study might be largely due to the regional one. The fish intake of fishing village in 1980, reported by Hirai *et al.* (16) was 250g per day, similar to that shown in the present value in the sea coast area. As shown in Fig 3, we found the distinct regional differences in fish intake between the sea coast and the mountainous regions, in all age groups. These regional differences of life-long dietary habbits, affect the regional changes of physical status and consequently the pattern of disease incidence. In this paper, we have shown the relationship between food groups intaken in summer and SMRs for vascular diseases. The significant inverse relations were found between the fish consumption and the SMR of cerebral haemorrhage. We also found significant inverse relation between the SMR of IHD and fish intake per cm of body height only within the value of 0.7. Whereas in the value greater than 0.7 of fish intake per cm of body height, a positive correlation was shown between them. The results from the correlation of food intakes and SMRs of disease on a regional level have much limitations to interprete their specific causal relationships.

In Japan, the lowest death rate from coronary heart disease was found in the island of Okinawa, where fish consumption in June was about 150g (17). In addition to this, mortality from cerebrovascular disease is also lower in Okinawa, The seasonal changes in food habits are much larger in mainland Japan (temperate zone) than those in Okinawa (subtropical zone) (18). Generally protein intake of Japanese in summer is lower compared to the intakes of the other seasons. Therefore, higher consumption of fishes in summer by Japanese might be of significance for the prevention of cerebral haemorrhage. High fish intake supplies much amount of protein, cholesterol and available biologically active compounds, including omega-3 fatty acids or amino acids or trace elements (19) having some conections with regulation of blood pressure. Yamori *et al.* (20), reported that fish protein especially S-containing amino acids lowered the blood pressure of spontaneous hypertension rats. The present study also showed the ecological inverse relationship between fish intake and incidence of hypertension plus borderline hypertension. The level of serum cholesterol had no significant negative association with the SMR of cerebral haemorrhage in the present study. This finding is consistent with the recent changes that the level of serum cholesterol is no longer a risk factor for stroke in Japan (21). No inverse relation between fish intake and SMR of IHD was found in the value with greater than 0.7 of fish intake per cm of body height. The percentage of energy provided by the macro-nutrients of people who ate fishes more than 200g per day, showed unsatisfied values with the Dietary Goals (23) recommended by US Goverment (unpublished date). Furthermore "Sashimi", eating raw fish, was the most prevalent method of fish preparation in the group with the higher fish intake. Thus they ate only fish with small amount of plant foods. Even the Alaskan living mainly on animal foods receive an intake of plant foods when they feed on the stomach contents of caribou (24). We postulated that the balance of nutrients including trace elements (25) may influence the incidence of IHD.

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