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Cruciferous Vegetable Consumption and Stomach Cancer: A Case-Control Study

Maia E.W. Morrison^a, Janine M. Joseph^b, Susan E. McCann^b, Li Tang^b, Hani M. Almohanna^b, Kirsten B. Moysich^b

^aScience Research Program, University at Buffalo, Buffalo, New York, 14260;

^bDepartment of Cancer Prevention and Control, Roswell Park Comprehensive Cancer Center, Buffalo, New York, 14263

Abstract

Objective—To investigate the association between regular cruciferous vegetable intake and stomach cancer.

Methods—A hospital-based, case-control study was conducted at Roswell Park Comprehensive Cancer Center in Buffalo, NY, which included 292 stomach cancer patients and 1168 cancer-free controls recruited between 1992 and 1998 as part of the Patient Epidemiology Data System (PEDS). Dietary and other epidemiologic and confounding variables were collected by questionnaire. Multivariable logistic regression analyses were utilized to estimate odds ratios (OR) and 95% confidence intervals (CI) for associations between usual pre-diagnostic cruciferous vegetable intake and stomach cancer, with adjustment for other stomach cancer risk factors and dietary characteristics.

Results—We observed strong inverse associations between stomach cancer and highest versus lowest intakes of total cruciferous vegetables (OR = 0.59, 95% CI: 0.42–0.83), raw cruciferous vegetables (OR = 0.53, 95% CI: 0.38–0.73), raw broccoli (OR = 0.61, 95% CI: 0.43–0.86), raw cauliflower (OR = 0.51, 95% CI: 0.35–0.73), and Brussels sprouts (OR = 0.66, 95% CI = 0.48–0.91).

Conclusions—These data suggest that consuming raw cruciferous vegetables may be associated with a lower odds of stomach cancer, even after considering other dietary characteristics.

Background

Although stomach cancer incidence has declined since the late 1930s, it still remains the second leading cause of cancer death worldwide [1, 2]. This may be due to the fact that stomach cancer symptoms can mimic those of stomach viruses and ulcers, thus resulting in a late diagnosis at an advanced stage [3]. In 2018, an estimated 26,240 new stomach cancer cases will be diagnosed in the United States (16,520 in men and 9,720 in women), which is

approximately 1.5% of all new cancer cases. Additionally, there will be approximately 10,800 stomach cancer deaths in 2018 – 1.8% of all cancer deaths [2].

Stomach cancer rates are highest in Eastern Asia, Eastern Europe, Japan, and central South America, which may be due to different dietary patterns and/or refrigeration availability [4, 5]. In some studies, researchers have found that salty foods increase the odds of *Helicobacter pylori* (*H. pylori*) infection, which has been linked to increase the odds of stomach cancer [6]. Those infected with *H. pylori* and consume high intakes of salted foods are at greater odds of stomach cancer than those not infected and have a low salted food diet [7]. Some researchers believe that the overall decline, worldwide, of stomach cancer incidence is due to the development and increased availability of refrigeration, which allows fresh fruits and vegetables to be transported from various locations. With fresh foods more accessible, there may have been a decrease in the intake of salted and smoked foods, which have been associated with increased odds of stomach cancer [2, 8].

Cruciferous vegetables have been shown, in experimental studies, to possess anti-carcinogenic properties [9] and have been associated with reduced odds of various cancers, including stomach, lung, breast, bladder, gastric, colorectal, and prostate [9–15]. The exact reasons underlying these associations are uncertain, but crucifers are high in vitamins, minerals, and other naturally occurring compounds that may contain cancer prevention properties, including vitamin C, folate, dietary fiber, phytoestrogens, selenium, and phytochemicals [16]. Dietary fiber may act as a detoxifier by mechanically stripping carcinogens from the epithelial surface. Water-soluble fiber, which is mainly found in fruits and vegetables, can reduce the glycemic load by delaying the absorption of starch. Hyperinsulinemia may be a result of a low or no fiber diet and has been shown to be associated with elevated odds of stomach cancer [17]. Fiber also contains ferulic acid and p-coumaric acid which could delay cell cycle progression, thereby reducing cancer cells' replicative potential [18].

