

Protective Effect of Allium Vegetables against Both Esophageal and Stomach Cancer: A Simultaneous Case-referent Study of a High-epidemic Area in Jiangsu Province, China

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To study the relation between allium vegetable intake and cancer of the esophagus (EC) and stomach (SC) in Yangzhong city, which is one of the highest-risk areas for these cancers in Jiangsu province, China, a simultaneous case-referent study was conducted using histopathologically confirmed cases (EC: $n=81$, SC: $n=153$) and population-based referents ($n=234$). A questionnaire was used to collect information on the general status of subjects, their dietary habits, frequency intake of allium vegetables and other foods, tea consumption, smoking and alcohol drinking. The odds ratios (ORs) and 95% confidence intervals (CIs) were estimated by a multiple logistic regression model. The results showed that frequent intake of allium vegetables (including garlic, onion, Welsh onion and Chinese chives), raw vegetables, tomatoes and snap beans, and tea consumption were inversely associated with the risk for EC and SC. In the highest consumption category (≥ 1 time/week) of garlic, onion, Welsh onion and Chinese chives, the adjusted ORs compared with the lowest category (< 1 time/month) were 0.30 (CI=0.19–0.47), 0.25 (CI=0.11–0.54), 0.15 (CI=0.08–0.26), and 0.57 (CI=0.23–1.42) for EC, and 0.31 (CI=0.22–0.44), 0.17 (CI=0.08–0.36), 0.22 (CI=0.15–0.31) and 0.40 (CI = 0.17–0.94) for SC, respectively. The main results in the present study suggested that allium vegetables, like raw vegetables, may have an important protecting effect against not only stomach cancer, but also esophageal cancer.

Key words: Case-referent study — Esophageal cancer — Stomach cancer — Allium vegetables — China

Recent epidemiologic studies of stomach cancer in relation to dietary habits suggest that the consumption of allium vegetables, especially garlic or onion, may reduce the risk of stomach cancer,^{1–5} but little research has been done on the inhibitory action of allium vegetables on esophageal cancer. In an experimental study using animals, Wargovich *et al.* identified the garlic-derived agent, diallyl sulfide, as a suppressing agent of N-nitrosomethylbenzylamine-induced esophageal carcinoma in rats.⁶

Yangzhong city is located in the southern part of Jiangsu province, which is one of the areas of highest incidence for both esophageal and stomach cancer in China. In 1990–1992, the age-adjusted mortality rates for esophageal and stomach cancer per 100,000 were 104.3 and 147.1 for males, and 88.3 and 80.5 for females, respectively.⁷ However, the incidence rates for these cancers in Pizhou, in the northern part of Jiangsu province, are remarkably low. When we compared the lifestyles of the residents in the two cities, we discovered that people in Pizhou conventionally consume large amounts of raw

allium vegetables, but the people in Yangzhong city do not. Furthermore, Pizhou people frequently consumed other anticancer foods such as raw vegetables, fruit, tomatoes and snap beans.^{8,9} However, it is not possible to evaluate the protective effective of allium vegetables or of these other anticancer foods only by ecological comparison. In order to confirm the efficacy of allium vegetables in the prevention of esophageal and stomach cancers, we conducted a case-referent study on the relationship between dietary allium vegetables and the risk for esophageal and stomach cancer in Yangzhong city.

MATERIALS AND METHODS

Study subjects Data on patients with cancer of the esophagus or stomach newly diagnosed during January to October, 1995 were collected from the Yangzhong Regional Cancer Registry. Cases confirmed by histopathological diagnosis, 81 esophageal cancer cases (44 males and 37 females) and 153 stomach cancer cases (110 males and 43 females), were used in the present study. Information on referent subjects was obtained from the household registration office of each county in Yangzhong city. Population-based referents (154 males and 80 females) were

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randomly selected from the same villages or towns where cases resided. At first, several referent subjects were matched to each case for sex and age (within 2 years) and finally the one whose home was nearest to that of the case was selected as the referent.

Questionnaire and data collection Interviews with the study subjects were conducted by rural physicians or medical administrators who were trained as interviewers, at hospitals or subjects' homes, using a structured questionnaire. The questionnaire elicited information about subjects' demographic background, income, smoking status, alcohol drinking, tea consumption, dietary habits, and food consumption frequency. The items on smoking included smoking status (current, ex- or never), age started smoking, age quit smoking, and number of cigarettes per day. Ex-smokers were defined as persons who had quit smoking more than one year before the interview. Drinking hab-

its included frequency, kinds of alcohol (beer, hard liquor, medium liquor, and fruit liquor) and total amount of alcohol consumption. Alcohol consumption for each type of beverage was determined by the average number of drinks consumed at one time, which was then converted into alcohol weight (grams). Tea drinking habits included regularity of drinking, years of drinking, kind of tea (green, jasmine or black tea), and amount of tea consumption. Tea consumption was rated according to the average number of grams consumed per month.

