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Intake of animal products and stroke mortality in the Hiroshima/Nagasaki Life Span Study

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Background To determine whether intake of animal products was associated with a reduced risk of stroke mortality in a large-scale population-based cohort in Japan.

Methods A self-administered questionnaire, including questions on dietary habits, was mailed to the members of the Life Span Study, a cohort of people exposed and non-exposed to atomic bomb radiation, who were alive as of 1 September 1979. Animal products included frequency intake of beef/pork, chicken, ham/sausage, milk, dairy products, eggs, fish, and broiled fish. Responses were obtained from 40 349 people (72%): 15 350 men (mean age 54 years) and 24 999 women (mean age 58 years). The subjects were followed for 16 years, and deaths were ascertained by linkage to the nationwide family registration system of Japan. The associations between diet and stroke mortality were examined using a Cox proportional hazard model.

Results During the follow-up period, 1462 stroke deaths occurred. Four animal products comprising eggs, dairy products, fish, and broiled fish were independently associated with a decreased risk of stroke mortality; while beef/pork, chicken, ham/sausage, and milk consumption were not associated with stroke death. A composite measure of eggs, dairy products, fish, and broiled fish intake was calculated, and the highest tertile was significantly inversely associated with total stroke mortality (Hazards Ratio [HR] = 0.80, 95% CI: 0.68, 0.93) compared with the lowest tertile. The protective effect of animal product intake on total stroke death was largely confined to intracerebral haemorrhage death; the RH of intracerebral haemorrhage death for the highest tertile of consumption was 0.72 (95% CI: 0.53–0.98) compared with the lowest tertile; animal products intake was not related to cerebral infarction mortality (HR = 0.84; 95% CI: 0.67–1.06).

Conclusions Intake of animal products such as eggs, dairy products, and fish may be protective against intracerebral haemorrhage, but is not related to cerebral infarction mortality.

Keywords Cerebrovascular disease, animal products, diet, mortality, longitudinal study, Japan

Stroke was the leading cause of death in Japan for the 30-year period ending in 1980 and is currently the third, following cancer and coronary heart disease. In the 1960s, the age-adjusted mortality rate from stroke in Japan was twice that in Western countries,[1] although international comparison might be difficult due to different diagnostic criteria and methodology used. During that period, in Japan, intracerebral haemorrhage was the predominant sub-type; this has been a common feature of East Asian countries.[2] Since the mid 1960s, there has been a steady and dramatic reduction in the stroke mortality rate,[3] declining by 30% in men and 20% in women between 1965 and 2000.[4] Recent data show that the age-standardized stroke mortality rate in Japan (56.7 per 100 000 population) is now

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similar to that in Germany (52.4) and the UK (51.8), although is still higher than that in the US (34.8);[5] death rates being standardized to the WHO World Standard Population.

Interestingly, while the decline in total stroke mortality largely represented that of intracerebral haemorrhage subtype,[4] cerebral infarction rates increased nearly fivefold in men and threefold in women between 1951 and 1984.[4] Since 1975, the cerebral infarction mortality rate is higher than that of intracerebral haemorrhage and is now the predominant subtype. This indicates that intracerebral haemorrhage and cerebral infarction are affected differently by lifestyle factors. Available data to date suggest that, other than age and hypertension, cerebral haemorrhage and infarction do not share the same risk factors.[6] Suggested risk factors for intracerebral haemorrhage include a history of coronary artery disease, low total cholesterol level, and a low intake of animal protein and fat.[7,8] High alcohol intake, high physical activity at work, and poor home heating may also be associated with stroke mortality, and together these three factors may contribute as much as high systolic blood pressure alone.[1] Risk factors for cerebral infarction include atrial fibrillation, smoking, high total cholesterol levels, low high-density lipoprotein cholesterol levels, and possibly, a low fish intake.[9,10]

It has been suggested that the observed change in stroke mortality rate may be explained by both improvements in preventive and medical care, and the acceleration of the 'westernization' or 'modernization' of Japanese lifestyles from the end of World War II.[11,12] Nationwide community-based hypertension control programmes, nutrition education campaigns to reduce salt intake, and improvements in hypotensive agents were clearly associated with a dramatic decline in average blood pressure levels and subsequent stroke incidence.[13,14] In addition, the extended period of strong economic growth from 1960 to 1975 brought about a series of socioeconomic changes including better working conditions, the mechanization of farming, improvements in household heating systems, changes in dietary habits, and developments of refrigeration and marketing.[15] Westernization of the diet included an increased consumption of meat, milk, eggs, dairy products, and fruit.[3,16]