Cruciferous vegetables also contain phytochemicals, intake of which has been found to be inversely associated with development of various cancers, including stomach. Of these phytochemicals, glucosinolates, which are found in cruciferous plants, are broken down by chewing, food processing, or when they are brought into contact with the plant defense enzyme, myrosinase. Isothiocyanates (ITC) are an important result of this process because they have been shown in *in vitro* and animal studies to have anti-carcinogenic properties, including protecting against chemically induced tumors [9, 19, 20], interacting with the epigenome to restore normal epigenetic landscape in malignant cells, and regulating the epigenetic machinery [21]. Cooking cruciferous vegetables can reduce or eliminate ITC content, thereby diminishing the chemoprotective properties of these foods. Given these anti-carcinogenic properties, high consumption of cruciferous vegetables, especially in raw form, may help reduce the odds of stomach cancer. Although there have been many findings that suggest that cruciferous vegetables are inversely associated with various cancers, there have been some studies showing this with limited support of significant results. Therefore, we examined the association between cruciferous vegetable consumption and stomach cancer using data from Roswell Park Comprehensive Cancer Center (Roswell Park).

Materials and Methods

This hospital-based, case-control study consisted of participants from the Patient Epidemiologic Data Systems study (PEDS), conducted at Roswell Park between 1982 and 1998. During the admission process, all patients were approached to complete an epidemiological questionnaire; approximately 50% of all individuals who received the questionnaire completed it. The current study included 292 patients with stomach cancer and 1168 patients with non-cancer diagnoses, frequency matched by sex, five-year categories of age, and five-year categories of year the survey was completed, in order to control for possible changes in population-wide changes in dietary habits over the almost two decades these epidemiologic data were collected. Patients included were predominantly Caucasian (93%) and between the ages of 20 and 95 years. We excluded individuals with a history of stomach ulcers, which can be a risk factor for stomach cancer (4% of cases, 2% of controls), and people who had responded to fewer than 50% of the food frequency questionnaire (FFQ) items (3% of cases, 1% of controls).

Each individual completed a comprehensive epidemiologic questionnaire, providing demographic information, physical activity, smoking history, alcohol intake, medical history, family history of cancer, occupational and residential exposures, and a 46-item food frequency questionnaire (FFQ). Although this FFQ was brief, it provided a detailed breakdown of an individual's consumption of vegetables, particularly cruciferous vegetables, with individuals reporting on usual consumption prior to their current illness, with five categories ranging from never to 5–7 servings per week. This FFQ was validated by Byers et al. [22], who determined that a large fraction of the variability of nutrient intake in a given population could be explained by a small number of foods in epidemiologic studies. Based on the category midpoints, continuous measures of individual food items were aggregated into groups, including total vegetables, total cruciferous vegetables, cooked cruciferous vegetables, raw cruciferous vegetables, non-cruciferous vegetables, total fruit, total meat, and vitamin C-providing foods, with mean servings per week of these food groups calculated for both cases and controls. The cruciferous vegetable group included cooked and raw broccoli, cooked and raw cabbage, cooked and raw cauliflower, Brussels sprouts, greens (including dandelion, turnip, and collard or mustard greens), kale, and sauerkraut. Intakes of total cruciferous, cooked cruciferous, raw cruciferous, and non-cruciferous vegetables were assigned to tertiles based on the distribution among the controls. Intakes of individual cruciferous vegetables were categorized as either < 1 or ≥ 1 serving per month.