The consumption frequencies of selected foods were rated in six categories (every day, 3–5 times/week, 1–2 times/week, 1–3 times/month, <1 time/month or never). Kinds of allium vegetables included garlic, onion, Welsh onion and Chinese chives.

Data analysis For data analysis, odds ratios (ORs) and 95% confidence intervals (95% CIs) for all items were cal-

Table I. Background Characteristics of Cancer Cases of the Esophagus or Stomach and Their Controls in Yangzhong

	No. (%) of											
	Men						Women					
	Controls		Cancer cases		Cancer cases		Controls		Cancer cases		Cancer cases	
		Esophagus	Stomach	Esophagus	Stomach	Esophagus	Stomach	Esophagus	Stomach	Esophagus	Stomach	
Age in years												
30–39	1	(0.6)	0	(0.0)	1	(0.9)	1	(1.3)	1	(2.7)	0	(0.0)
40–49	18	(11.7)	9	(20.5)	9	(8.2)	14	(17.5)	4	(10.8)	10	(23.3)
50–59	46	(29.9)	12	(27.3)	35	(31.8)	33	(41.3)	16	(43.2)	17	(39.5)
60–69	63	(40.9)	15	(34.1)	47	(42.7)	20	(25.0)	11	(29.7)	8	(18.6)
70–79	26	(16.9)	8	(18.2)	18	(16.4)	12	(15.0)	5	(13.5)	8	(18.6)
Total	154	(100)	44	(100)	110	(100)	80	(100)	37	(100)	43	(100)
Mean age (years)	60.3		59.5		60.4		58.2		59.1		57.9	
Income (yuan/month)												
1–199	64	(41.6)	29	(65.9)	67	(60.9)	30	(37.5)	27	(73.0)	26	(60.5)
200–399	48	(31.2)	13	(29.5)	36	(32.7)	32	(40.0)	10	(27.0)	16	(37.2)
≥400	38	(24.7)	1	(2.3)	6	(5.5)	16	(20.0)	0	(0.0)	1	(2.3)
Unknown	4	(2.6)	1	(2.3)	1	(0.9)	2	(2.5)	0	(0.0)	0	(0.0)
			$P^a)=0.001$		$P^a)=0.001$				$P^a)=0.001$		$P^a)=0.009$	
Education in years												
0	19	(12.3)	12	(27.3)	19	(17.3)	55	(68.8)	27	(73.0)	24	(55.8)
1–6	75	(48.7)	22	(50.0)	67	(60.9)	19	(23.8)	8	(21.6)	17	(39.5)
7–11	56	(36.4)	10	(22.7)	18	(16.4)	6	(7.5)	1	(2.7)	1	(2.3)
≥12	0	(0.0)	0	(0.0)	3	(2.7)	0	(0.0)	0	(0.0)	0	(0.0)
Unknown	4	(2.6)	0	(0.0)	3	(2.7)	0	(0.0)	1	(2.7)	1	(2.3)
			$P^a)=0.036$		$P^a)=0.001$				$P^a)=0.583$		$P^a)=0.109$	
Occupation												
Farmer	105	(68.2)	31	(70.5)	57	(51.8)	73	(91.3)	34	(91.9)	37	(86.0)
Laborer	26	(16.9)	9	(20.5)	26	(23.6)	6	(7.5)	3	(8.1)	6	(14.0)
Administrator	9	(5.8)	0	(0.0)	9	(8.2)	1	(1.3)	0	(0.0)	0	(0.0)
Other	12	(7.8)	3	(6.8)	17	(15.5)	0	(0.0)	0	(0.0)	0	(0.0)
Unknown	2	(1.3)	1	(2.3)	1	(0.9)	0	(0.0)	0	(0.0)	0	(0.0)
			$P^a)=0.287$		$P^a)=0.016$				$P^a)=0.788$		$P^a)=0.403$	

a) P value by Mantel-Haenszel χ^2 test between cases and controls.