A previous study conducted in the whole of Japan between 1965 and 1982 among 223 170 men and women suggested that an increased consumption of animal products might be protective against cerebrovascular disease mortality.[17] The aim of the present study is to examine whether a high intake of animal products estimated from a food frequency questionnaire (FFQ) is associated with a subsequent reduction in total stroke mortality, and whether the associations are different between the two main subtypes intracerebral haemorrhage and cerebral infarction, using a cohort of more than 55 000 Japanese atomic bomb-survivors men and women living in the community.

Methods

Study subjects

The Life Span Study (LSS) cohort originally comprised 120 321 Hiroshima and Nagasaki atomic bomb survivors and their non-exposed controls. Since 1950, it has been followed up by the Atomic Bomb Casualty Commission (ABCC), later the Radiation Effects Research Foundation (RERF).[18] A self-administered questionnaire including items on dietary habits was mailed to 55 650 people who were alive as of 1 September 1979.[19] The mail survey was completed in January 1980 for men, and in February 1981 for women. Responses were obtained from 40 349 people (72.5%). After excluding prevalent cases of cancer (n = 476), self-reported cases of stroke (n = 392), ischaemic heart disease (n = 2250), and both stroke and ischaemic heart disease (n = 101), the study population consisted of 37 130 people, of whom 14 209 were men and 22 921 were women. The mean age of the subjects was 56 years (range: 34–103).

Ascertainment of dietary habits

The questionnaire included items on age, anthropometric measurements, smoking, and other lifestyle factors, and a 22-item FFQ. Details on the FFQ have been reported elsewhere.[20] The FFQ included questions on the consumption frequency of nine animal products: beef and pork, pork products such as ham/sausage, chicken, milk, eggs, dairy products (butter and cheese, excluding margarine), fish excluding broiled and dry fish, broiled fish, and dry fish. Subjects were asked to state how frequently they ate each food item, based on four categories: 'never', '≤once/week', '2–4 times/week', and 'almost daily'.

A previous validation study found the mean daily intakes of animal foods estimated from the FFQ to be significantly associated with intake as estimated from a 24-hour dietary record, with Spearman correlation coefficients ranging from 0.17 to 0.32 across categories of intake. However, intake of 'dry fish' from the FFQ was not correlated with intake from the 24-hour dietary record, and was therefore excluded from the present analysis.[20]

First, the relationship between stroke mortality and each animal product intake was analysed separately. The FFQ validation study showed that the mean intake in weight of a food item that was recorded as missing on the questionnaire was similar to that of the 'never', or '≤once/week' frequencies. We concluded that those who did not report their intake in the FFQ scarcely or never ate the food.[20] We therefore grouped those with missing values together with the lowest frequency category, and were thus able to include the entire study population in the analysis.

Second, mortality risks were related to a composite variable of total intake of animal products and of their subsets. First, the intake of each food product was categorized into three groups: missing, never and ≤once/week (scored as 0), 2–4 times/week (scored as 1), and almost daily (scored as 2). All animal product intake was then defined as the sum of scores (0–1–2) of beef and pork, chicken, pork products, milk, egg, dairy products, fish excluding broiled/dry fish, and broiled fish. Another composite variable included the animal products significantly inversely associated with stroke mortality. Fish product intake was defined as the sum of scores of fish excluding broiled/dry fish, and broiled fish. The three composite variables were then categorized into three levels of consumption—low, moderate, and high—with the number of subjects in each category equally distributed. The mean daily intake of animal foods in each category was estimated by multiplying the frequency of consumption from the FFQ with an average portion size according to the mean intake derived the 24-hour diaries.

Follow-up and ascertainment of stroke death cases

Stroke death cases were ascertained by linkage to the nationwide family registration system of Japan.[18,21] Copies of death certificates are regularly obtained by RERF for all deceased LSS cohort members, and trained coders enter the appropriate codes into the database. The ascertainment is virtually complete, since the death certificates are available as long as the subjects reside within Japan, and the number of emigrants is small. Causes of deaths were coded according to the International Classification of Diseases codes.[22] Follow-up was started on 1 January 1980 for men and 1 February 1981 for women, and continued until the date of stroke death, death from other causes, or 31 December 1996, whichever came earliest.