Statistical analysis

We compared characteristics of cases and controls with Pearson's chi-square for categorical variables and Student's t-test for continuous variables. Odds ratios (OR) and 95% confidence intervals (CI) were estimated with multivariable logistic regression to estimate the association between each category of intake of cruciferous vegetables, other food groups, and individual foods, and stomach cancer, adjusted for age, body mass index (BMI), sex, smoking status, total meat intake, education, and family history of stomach cancer. In all cases, the lowest level of intake was the referent group. Covariates were considered for inclusion if they differed significantly ($p < 0.20$) between cases and controls; if their

inclusion altered the crude association between stomach cancer and intake of cruciferous vegetables by more than 10%, or if there was an *a priori* reason based on biological plausibility or previous literature to include them. Adjustment for net vegetables (all vegetables not included in the primary exposure within each analysis) was considered but was not included in the final adjusted models because it did not substantially alter the overall associations. We also performed subgroup analysis to assess the association between cruciferous vegetable consumption and stomach cancer by smoking status, BMI, and sex. All analyses were performed with SAS for Windows, version 9.4. In the final models, p-values of ≤ 0.05 were considered statistically significant.

Results

Descriptive characteristics of the study participants are shown in Table 1. The participants' average age was approximately 62.7 years old at the time of enrollment, and there were more than three times as many males as females (77.7% versus 22.3%). Cases were significantly more likely than controls to have no college education (67.1% versus 55.7%), to have more pack years of smoking (30.6 versus 25.1), to have a family history of stomach cancer (9.3% versus 5.1%), and to consume more meat (9.8 versus 8.1 servings per week). There were no significant differences observed between the cases and controls for age at enrollment, sex, BMI, current smoking status, and intake of alcohol, total vegetables, total fruit, and vitamin C-providing foods.

Multivariable-adjusted OR and 95% CI for the associations between stomach cancer and intakes of total vegetables, cruciferous vegetables (total, cooked, and raw), and non-cruciferous vegetables are presented in Table 2. We observed a significant inverse association between stomach cancer and the highest tertile of intake of total cruciferous vegetables (OR = 0.59, 95% CI: 0.42–0.83) and raw cruciferous vegetables (OR = 0.53, 95% CI: 0.38–0.73). No associations were observed for the highest tertiles of total vegetables (OR = 0.72, 95% CI: 0.50–1.03), cooked cruciferous (OR = 0.72, 95% CI: 0.51–1.01), or non-cruciferous vegetables (OR = 1.04, 95% CI: 0.73–1.47). When measured as continuous variables, there were significant inverse dose-dependent associations between intakes of total cruciferous (p for trend = 0.01), cooked cruciferous (p = 0.04), and raw cruciferous (p = < 0.01) and stomach cancer. We observed that one additional serving per week of raw cruciferous vegetables was associated with the greatest reduction in odds of stomach cancer (OR = 0.86, 95% CI: 0.78–0.95), followed by total cruciferous vegetables (OR = 0.94, 95% CI: 0.90–0.98), and cooked cruciferous vegetables (OR = 0.94, 95% CI: 0.89–1.00).

The multivariable-adjusted models of the associations between consumption of individual cruciferous vegetables and the odds of stomach cancer are shown in Table 3. Compared to intake of < 1 serving per month, intake of ≥ 1 serving per month was associated with a significantly lower odds of stomach cancer for raw broccoli (OR = 0.61, 95% CI: 0.43–0.86), raw cauliflower (OR = 0.51, 95% CI: 0.35–0.73), and Brussels sprouts (OR = 0.66, 95% CI: 0.48–0.91). No significant associations were observed for cooked broccoli (OR = 0.88, 95% CI: 0.67–1.15), cooked cabbage (OR = 0.80, 95% CI: 0.61–1.06), raw cabbage (OR = 0.77, 95% CI: 0.59–1.01), cooked cauliflower (OR = 0.93, 95% CI: 0.71–1.21),

greens (OR = 0.80, 95% CI: 0.53–1.20), kale (OR = 1.09, 95% CI: 0.58–2.07), and sauerkraut (OR = 0.82, 95% CI: 0.59–1.14).