culated for both cases and referents using unconditional logistic regression models. All referents were combined and used for the calculation of ORs for esophageal cancer and stomach cancer after adjustment for sex and age (continuous). To control for confounding factors, ORs and their 95% CIs were estimated by a multivariate logistic regression model which included age, sex, income (<200 yuan vs. ≥200 yuan), smoking (current and former vs. never), alcohol drinking (drinkers vs. non-drinkers), tea consumption (frequent vs. occasional or less) and intake of leftover rice gruel (frequent vs. occasional or less), pickled vegetables (frequent vs. occasional or less), fruit (<1 time/week vs. ≥1 times/week), meat (<1 time/week vs. ≥1 times/week), eggs (<1 time/week vs. ≥1 times/week), snap beans (<1 time/month vs. ≥1 times/month) and tomato (<1 time/month vs. ≥1 times/month). The SAS procedure logistic was used for calculations. *P* values were calculated by

means of the Mantel-Haenszel χ^2 test, when background characteristics were compared between cases and controls.

RESULTS

All the recruited cases and referents were interviewed and completed the questionnaire, yielding a response rate of 100%. Table I presents the distribution of age, income, education level and occupation in cases and referents. The average age of patients with esophageal cancer was 59.5 years in males and 59.1 years in females, and that of stomach cancer patients was 60.4 years in males and 58.2 years in females. Corresponding figures for the referents were 60.3 years and 58.2 years, respectively. It is noteworthy that a high proportion of cases, especially those with esophageal cancer, had significantly lower incomes than the control group. In general, women in the present study

Table II. Age and Sex-adjusted ORs and Their 95% CIs for Cancer of the Esophagus or Stomach for Smoking, Alcohol and Tea Drinking Habits

	Controls No.	Esophageal cancer			Stomach cancer		
		No.	OR	95%CI	No.	OR	95%CI
Smoking status							
Never	124	45	1.00		77	1.00	
Current and former	110	36	2.46	0.98–6.14	74	0.93	0.51–1.70
Alcohol drinking habit							
Occasional or less	145	58	1.00		89	1.00	
Regular	89	23	0.78	0.38–1.63	64	1.40	0.80–2.46
Tea consumption							
0 g/month	136	61	1.00		105	1.00	
1–199 g/month	35	9	0.63	0.28–1.42	17	0.54	0.28–1.04
≥200 g/month	56	9	0.42	0.19–0.95	22	0.44	0.24–0.80

Table III. Age and Sex-adjusted ORs and Their 95% CIs for Cancer of the Esophagus or Stomach for Dietary Habits

	Controls No.	Esophageal cancer			Stomach cancer		
		No.	OR	95%CI	No.	OR	95%CI
Speed of eating							
Slow or moderate	187	58	1.00		103	1.00	
Quick	47	23	1.42	1.04–1.93	50	1.36	1.07–1.74
Regularity of eating							
Regular	208	64	1.00		115	1.00	
Irregular	26	17	2.27	1.15–4.49	38	2.60	1.49–4.52
Temperature of food							
Warm or cold	219	74	1.00		134	1.00	
Hot	15	7	1.11	0.74–1.39	19	1.27	1.00–1.61
Salty food preference							
Dislike	183	70	1.00		96	1.00	
Like	51	11	0.58	0.29–1.19	57	2.08	1.32–3.28

had achieved lower levels of education compared with men, and male cases had had shorter education than referents.

Table II shows the ORs for smoking status, alcohol drinking habit and tea consumption for esophageal and stomach cancers. There was a high OR among smokers for esophageal cancer (OR=2.46, 95%CI: 0.98–6.14) and relatively high OR among alcohol drinkers for stomach cancer (OR=1.40, 95%CI: 0.80–2.46), but their confidence limits included 1.0. Remarkably, tea consumption lowered ORs for both esophageal and stomach cancer. As com-

pared with the group of non tea-drinkers, the OR among the high consumption group (≥ 200 g/month) decreased to 0.42 (95%CI: 0.19–0.95) for esophageal cancer and 0.44 (95%CI: 0.24–0.80) for stomach cancer.