Statistical analysis

The association between animal product intake and stroke mortality was examined using a Cox proportional hazard model, and hypothesis tests and CI were based on Wald statistics. Age was the primary time scale in all analyses and baseline rates were stratified by sex and birth cohort. All multivariate analyses were adjusted for possible confounding variables: smoking status (never, past, and current), alcohol-drinking status (never, past, and current), body mass index (BMI) calculated from the self-reported height and weight (<19, 19–<22, 22–<25, and 25+ kg/m^2), education level (junior high school or lower, high school, and junior college/university or higher), self-reported histories (yes, no) of diabetes mellitus or hypertension, radiation dose (continuous variable in mSv), and city (Hiroshima, Nagasaki). The analyses were carried out using the SAS software version 8.[23]

Results

During the observation period, 1462 deaths from stroke were identified, including 655 cases (45%) attributed to cerebral infarction, 354 (24%) attributed to intracerebral haemorrhage, 116 (8%) attributed to subarachnoid haemorrhage, and 337 (23%) attributed to other cerebrovascular disease. The percentage distributions of cerebrovascular disease deaths were similar between the sexes (Table 1).

The frequency distribution of animal product intakes is shown in Table 2. More than half of the subjects consumed beef and pork, fish, or eggs at least twice each week. In contrast, half of the subjects consumed broiled fish once or less each week, and about 40% had chicken and pork products once or less a week. One-fifth of the study population indicated 'never' as the frequency for eating dairy products.

The association between non-dietary factors and mortality from total stroke, intracerebral haemorrhage, and cerebral infarction are shown in Table 3. Current smoking was significantly associated with an increased risk of total stroke, intracerebral haemorrhage, and infarction. Past alcohol drinkers also had a significantly increased risk of total stroke and intracerebral haemorrhage, although current drinkers did not. There was a U-shaped association between BMI and stroke mortality, with a BMI of 22–25 kg/m^2 having the lowest risk of all types of stroke. A high education was associated with reduced mortality from all types of stroke, although these associations were not statistically significant. As expected, a previous history of diabetes and hypertension were also significantly related to an increased risk of total stroke, intracerebral haemorrhage, and cerebral infarction mortality.

The association between stroke mortality and each animal product is presented in Table 4. Daily intake of each animal product was associated with a decrease risk of total stroke, except beef and pork intakes which were not associated, and chicken intake which was positively associated with the risk of stroke mortality. Adjustment for each other animal product intake did not alter the risks; egg, dairy products, fish, and broiled fish remained associated with a decrease risk of stroke mortality.

The associations between composite scores of animal intake and stroke mortality and the two subtypes are shown in Table 5. Intake of all animal products was associated with a 12% (95% CI: 23%, 0%) reduction in total stroke death, and a significant

Table 1 Distribution of cerebrovascular deaths in men and women

	Assigned ICD Codes		Men		Women		Total	
Type of cerebrovascular disease	9th Revision	10th Revision	No	%	No	%	No	%
Subarachnoid haemorrhage	430	I60, I69.0	27	5.0	89	9.6	116	7.9
Intracerebral haemorrhage	431, 432	I61, I62, I69.1, I69.2	140	26.1	214	23.1	354	24.2
Cerebral infarction	433, 434	I63, I69.3	247	46.0	408	44.1	655	44.8
Other cerebrovascular diseases	435–438	I64–I68, I69.4, I69.8	123	22.9	214	23.1	337	23.1
Total			537	36.7	925	63.3	1462	100.0

Table 2 Response frequencies for eight food frequency questions relating to animal products

	Never		<Once/week		2–4 times/week		Almost daily		Missing	
Dietary factors	No.	%	No.	%	No.	%	No.	%	No.	%
Beef and pork	1160	3.1	8574	23.1	21 482	57.9	3237	8.7	2677	7.2
Chicken	2360	6.4	16 061	43.3	12 951	34.9	677	1.8	5081	13.7
Pork products	5287	14.2	14 749	39.7	8536	23.0	1284	3.5	7274	19.6
Milk	6021	16.2	8005	21.6	7435	20.0	10 371	27.9	5298	14.3
Eggs	716	1.9	6882	18.5	16 231	43.7	10 977	29.6	2324	6.3
Dairy products	7516	20.2	12 038	32.4	5418	14.6	3960	10.7	8198	22.1
Fish (except broiled)	561	1.5	9895	26.6	19 807	53.3	4398	11.8	2469	6.6
Broiled fish	1631	4.4	18 326	49.4	10 864	29.3	802	2.2	5507	14.8