In stratified analyses of the association between cruciferous vegetables intake and stomach cancer, we observed a lower odds of stomach cancer for the highest tertile of intake in each subgroup of smoking status, BMI, and sex, as shown in Table 4, although the associations only achieved significance among former smokers (OR = 0.54, 95% CI: 0.33–0.88), normal-weight individuals (OR = 0.53, 95% CI: 0.30–0.92), and males (OR = 0.54, 95% CI: 0.36–0.81), potentially owing to larger samples sizes in these three strata.

Discussion

Identification of potential chemopreventive strategies is important for stomach cancer, since early detection is confounded by symptoms similar to those of stomach ulcers and viruses, thus resulting in a greater likelihood of diagnosis at an advanced stage and less possibility of successful treatment [3]. In countries with higher incidence of stomach cancer, residents are screened more frequently, which has helped detect this disease at an earlier and curable stage. This type of routine, population-level screening has not been found to be beneficial in the United States, where there is a lower incidence of stomach cancer [23]. Consequently, other preventive strategies, such as reducing salt intake and consuming more plant-based foods, may be more relevant [24–26]. Over the years, there has been increased interest in studying the role of cruciferous vegetables and various cancers. A meta-analysis of the association between cruciferous vegetables and gastric cancer provided evidence that high intake of cruciferous vegetables was inversely associated with odds of both gastric cancer and non-cardia gastric cancer [20]. Various case-control studies have also found that cruciferous vegetables may decrease the odds of stomach cancer [20]. Additionally, some cohort studies have found similar results, where Brassicas and raw vegetables were inversely associated with gastric cancer risk, and consumption of overall vegetables were found to be protective against stomach cancer [6, 27, 28].

In our hospital-based case-control study, we observed that higher intakes of total cruciferous vegetables, particularly raw, as well as raw broccoli, raw cauliflower, and Brussels sprouts, were inversely associated with stomach cancer. The significant inverse association between intake of cruciferous vegetables and stomach cancer observed in the entire study population was maintained among former smokers, normal-weight individuals, and males, although smaller cell sizes in the other strata could have meant that the study was underpowered to see a significant association in those strata. Additionally, the lack of association between non-cruciferous vegetables intake and stomach cancer suggests that the significant inverse association observed between cruciferous vegetables and stomach cancer was not due to intake of cruciferous vegetables being highly correlated with that of non-cruciferous vegetables, which might have alternative, confounding chemoprotective mechanisms.

Cooking cruciferous vegetables can reduce the ITC content, thus decreasing the anti-carcinogenic effect of these phytochemicals [9]. ITCs are the hydrolysis product of glucosinolates, broken down by the enzyme myrosinase, which is inactivated by heat [29]. One previous study analyzed the ITC content of commonly consumed crucifers, employing

high-performance liquid chromatography-based cyclocondensation assays [30]. In three other studies, human volunteers were asked to consume various types of cruciferous vegetables, and ITC levels were subsequently obtained from urine samples [29, 31, 32]. These studies demonstrated higher concentrations of ITC in the raw form of the vegetables and in the urine of subjects consuming raw crucifers. Results from our study are consistent with these findings, as we found that the overall inverse association between intake of cruciferous vegetables and stomach cancer was largely confined to raw crucifers.

Some studies have also hypothesized that the ITCs present in cruciferous vegetables act as a bactericide against the *H. pylori* infections, which are an established risk factor for stomach cancer. In one study, patients who had evidence of an active *H. pylori* infection were enrolled in a broccoli sprout intervention. Broccoli sprouts were used because they are rich in ITCs and contain more precursor glucosinolates than mature broccoli. This study found that consuming broccoli sprouts may potentially eliminate the *H. pylori* infection [33]. Another study observed the association between broccoli sprouts and *H. pylori* in infected mice and humans. This study observed that regular consumption of broccoli sprouts among infected mice decreased corpus gastritis and helped protect against gastric mucosal inflammation, both of which are precursors of gastric cancer [34, 35]. Similar evidence was found in human trials, where consuming consistent amounts of broccoli sprouts had a direct antibacterial effect on *H. pylori*, which led to reduced gastritis [36]. Sulforaphane, a compound within the ITC group, has also been observed as a bactericidal against *H. pylori* [37].