The overall association of speed of eating, time of eating, temperature of food and salty food preference with risk of esophageal or stomach cancer is given in Table III. The ORs for esophageal and stomach cancer were significantly higher in subjects who eat quickly or irregularly. Intake of hot food significantly increased the OR for stom-

Table IV. Age and Sex-adjusted ORs and Their 95% CIs for Cancer of the Esophagus or Stomach for Selected Foods Intake

	Controls No.	Esophageal cancer			Stomach cancer		
		No.	OR	95%CI	No.	OR	95%CI
Raw vegetables							
Almost never	25	39	1.00		72	1.00	
Occasionally	142	37	0.16	0.11–0.23	64	0.13	0.10–0.18
Frequently	61	5	0.07	0.03–0.19	13	0.07	0.04–0.13
Tomatoes							
<1 time/month	7	41	1.00		82	1.00	
1–3 times/month	79	40	0.08	0.03–0.20	69	0.08	0.03–0.17
≥ 1 times/week	148	0	—		2	0.00	0.00–0.00
Snap beans							
<1 time/week	28	64	1.00		119	1.00	
1–2 times/week	192	16	0.04	0.02–0.07	28	0.03	0.02–0.06
≥ 3 times/week	14	1	0.04	0.00–0.30	6	0.09	0.03–0.27
Eggs							
<1 time/week	136	33	1.00		56	1.00	
1–2 times/week	76	32	1.71	0.97–3.00	61	1.98	1.25–3.13
≥ 3 times/week	22	16	3.35	1.54–7.30	36	3.79	2.20–7.10
Fruit							
<1 time/month	28	30	1.00		46	1.00	
1–3 times/month	169	21	0.09	0.04–0.19	54	0.20	0.11–0.35
≥ 1 time/week	37	30	0.75	0.36–1.55	53	0.88	0.47–1.67
Soybean products							
<1 time/week	33	22	1.00		56	1.00	
1–2 times/week	181	48	0.52	0.22–1.24	89	0.38	0.19–0.78
≥ 3 times/week	20	11	1.28	0.26–6.31	8	0.20	0.04–1.02
Meat							
<1 time/week	30	38	1.00		62	1.00	
1–2 times/week	191	34	0.13	0.07–0.24	72	0.18	0.11–0.31
≥ 3 times/week	13	9	0.61	0.22–1.70	19	0.70	0.30–1.64
Pickled vegetables							
Almost never	19	2	1.00		8	1.00	
Occasionally	125	40	3.20	2.23–4.58	62	1.07	0.88–1.45
Frequently	90	39	3.69	2.53–5.39	82	2.37	1.75–3.20
Leftover rice gruel							
Almost never	62	15	1.00		39	1.00	
Occasionally	153	53	1.42	0.74–2.71	89	0.94	0.58–1.52
Frequently	19	13	2.97	1.14–7.74	25	2.75	1.26–6.01

Table V. Estimated ORs and Their 95% CIs for Cancer of the Esophagus or Stomach for Allium Vegetable Intake

	Controls		Esophageal cancer				Stomach cancer				
	No.	No.	OR ^{a)}	95%CI	OR ^{b)}	95%CI	No.	OR ^{a)}	95%CI	OR ^{b)}	95%CI
Garlic											
<1 time/month	24	38	1.00		1.00		65	1.00		1.00	
1-3 times/month	40	15	0.24	0.11-0.52	0.48	0.19-1.25	37	0.33	0.17-0.63	0.40	0.21-0.76
≥1 time/week	170	28	0.10	0.05-0.20	0.30	0.19-0.47	51	0.11	0.06-0.20	0.31	0.22-0.44
Onion											
<1 time/month	67	67	1.00		1.00		137	1.00		1.00	
1-3 times/month	118	12	0.10	0.05-0.20	0.45	0.06-3.42	14	0.05	0.03-0.10	0.51	0.10-2.77
≥1 time/week	49	2	0.04	0.01-0.16	0.25	0.11-0.54	2	0.02	0.01-0.10	0.17	0.08-0.36
Green Chinese onion (Welsh onion)											
<1 time/month	34	49	1.00		1.00		94	1.00		1.00	
1-3 times/month	32	19	0.42	0.20-0.86	1.35	0.34-5.42	35	0.41	0.22-0.76	0.30	0.13-0.70
≥1 time/week	168	13	0.05	0.03-0.11	0.15	0.08-0.26	24	0.05	0.03-0.09	0.22	0.15-0.31
Chinese chives											
<1 time/month	66	49	1.00		1.00		82	1.00		1.00	
1-3 times/month	155	30	0.26	0.15-0.45	0.67	0.12-3.86	69	0.36	0.23-0.55	0.45	0.09-2.33
≥1 time/week	13	2	0.20	0.04-0.93	0.57	0.23-1.42	2	0.13	0.03-0.59	0.40	0.17-0.94

a) ORs and their 95% CIs were estimated by a logistic regression model adjusted for age and sex.

b) ORs and their 95% CIs were estimated by a logistic regression model adjusted for age, sex, income, smoking, drinking, tea consumption and intake of leftover gruel, pickled vegetables, meat, fruit, tomatoes, eggs and snap beans.

ach cancer. A preference for salty food increased the risk of stomach cancer, with an OR of as much as 2.08 (95%CI: 1.32-3.28); on the other hand, a preference for salty food decreased the OR for esophageal cancer, but this was not statistically significant.