Table 3 Relative risk (HR) and 95% CI between non-dietary risk factors and stroke mortality

	Total stroke			Intracerebral haemorrhage			Cerebral infarction		
Risk factors	No. cases	HR[a]	95% CI	No. cases	HR[a]	95% CI	No. cases	HR[a]	95% CI
Sex									
Female	925	1.00		214	1.00		408	1.00	
Male	537	1.07	0.92, 1.25	140	1.01	0.73, 1.39	247	1.21	0.97, 1.52
Smoking									
Non-smoker	800	1.00		188	1.00		351	1.00	
Current smoker	404	1.44	1.24, 1.68	118	1.44	1.06, 1.95	172	1.44	1.15, 1.81
Past smoker	198	1.12	0.93, 1.35	38	0.87	0.57, 1.32	99	1.20	0.91, 1.56
Alcohol									
Non-drinker	717	1.00		170	1.00		317	1.00	
Current drinker	560	0.99	0.87, 1.12	149	1.04	0.80, 1.35	255	1.01	0.83, 1.22
Past drinker	85	1.43	1.10, 1.86	20	1.78	1.05, 3.00	39	1.19	0.80, 1.76
Body mass index[b] (kg/m^2)									
<19	294	1.00		73	1.00		126	1.00	
19–<22	414	0.83	0.71, 0.97	120	0.91	0.67, 1.23	168	0.81	0.64, 1.02
22–<25	267	0.63	0.53, 0.75	68	0.53	0.37, 0.76	124	0.73	0.56, 0.94
25+	201	0.90	0.74, 1.09	47	0.73	0.49, 1.07	94	1.06	0.80, 1.40
Education level									
Low	850	1.00		186	1.00		394	1.00	
Middle	369	0.89	0.78, 1.01	109	0.97	0.75, 1.26	156	0.92	0.76, 1.12
High	80	0.84	0.66, 1.08	25	0.95	0.61, 1.50	33	0.83	0.57, 1.21
History of diabetes									
No	1293	1.00		311	1.00		571	1.00	
Yes	169	1.19	1.01, 1.41	43	1.23	0.89, 1.72	84	1.28	1.00, 1.62
History of hypertension									
No	794	1.00		179	1.00		352	1.00	
Yes	668	1.64	1.47, 1.84	175	2.23	1.78, 2.79	303	1.55	1.32, 1.82

[a] HR stratified by birth cohort and sex, and adjusted for city, radiation dose, and for each other.

[b] Body mass index calculated from self-report data.

24% (95% CI: 42%, 1%) reduction in the risk of intracerebral haemorrhage mortality in the highest tertile as compared with the lowest tertile (Table 5). The association between total animal product intake and intracerebral haemorrhage mortality also showed a significant linear dose–response relationship; additional adjustment for fruit and vegetables consumption, suggested protective factors of stroke, did not materially alter the findings (fruit and vegetables adjusted stroke mortality HR = 0.96 [95% CI: 0.84, 1.09], intracerebral haemorrhage HR = 0.81 [95% CI: 0.62, 1.06]). The risk of cerebral infarction death was not associated with animal product consumption. A composite variable comprising animal products that were found to be significantly inversely associated with stroke mortality, as shown in Table 4, was calculated by summing of scores of egg, dairy products, fish, and broiled fish products, in a manner identical to that for total animal product intake. Intake of significant animal products was associated with a significant 20% (95% CI: 32%, 7%) reduction in total stroke death, and a significant 28% (95% CI: 47%, 2%) reduction in the risk of intracerebral haemorrhage mortality in the highest tertile compared with the lowest (Table 5). Intake of total fish products was also associated with a significant 15% (95% CI: 25%, 2%) reduction in total stroke death, and a significant 30% (95% CI: 46%, 8%) reduction in the risk of intracerebral haemorrhage mortality in the highest tertile compared with the lowest (Table 5). Neither total animal products, nor significant animal products, or total fish products were significantly associated with a reduction in cerebral infarction death. These findings were not affected by adjustment for fruit and vegetables consumption: significant animal products stroke mortality HR = 0.86 (95% CI: 0.74, 1.01), intracerebral haemorrhage HR = 0.79 (95% CI: 0.58, 1.08); total fish products stroke mortality HR = 0.96 (95% CI: 0.84, 1.10), intracerebral haemorrhage HR = 0.81 (95% CI: 0.62, 1.05).