One possible limitation of this study is our lack of knowledge of the subjects' exposure to *H. pylori*, which appears to interact with diet to alter an individual's odds of developing stomach cancer [38]. It is difficult, however, to account properly for the effect of latency and other etiologic nuances of the *H. pylori*, stomach cancer association: carrying the *H. pylori* bacteria does not guarantee development of stomach cancer, but the longer the time of infection, the greater the chance stomach cancer will develop [16]. Additionally, *H. pylori* does not colonize in cancerous areas, and there is evidence that the organism can be lost in the stomach of those with the disease, thus testing negative for the bacteria even if they have had it in the past [39].

Other limitations include a relatively small sample size, limiting our capacity for subgroup analysis. Furthermore, since the study population was largely white, we cannot generalize these findings to other racial or ethnic groups. We must also acknowledge that there may not have been accurate recollection of dietary intakes, and that this misclassification had the potential to be differential, with stomach cancer cases possibly having heightened recollection of dietary practices. Additionally, there is the possibility of reverse causation. Both stomach cancer and cruciferous vegetables can cause gastric upset, so individuals with undiagnosed stomach cancer might have avoided eating these vegetables in order to prevent stomach upset. If this were the case, the lower intake of crucifers among cases was a result, not a cause, of the stomach cancer. In order to address potential reverse causation, we separately conducted these analyses in a dataset that included BMI as a matching variable, with multivariable analyses that included other vegetables as a covariate. We did this because, although stomach upset may cause lower intake of cruciferous vegetables, these

symptoms can also cause weight loss and lower intake of other vegetables. With vigorous control of these factors, the significant association, if maintained, would be less biased by reverse confounding. Indeed, the results obtained in this separate analysis were almost identical to those from the original data set.

In conclusion, this study suggests that consuming high intakes of cruciferous vegetables, specifically raw broccoli, raw cauliflower, and Brussels sprouts, may be associated with lower odds of stomach cancer. Although the case-control design of this study prohibits etiologic conclusions, these findings add to the body of evidence suggesting that cruciferous vegetable intake should be explored as a possible chemoprotective lifestyle intervention.

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Table 1

Descriptive Characteristics of Stomach Cancer Cases and Controls from Roswell Park Comprehensive Cancer Center's Patient Epidemiologic Data System, Buffalo NY (1982–1998)

	Cases (n = 292)	Controls (n = 1168)	p-value * †
	<i>Mean (± SD) N (%)^I</i>	<i>Mean (± SD) N (%)</i>	
Age at Enrollment (years)	62.9 (± 12.5)**	62.7 (± 12.5)	0.81
Sex			
Male	227 (77.7)	908 (77.7)	1.00
Female	65 (22.3)	260 (22.3)	
Education			
High School	196 (67.1)	651 (55.7)	< 0.01
At least some college	96 (32.9)	517 (44.3)	
Body Mass Index (BMI) (kg/m ²)	25.8 (± 4.3)	26.3 (± 4.4)	0.08
BMI (kg/m ²)			
Underweight (< 18.5)	4 (1.4)	14 (1.2)	0.06
Normal Weight (18.5–24.99)	113 (38.7)	461 (39.5)	
Overweight (25.0–29.99)	132 (45.2)	490 (42.0)	
Obese (≥ 30.0)	33 (11.3)	186 (15.9)	
Smoking Status			
Never	98 (33.6)	425 (36.4)	0.20
Former (< 1 year)	21 (7.2)	53 (4.5)	
Former (> 1 year)	133 (45.6)	491 (42.0)	
Current	39 (13.4)	194 (16.6)	
Pack Years of Smoking	30.6(± 40.5)	25.1 (± 32.1)	0.03
Alcohol Intake (SPW)			
< 2	136 (46.6)	534 (45.7)	0.79
≥ 2	156 (53.4)	634 (54.3)	
Family History Of Stomach Cancer			
Yes	27 (9.3)	59 (5.1)	< 0.01
No	265 (90.8)	1109 (95.0)	
Total Vegetable SPW	18.5 (± 9.8)	19.1 (± 10.2)	0.38
Total Fruit SPW	10.7 (± 7.8)	11.3 (± 7.9)	0.25
Total Meat SPW	9.8 (± 6.4)	8.1 (± 5.6)	< 0.01
Vitamin C—Providing Foods SPW	9.6 (± 5.9)	10.1 (± 6.2)	0.30