Age- and sex-adjusted ORs for selected items for esophageal or stomach cancer are presented in Table IV. Frequent intake of raw vegetables, tomatoes and snap beans notably decreased the ORs for esophageal and stomach cancer. Frequent intake of meat and fruit also decreased the ORs for esophageal and stomach cancer, but this was not statistically significant in the highest intake category. The OR for stomach cancer gradually decreased with increase in the frequency of soybean product consumption, whereas regular intake of pickled vegetables, leftover rice gruel and eggs markedly increased the ORs for esophageal and stomach cancers.

Table V lists the main results regarding the protective association of intake of allium vegetables and risk of esophageal or stomach cancer. The age- and sex-adjusted ORs for esophageal and stomach cancer decreased inversely with the intake frequency of garlic, onion, Welsh onion and Chinese chives. After adjustment for other factors, in the highest intake category of garlic, onion, Welsh onion and Chinese chives, the ORs versus the lowest category were 0.30 (CI=0.19-0.47), 0.25 (CI=0.11-0.54), 0.15 (CI=0.08-0.26) and 0.57 (CI=0.23-1.42) for esophageal cancer, and 0.31 (CI=0.22-0.44), 0.17 (CI=0.08-

0.36), 0.22 (CI=0.15-0.30), 0.40 (CI=0.17-0.94) for stomach cancer, respectively.

DISCUSSION

From this case-referent study, the most important result is that frequent intake of allium vegetables (including garlic, onion, Welsh onion and Chinese chives), like raw vegetables, tomatoes and snap beans, greatly lowers the OR for both esophageal and stomach cancer. This result is consistent with the results of our earlier ecological study on the inverse relationship between mortality rates for esophageal and stomach cancer and consumption of allium vegetables, raw vegetables, tomatoes and snap beans.⁷⁻⁹⁾ The results of nine out of eleven epidemiological studies, including those of a cohort study, have suggested a decreased risk of stomach cancer with increased consumption of garlic, onion or related allium vegetables.⁵⁾ The results of the present study support an inverse association between allium vegetable consumption and risk of stomach cancer, and, furthermore, they indicate that allium vegetable consumption may also reduce the risk of esophageal cancer in humans.

A large number of experimental studies have shown that allium vegetables, especially garlic extract, may protect against the development of cancer through a variety of mechanisms. Garlic organosulfur compounds may scavenge free radicals, modulate the immune system, inhibit

carcinogen-induced DNA binding and adduct formation, modulate enzymes of the detoxification system, and inhibit the initiation and promotion processes of carcinogenesis.¹⁰⁾ Fresh garlic significantly reduces the percentage of mice developing methylcholanthrene-induced tumors of the uterine cervix.¹¹⁾ A garlic diet may inhibit dimethylhydrazine-induced colon cancer in rats.¹²⁾ Garlic and associated allyl sulfur compounds, water-soluble S-allyl cysteine and oil-soluble diallyl disulfide, are effective inhibitors of mammary carcinogenesis induced by N-methyl-N-nitrosourea in rats.¹³⁾ Garlic oil topically applied in the initiating phase of benzo(a)pyrene-induced skin carcinogenesis decreases the number of mice with skin tumors, together with the mean number of tumors per mouse.¹⁴⁾ Allyl methyl disulfide may induce an increase of glutathione S-transferase activity and inhibit tumor development in both forestomach and lungs.¹⁵⁾ The juice of the onion contains considerable amounts of S-methyl methanethiosulfonate (MMTS) and its precursor (S-methyl-L-cysteinesulfoxide). MMTS may significantly suppress chromosome aberrations induced by aflatoxin B1 (an indirect-acting carcinogen) and methyl methanesulfonate (a direct-acting carcinogen) in rat bone marrow cells.¹⁶⁾ *Helicobacter pylori* (HP) infection has been linked to stomach cancer and precancerous stomach lesions.¹⁷⁻¹⁹⁾ *In vitro*, garlic extracts have a potent capacity to eliminate HP.²⁰⁾ We have no information about HP infection in Yangzhong city, but our data from another high-risk area for stomach cancer (Huaian city of Jiangsu province) indicate that frequent intake of raw garlic and Welsh onion may decrease the OR for HP infection (unpublished results). These studies indicate that a protective role of allium vegetables may not be limited to a particular species, organ, or carcinogen.²¹⁾