Discussion

In this large-scale population-based cohort study in Japan, consumption of egg, dairy products, and fish was significantly and inversely associated with the risk of all stroke mortality. However, considering the pathological and aetiological differences of intracerebral haemorrhage and cerebral infarction, it is important to examine these subtypes separately.[6] Animal product consumption was negatively associated with intracerebral haemorrhage mortality, but not related to cerebral infarction death.

The analysis of the health effects of a vegetarian diet is of interest in the investigation of the health effects of meat or animal products intake. Unfortunately, the data on the rate of stroke mortality among vegans (people who consume no animal products) compared with meat-eaters is sparse and further research is clearly needed to determine whether these individuals are at an increased risk. Several studies have shown vegetarians, who consume animal protein in the form of milk,

Table 4 Relative risk (HR) and 95% CI between each animal product intake and total stroke mortality

		Total stroke		
Dietary factor	**No. subjects**	No. cases	HR (95%CI)	***P*-trend**
Beef and pork				
Never	1160	93	1.00 (reference)	
≤1 time/week	8574	420	0.83 (0.65, 1.06)	
2–4 times/week	21 482	630	0.80 (0.63, 1.02)	
Almost daily	3237	81	1.01 (0.73, 1.38)	0.857
Chicken				
Never	2360	102	1.00 (reference)	
≤1 time/week	16 061	511	0.88 (0.70, 1.10)	
2–4 times/week	12 951	479	0.99 (0.79, 1.25)	
Almost daily	677	40	1.43 (0.98, 2.10)	0.011
Pork products				
Never	5287	284	1.00 (reference)	
≤1 time/week	14 749	425	0.96 (0.82, 1.12)	
2–4 times/week	8536	219	1.03 (0.85, 1.24)	
Almost daily	1284	30	0.90 (0.61, 1.33)	0.812
Milk				
Never	6021	258	1.00 (reference)	
≤1 time/week	8005	289	1.06 (0.89, 1.26)	
2–4 times/week	7435	204	1.02 (0.84, 1.23)	
Almost daily	10 371	343	0.94 (0.79, 1.12)	0.232
Eggs				
Never	716	52	1.00 (reference)	
≤1 time/week	6882	315	0.75 (0.55, 1.01)	
2–4 times/week	16 231	563	0.77 (0.57, 1.03)	
Almost daily	10 977	329	0.70 (0.51, 0.95)	0.185
Dairy products				
Never	7516	371	1.00 (reference)	
≤1 time/week	12 038	321	0.99 (0.84, 1.16)	
2–4 times/week	5418	132	1.00 (0.81, 1.23)	
Almost daily	3690	85	0.73 (0.57–0.94)	0.024
Fish (except broiled)				
Never	561	31	1.00 (reference)	
≤1 time/week	9895	395	0.82 (0.57, 1.19)	
2–4 times/week	19 807	657	0.74 (0.51, 1.06)	
Almost daily	4398	177	0.71 (0.48, 1.05)	0.046
Broiled fish				
Never	1631	82	1.00 (reference)	
≤1 time/week	18 326	577	0.82 (0.64, 1.04)	
2–4 times/week	10864	386	0.83 (0.65, 1.06)	
Almost daily	802	23	0.60 (0.37, 0.98)	0.428

HR stratified by sex and birth cohort, and adjusted for city, radiation dose, self-reported body mass index, smoking status, alcohol habits, education level, history of diabetes, or hypertension.

HR for missing category not shown.

egg, and dairy products, to not have an elevated rate of stroke mortality compared with non-vegetarians,[24–26] despite their lower levels of cholesterol.[27]

In Japan, consumption of animal products has generally increased since World War II. Intakes of fish/shellfish, eggs, milk, and meats increased until 1970–1975 and have been constant thereafter, whilst the intake of dairy products has been constantly increasing (Figure 1).[28,29] Nevertheless, the consumption in Japan is lower than that of Western countries. During the study period, the proportion of energy from animal products in Japan represented half of the estimated energy intake compared with that in Western countries (Japan 18%, UK 37%, USA 36%).[30]

Two longitudinal studies carried out in Japan in the 1970s also found an inverse association between the intake of animal products and stroke incidence or mortality, although these associations were weak and not statistically significant.[31,32] Recently, Kinjo *et al.* reported similar results to those in this study, in a Japanese cohort of more than 220 000 subjects followed from 1966 to 1981.[17] Intakes of 'dairy milk', 'meat', and 'fish' were each significantly, inversely associated with mortality risk of intracerebral haemorrhage. Dairy milk and meat were also related to a decreased risk of cerebral infarction, but the risk reductions were smaller than for intracerebral haemorrhage, and fish consumption was not associated with cerebral infarction.