^ITotal categorical values may not sum to 100% due to missing data and rounding.

SD = standard deviation; N = number; SPW = Servings per week

† Tested by chi-squared test of differences in proportion.

* Tested by Student's t-test for difference in mean.

Association between Stomach Cancer and Intake of Cruciferous Vegetables and Other Food Groups of Interest among Cases and Controls from Roswell Park Comprehensive Cancer Center's Patient Epidemiologic Data System, Buffalo NY (1982–1998).

Table 2

	Cases (N = 282) Tertile N(%)	Controls (N = 1146) Tertile N(%)	Age-Adjusted		² Multivariable-Adjusted	
			OR (95% CI)	P for trend	OR (95% CI)	P for trend
Total Vegetables (SPW)						
T1 T1 (0 – 13.6)	91 (32.3)	378 (33.0)	1.00		1.00	
T2 (13.7 – 21.9)	116 (41.1)	388 (33.9)	1.20 (0.89–1.63)		1.17 (0.85–1.61)	
T3 (> 21.9)	75 (26.6)	380 (33.2)	0.80 (0.57–1.11)		0.72 (0.50–1.03)	
Per Additional 1 SPW			0.99 (0.98–1.01)	0.37	0.99 (0.98–1.00)	0.16
Total Cruciferous Vegetables (SPW)						
T1 (0 – 1.6)	110 (39.0)	377 (33.9)	1.00		1.00	
T2 (1.7 – 3.9)	103 (36.5)	381 (33.3)	0.94 (0.69–1.26)		0.95 (0.70–1.30)	
T3 (> 3.9)	69 (24.5)	388 (33.9)	0.62 (0.45–0.86)		0.59 (0.42–0.83)	
Per Additional 1 SPW			0.95 (0.91–0.99)	0.01	0.94 (0.90–0.98)	0.01
Cooked Cruciferous (SPW)						
T1 (0 – 1.0)	99 (35.1)	366 (31.9)	1.00		1.00	
T2 (1.1 – 2.5)	105 (37.2)	397 (34.6)	0.95 (0.70–1.29)		0.98 (0.72–1.35)	
T3 (> 2.5)	78 (27.7)	383 (33.4)	0.75 (0.54–1.04)		0.72 (0.51–1.01)	
Per Additional 1 SPW			0.95 (0.90–1.01)	0.08	0.94 (0.89–1.00)	0.04
Raw Cruciferous (SPW)						
T1 (0 – 0.4)	129 (45.7)	409 (35.7)	1.00		1.00	
T2 (0.5 – 1.0)	86 (30.5)	327 (28.5)	0.87 (0.64–1.18)		0.84 (0.62–1.16)	
T3 (> 1.0)	67 (23.8)	410 (35.8)	0.52 (0.38–0.72)		0.53 (0.38–0.73)	
Per Additional 1 SPW			0.86 (0.78–0.95)	< 0.01	0.86 (0.78–0.95)	< 0.01
Non-Cruciferous Vegetables (SPW)						
T1 (0 – 11.1)	81 (28.7)	376 (32.8)	1.00		1.00	
T2 (11.2 – 17.8)	109 (38.7)	392 (34.2)	1.22 (0.89–1.67)		1.26 (0.91–1.76)	
T3 (> 17.8)	92 (32.6)	378 (33.0)	1.07 (0.77–1.48)		1.04 (0.73–1.47)	
Per Additional 1 SPW			1.00 (0.98–1.02)	0.97	1.00 (0.98–1.01)	0.62

SPW = Servings per week; T = tertile; OR = odds ratio; CI = confidence interval; SD = standard deviation. Based on distribution in the controls.