Epidemiological evidence suggests that nitrosamines are important carcinogens in the development of esophageal cancer. Bacterial colonization of the stomach may cause nitrate reduction and formation of N-nitroso compounds.^{22, 23)} A correlation has been found between lesions of the esophageal epithelium and the amount of nitrosamines present in gastric juice.²⁴⁾ There is clear evidence of a positive relationship between nitrosamine exposure level and mortality rates for esophageal cancer.²⁵⁾ It is possible that allium vegetables, acting through their anti-fungal and anti-bacterial properties, inhibit gastric bacterial growth, and thus reduce the endogenous formation of N-nitroso compounds. Extracts of garlic and onion can significantly reduce nitrosamine formation and bioactivation.²⁶⁾ In a carcinogenicity experiment it was found that diallyl sulfide (DAS) completely inhibited the formation of esophageal carcinoma in rats treated with a carcinogenic dose of N-nitrosomethylbenzylamine (NMBA).⁶⁾ DAS has been shown to be a specific inhibitor of NMBA metabolism.²⁷⁾ In the present study, we found that frequent

intake of pickled vegetables and leftover rice gruel increase the risk for cancer of esophagus or stomach. It is also possible that frequent intake of pickled vegetables or leftover rice gruel (it is usually left for several hours, or for a whole day at room temperature) increased the intake of bacteria and fungi, or nitrosamine or nitrate.

Our study suggests that a decreased risk of esophageal and stomach cancer is associated with increased consumption of allium vegetables (garlic, onion, Welsh onion and Chinese chives). Even after adjustment for other risk factors, allium vegetables may still significantly decrease the ORs for esophageal and stomach cancer. All these results indicate that allium vegetable consumption has a strong preventive action against esophageal and stomach cancer.

Furthermore, we have also suggested that there may be a reduction in the risk of esophageal and stomach cancer associated with increased tea consumption and intake of raw vegetables, tomatoes and snap beans, and that there may be an increment in the risk of both types of cancers associated with quick eating, irregularity of eating, and frequent intake of pickled vegetables, leftover gruel and eggs. We have also observed that intake of hot food and preference for salty food were associated with an increased risk of stomach cancer, and intake of soybean products was associated with a reduced risk of this cancer. These results, except for the role of eggs, are broadly similar to those of other studies on esophageal or stomach cancer. Eggs are also regularly consumed, cooked in almost the same way, in Jiangsu province, China. The reason for increased ORs for esophageal and stomach cancer for frequent consumption of eggs in Yangzhong city remains unclear. Frequent intake of leftover rice gruel was found to be associated with increased risk of esophageal or stomach cancer in the present study. It is unclear how leftover gruel plays a role in the risk of these types of cancer, although bacterial contamination may be a factor. One finding of the present study is that cases typically have relatively low incomes. It is possible that low income leads to a lower consumption of tea, fresh vegetables, fruit and meat, and to a higher consumption of pickled vegetables, leftover rice gruel and eggs (usually, these are home-produced or relatively cheap in Yangzhong city).

Although many studies from developed countries have shown that smoking and alcohol consumption increase the risk of esophageal or stomach cancer,²⁸⁻³¹⁾ no such association was found to be significant in our study. A possible reason is that the risk impact of tobacco and alcohol in China may still be small compared with that in developed countries, because the average exposure level to those factors in China was very low before 1980.

In this study, all cases were histopathologically confirmed and referents were randomly selected from a resident population, so selection bias may safely be discounted. However, several potential limitations of this

study should be noted. The small number of esophageal cancer cases may reduce the power of the study. The questionnaire administered did not include the amount of food intake, so a dose-effect relationship between allium vegetable consumption and risk for esophageal or stomach cancer could not be identified, if it exists. In order to clarify this point, it would be necessary to undertake an additional analytical epidemiological study, but in a low risk area, such as Pizhou city, where the consumption of allium vegetables is high by Chinese standards.

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ACKNOWLEDGMENTS

This work was supported in part by a Grant-in-Aid for International Scientific Research, Special Cancer Research (08042015) from the Ministry of Education, Science, Sports and Culture, Japan, and by a grant from the Japan-China Sasagawa Medical Scholarship Foundation.

(Received January 28, 1999/Revised March 18, 1999/Accepted March 24, 1999)

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