After Japan's recent high economic growth period (1975), serum cholesterol levels in the Japanese population have been increasing along with the intakes of animal products.[33–35] The association between serum cholesterol concentrations and the risk of stroke mortality has been examined extensively. Hypocholesterolaemia is consistently associated with an increased risk of intracerebral haemorrhage mortality among Japanese living in Japan,[15,36–39] Japanese Americans,[40,41] and Caucasians.[42,43] A low cholesterol level, associated with severe hypertension, is thought to involve a weakening of the endothelium of cerebral arteries, and could, in part, explain the observed protective association of animal products consumption with intracerebral haemorrhage.[44]

Previous findings from prospective studies on the relationship between serum cholesterol levels and cerebral infarction are inconsistent: low serum cholesterol level has been associated with a decreased risk,[42,45] with no association,[14,15,37,38,40] and with an increased risk.[13,44,46] Cerebral infarction can be classified into two types according to the size and location of responsible arteries: (1) cervical and cortical or large arteries, and (2) penetrating or small arteries.[47] Recent studies suggest that the intake of animal products and related factors may have different effects on these two types of cerebral infarction. Pathogenesis of large arteries infarction involves high cholesterol levels and atherogenesis, while pathogenesis of small arteries infarction is related to a weakening of the smaller arteries endothelium due to low serum cholesterol levels associated with sustained mild or moderate hypertension.[44] In a male cohort in the US, fat intake predisposed to atherosclerosis in the larger vessels, but was protectively associated with the integrity of the smaller intracranial vessels.[46] An autopsy study of members of the Honolulu Heart Program showed that protein and fat from animal sources were not associated with atherosclerosis in the small cerebral vessels, while they increased the risk of atherosclerosis in large arteries.[48] Infarction in small arteries used to be the most prevalent sub-type of cerebral infarction in Japan before the 1970s, opposite to that of Caucasians.[44,49,50] However, concomitant with the rise in serum cholesterol levels, cerebral infarction in the region of the large arteries is increasing.[47] This may suggest that animal products will not remain a somewhat protective factor of cerebral infarction in Japan, but become a risk factor of infarction through their atherogenic effects on large arteries. However, among the present population, no protective or risk factor association was observed.

Another factor that may complicate the interpretation of the results for cerebral infarction is the difference in fat composition

Table 5 Relative risk (HR) and 95% CI between intake of animal products and stroke mortality

Dietary factor	Median intake (range) in g/day	No. subjects	Total stroke		Intracerebral haemorrhage		Cerebral infarction	
			No. cases	HR (95% CI)[a]	No. cases	HR (95% CI)[a]	No. cases	HR (95% CI)[a]
All animal products[b]								
Low	121 (91–141)	12 311	683	1.00 (reference)	173	1.00 (reference)	303	1.00 (reference)
Moderate	180 (148–251)	10 956	405	0.92 (0.81, 1.05)	86	0.71 (0.54, 0.93)	191	1.00 (0.83, 1.21)
High	231 (209–326)	13 863	374	0.88 (0.77, 1.00)	95	0.76 (0.58, 0.99)	161	0.89 (0.73, 1.09)
P-trend				0.0445		0.0266		0.3004
Significant animal products[c]								
Low	31 (30–40)	10 019	546	1.00 (reference)	138	1.00 (reference)	240	1.00 (reference)
Moderate	62 (58–73)	17 569	656	0.87 (0.77, 0.98)	148	0.67 (0.53, 0.86)	299	0.95 (0.79, 1.13)
High	102 (94–105)	9542	260	0.80 (0.68, 0.93)	68	0.72 (0.53, 0.98)	116	0.84 (0.67, 1.06)
P-trend				0.0048		0.0061		0.2330
Fish products[d]								
Low	18 (11–18)	11 178	552	1.00 (reference)	142	1.00 (reference)	239	1.00 (reference)
Moderate	30 (30–30)[e]	13 794	471	0.85 (0.75, 0.97)	110	0.70 (0.54, 0.91)	209	0.90 (0.74, 1.09)
High	46 (46–65)	12 158	439	0.85 (0.75, 0.98)	102	0.70 (0.54, 0.92)	207	0.94 (0.77, 1.14)
P-trend				0.0169		0.0078		0.4999

[a] HR stratified by sex and birth cohort, and adjusted for city, radiation dose, self-reported body mass index, smoking status, alcohol habits, education level, self-reported history of diabetes, or hypertension.