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Total categorical values may not sum to 100% due to missing data and rounding.
2
Adjusted for age, BMI, sex, smoking status, total meat, education, and family history of stomach cancer.

Table 3

Association between Stomach Cancer and Intake of Specific Cruciferous Vegetables in Roswell Park Comprehensive Cancer Center's Patient Epidemiologic Data System, Buffalo NY (1982–1998).

	Number (%) ¹		OR (95% CI)	
	Cases (n = 292)	Controls (n = 1168)	Age-Adjusted	² Multivariable-Adjusted
Cooked Broccoli (SPM)				
< 1	118 (42.3)	432 (37.9)	1.00	1.00
1	161 (57.7)	707 (62.1)	0.82 (0.63–1.06)	0.88 (0.67–1.15)
Raw Broccoli (SPM)				
< 1	222 (81.6)	799 (70.9)	1.00	1.00
1	50 (18.4)	328 (29.1)	0.54 (0.39–0.75)	0.61 (0.43–0.86)
Cooked Cabbage (SPM)				
< 1	177 (63.7)	691 (60.7)	1.00	1.00
1	101 (36.3)	448 (39.3)	0.91 (0.70–1.19)	0.80 (0.61–1.06)
Raw Cabbage (SPM)				
< 1	145 (52.9)	535 (47.1)	1.00	1.00
1	129 (47.1)	602 (53.0)	0.81 (0.62–1.05)	0.77 (0.59–1.01)
Cooked Cauliflower (SPM)				
< 1	134 (48.4)	525 (46.1)	1.00	1.00
1	143 (51.6)	613 (53.9)	0.91 (0.71–1.18)	0.93 (0.71–1.21)
Raw Cauliflower (SPM)				
< 1	231 (84.6)	818 (72.5)	1.00	1.00
1	42 (15.4)	310 (27.5)	0.47 (0.33–0.67)	0.51 (0.35–0.73)
Brussel Sprouts (SPM)				
< 1	212 (77.9)	798 (70.6)	1.00	1.00
1	60 (22.1)	332 (29.4)	0.66 (0.49–0.90)	0.66 (0.48–0.91)
Greens + Kale (SPM)				
< 1	186 (66.0)	683 (59.6)	1.00	1.00
1	96 (34.0)	463 (40.4)	0.73 (0.56–0.96)	0.84 (0.60–1.18)
Sauerkraut (SPM)				
< 1	213 (77.2)	873 (76.7)	1.00	1.00
1	63 (22.8)	265 (23.3)	0.97 (0.71–1.32)	0.82 (0.59–1.14)

OR = odds ratio; CI = confidence interval; SPM = Servings per month

¹Total categorical values may not sum to 100% due to missing data from food frequency questionnaire and rounding.

²Adjusted for age, BMI, sex, smoking status, total meat, education, and family history of stomach cancer.

³Includes dandelion, turnip, and collard or mustard greens.

Cruciferous Vegetable Consumption and Risk of Stomach Cancer by Smoking Status, BMI, and Sex in Roswell Park Comprehensive Cancer Center's Patient Epidemiologic Data System, Buffalo, NY (1982–1998).

Table 4

	<i>I</i> _{Number (%)}		OR (95% CI)	
	Cases	Controls	Age-Adjusted	<i>I</i> _{Multivariable-Adjusted}
Smoking Status (SPW)				
Never				
T1 (0–1.63)	38 (38.8)	131 (31.0)	1.00	1.00
T2 (1.75–3.88)	29 (29.6)	142 (33.6)	0.71 (0.42–1.22)	0.68 (0.39–1.19)
T3 (4.00–22.38)	31 (31.6)	150 (35.5)	0.72 (0.42–1.22)	0.63 (0.36–1.09)
<i>P for trend</i>			0.46	0.15
Former				
T1 (0–1.63)	57 (38.8)	171 (32.0)	1.00	1.00
T2 (1.75–3.88)	58 (39.5)	176 (33.0)	0.96 (0.63–1.45)	1.04 (0.68–1.60)
T3 (4.00–25.00)	32 (21.8)	187 (35.0)	0.52 (0.32–0.82)	0.54 (0.33–0.88)
<i>P for trend</i>			0.01	0.02
Current				
T1 (0–1.63)	15 (40.5)	75 (39.7)	1.00	1.00
T2 (1.75–3.88)	16 (43.2)	63 (33.3)	1.46 (0.68–3.14)	1.21 (0.53–2.77)
T3 (4.00–25.00)	6 (16.2)	51 (27.0)	0.35 (0.22–1.66)	0.41 (0.13–1.28)
<i>P for trend</i>			0.41	0.15
BMI (SPW)				
Normal Weight (18.5–24.99 kg/m ²)				
T1 (0–1.63)	45 (39.8)	141 (30.7)	1.00	1.00
T2 (1.75–3.88)	42 (37.2)	159 (34.6)	0.83 (0.52–1.34)	0.92 (0.56–1.51)
T3 (4.00–20.63)	26 (23.0)	159 (34.6)	0.51 (0.30–0.86)	0.53 (0.30–0.92)
<i>P for trend</i>			0.02	0.03
Overweight (25.0–29.99 kg/m ²)				
T1 (0–1.63)	52 (39.4)	172 (35.2)	1.00	1.00
T2 (1.75–3.88)	46 (34.9)	164 (33.5)	0.92 (0.59–1.45)	0.86 (0.54–1.36)
T3 (4.00–25.00)	34 (25.8)	153 (31.3)	0.73 (0.45–1.19)	0.66 (0.40–1.08)

	<i>I</i> ¹ Number (%)		OR (95% CI)	
	Cases	Controls	Age-Adjusted	<i>I</i> ¹ Multivariable-Adjusted
<i>P for trend</i>				<i>0.16</i>
Obese (30.0 kg/m ²)				
T1 (0.13–1.63)	12 (36.4)	62 (33.7)		1.00
T2 (1.75–3.88)	15 (45.5)	55 (29.9)	1.39 (0.60–3.24)	1.69 (0.68–4.16)
T3 (4.00–26.00)	6 (18.2)	67 (36.4)	0.44 (0.15–1.25)	0.51 (0.17–1.51)
<i>P for trend</i>			<i>0.12</i>	<i>0.23</i>
Sex (SPW)				
Female				
T1 (0–1.63)	20 (31.3)	77 (30.2)	1.00	1.00
T2 (1.75–3.88)	21 (32.8)	73 (28.6)	1.11 (0.56–2.22)	1.04 (0.51–2.14)
T3 (4.00–26)	23 (35.9)	105 (41.2)	0.86 (0.44–1.67)	0.71 (0.35–1.44)
<i>P for trend</i>			<i>0.59</i>	<i>0.18</i>
Male				
T1 (0–1.63)	90 (41.3)	300 (33.7)	1.00	1.00
T2 (1.75–3.88)	82 (37.6)	308 (34.6)	0.900 (0.65–1.26)	0.92 (0.65–1.30)
T3 (4.00–25.00)	46 (21.1)	283 (31.8)	0.55 (0.38–0.81)	0.54 (0.36–0.81)
<i>P for trend</i>			<i>0.01</i>	<i>0.01</i>

SPW= servings per week; T = tertile; OR = odds ratio; CI = confidence interval

¹ Adjusted for age, BMI, sex, smoking status, total meat, education, and family history of stomach cancer.