[b] Beef and pork, chicken, pork products, milk, egg, dairy products, fish, broiled fish.

[c] Egg, dairy products, fish, broiled fish.

[d] Fish, broiled fish.

[e] Based on one estimate.

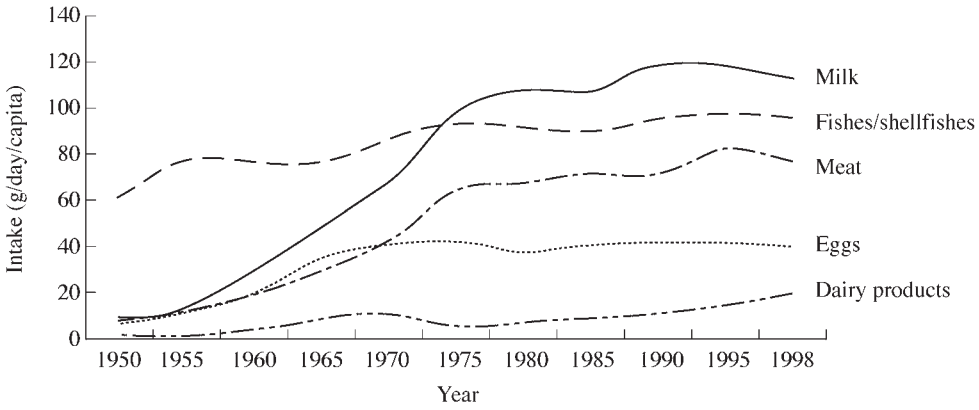

Figure 1 Temporal trends in intakes of animal products in Japan between 1959 and 1998, estimated from the National Nutrition surveys, based on a 24-hour diary

from meat and fish. Meat products are rich in saturated fatty acids, thought to be a risk factor for cerebral infarction via its atherogenecity. Conversely, fish products are rich in poly-unsaturated fatty acids and n-3 fatty acids, and are thought to protect against cerebral infarction via their hypolipidaemic, hypotensive, antiatherogenic, and antithrombotic effects.[10] Unfortunately, such detailed information on the subtypes of cerebral infarction was unavailable in the present data.

Other limitations in the present study include the unavailability of data to assess the reproducibility of the FFQ, although the FFQ has been validated. The FFQ included no information on portion size and nutrient intakes could not be estimated.[51] However, possible misclassifications between haemorrhage and infarction strokes were unlikely because computerized tomography diagnosis was already in use when the study was initiated and thus the quality and reliability of death certificate information was likely to be sufficient.[52]

Although the study population is unique in the fact that most of the people had been exposed to ionizing radiation, there is no association between stroke risk and radiation exposure in the LSS cohort.[21] Moreover, diet is not known to be associated with radiation exposure.[51] Therefore, the present findings are also applicable to the general population.

In conclusion, the large-scale population-based cohort study in Japan suggests that, in a country where animal product intake is generally low, a consumption of eggs, dairy products, and fish may reduce the risk of mortality from intracerebral haemorrhage.

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Traditional Japanese sushi. Photograph by Eric Grant.

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Commentary: Protection from stroke by eating animal foods? Surely not!

Gary Fraser

Many vegetarians, like myself have almost come to expect the data to indicate that they have an advantage, whatever the disease that is being considered. Thus, it is disquieting to find evidence in a quite different direction for at least one subtype of stroke. This evidence is not yet compelling and has some inconsistencies, but cannot easily be dismissed. Could it really be true, as the data presented by Sauvaget *et al.* in this edition of the *International Journal of Epidemiology* suggest, that eating more animal products reduces risk of some types of stroke?[1]

Over a number of years, reports about Japanese in Japan & Hawaii, and from others, have suggested a negative association between consumption of fish,[2–5] dairy foods,[6,7] multiple animal foods,[8,9] animal protein,[8,10–13] animal fat,[11,12,14] and either

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