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ORIGINAL RESEARCH

Mediterranean Dietary Pattern is Associated with Lower Odds of Gastric Cancer: A Case–Control Study

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Background: Diet pattern is an important modifiable lifestyle factor. However, epidemiological studies show that the association between dietary patterns and gastric cancer (GC) is conflicting. This study aims to assess the impact of several dietary choices on the risk of GC among newly diagnosed Jordanian patients.

Methods: A case–control study was conducted at major oncology centers and hospitals in Jordan. Study participants included 172 patients with incident gastric cancer and 314 controls. Data was collected using interview-based questionnaires. Dietary intake was estimated using a validated Arabic and reproducible food-frequency questionnaire (FFQ). Dietary patterns were derived using Principal Component Analysis (PCA). Multinomial logistic regression was used to estimate the association between dietary patterns and GC.

Results: Four dietary patterns were itemized; "Mediterranean", "Prudent", "Unhealthy" and "High-fruit" dietary patterns. The "Mediterranean" dietary pattern, which includes a diet rich in fresh fruits, vegetables, milk, yogurt, lentils, and olive oil was associated with a significant decrease in the odds ratio (OR) of GC for the third and fourth quartiles (OR, 0.394 (confidence interval (CI): 0.211–0.736); 0.212 (CI: 0.107–0.419), respectively) after adjusting for age, gender, body mass index, smoking, marital status, total energy intake, education level, and physical activity. While the "Unhealthy" and "Prudent" dietary patterns enhance the risk of developing GC, this risk was insignificant at any quartile. Additionally, the "High-Fruit" dietary pattern shows an insignificant protective effect against the risk of GC.

Conclusion: The "Mediterranean" dietary pattern was associated with a reduced risk of GC among Jordanians. However, the other three identified dietary patterns were not significantly associated with the risk of GC.

Keywords: dietary patterns, gastric cancer, retrospective, case–control study

Introduction

Despite a reported decline in the incidence rate of gastric cancer (GC), the absolute number of new cases has increased to more than 1.3 million in 2015.[1] As the fourth most common malignancy in the world, GC is known for its poor survival rates as it is the second most common cause of cancer-related deaths globally.[2] Although the global incidence of GC is gradually decreasing, this malignancy is still expected to display an absolute increasing trend in the next several decades.[3] Thus, primary prevention must be an area of focus for the improvement of the prognosis of gastric cancer.[3]

Growing evidence shows that GC is induced by the combined synergistic effects of *Helicobacter pylori* infection, genetic instability, and behavioural and environmental factors, including diet.[4] Diet has been implicated as a leading contributor to cancer[5] in agreement with other studies on nutrition and gastric cancer that suggested the relevancy of dietary factors.[6]

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However, it is difficult to attribute individual foods and nutrients to disease risk in observational studies,[7] due to the collinearity that exists between foods and nutrient-nutrient interactions.[8] Therefore, a more appropriate method for assessing the combined effect of food and nutrient interaction is to explore the association between dietary patterns and disease.[9]

Previous diet-disease studies suggested that different food patterns have different effects on gastrointestinal tumors.[6] The majority of these studies have identified that Western, Unhealthy, Healthy and Prudent dietary patterns play a role in disease outcome.[7,10] However, the association of these dietary patterns and comparability across different populations remains unclear. Particularly, the association of a Western diet with GC. A case–control study from Iran reported that the Western dietary pattern which is typically high in processed meat, sweets, soft drinks, high-fat dairy, fast food, and sauces is directly associated with the risk of GC.[11] Similarly, a case–control study conducted by researchers in Canada also found that the Western dietary pattern is associated with increased odds of GC.[7] While another study reported no effect of the Western dietary pattern on the risk of GC.[10] Additionally, a study conducted in Japan also found that a Western diet was not associated with the risk of GC.[12]

Due to the mixed results in the literature on the role of diet and dietary patterns on GC, our study aimed to explore the association between dietary patterns and the risk of GC in Jordan. Additionally, the study highlighted the role of dietary patterns in preventing or developing to GC in a country where both Mediterranean and Western diets are contemporary.

Methods

Study Design and Participants

This case–control study was conducted in Jordan between March 2015 and August 2018. Two hundred and fourteen GC patients with a confirmed medical diagnosis of gastric cancer were invited to participate in this study. However, only 172 patients accepted to participate in this study. Additionally, 350 controls were also invited to join the study. The control group included 314 individuals who were conveniently selected from the community without the diagnosis of any form of cancer. The response rate for the cases 80% was and for the controls was 90%. The population-based controls were matched to the cases based on age, occupation, and marital status. The ratio of cases to controls in this study was 1:2.

The inclusion criteria for both cases and controls included Jordanian nationality, 18 years or older at the time of enrollment, ability to communicate verbally, and free of any chronic diseases that require major dietary modifications such as kidney disease, liver disease, or celiac disease. For the cases, patients were conveniently enrolled if they were diagnosed with GC in the last six months. Exclusion criteria included individuals who were pregnant and lactating, following a vegetarian diet, critically ill, hospitalized, and unable to communicate verbally. Only participants with diabetes mellitus, cardiovascular diseases and hypertension were included. Around 28 participants were complaining of diseases that did not require major changes in diet (gallbladder, arthritis, migraine and knee joint replacement).

Cases were enrolled from four hospitals including an oncology center. These hospitals were King Hussein Cancer Center, King Abdullah University Hospital, Jordan University Hospital, and Al-Bashir Hospital. The selected cases represent almost the entire population of GC patients.

The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Institutional Review Board Ethics Committee of the King Hussein Cancer Center (IRB No. 15 KHCC 03, Amman, Jordan), King Abdullah University Hospital, Jordan University Hospital, and Al-Bashir Hospital. Informed consent was obtained from all participants before enrollment in the study and they were all informed about the purpose and the procedure of the study.

Data Collection

Trained dietitians completed personal, physical activity, and food frequency questionnaires via in-person interviews. The personal questionnaire included questions related to age, gender, marital status, educational level, employment status, family income/month, smoking status, previous and current health problems, and family history of cancer.

Dietary Assessment

Data on diet was collected using a validated Arabic food frequency questionnaire (FFQ) for dietary assessment.[13] Standardized food models (NASCO, Saugerties, NY, USA) and standard measuring tools were used (NASCO, Saugerties, NY, USA) to estimate portion sizes. Food lists in the FFQ were categorized based on the type of food: 21 items of fresh and dried fruits and juices; 21 items of fresh and cooked vegetables; 8 items of the most common consumed cereals; 9 items of milk and dairy products; 4 items of legumes; 16 items of all types of meat; 4 items of soups and sauces; 5 items of drinks; 4 items of snacks and sweets; and 14 items of herbs and spices. Total energy intakes were analyzed using dietary analysis software (Food Processor SQL version 10.1.129; ESHA, USA) with additional data on foods consumed in Jordan[14] to estimate daily intake of energy.

Anthropometric Measurements

Participants' body weight and height were measured using standardized techniques and calibrated tools using a calibrated scale (Omron, Japan).[15] Body mass index (BMI) was calculated by dividing weight (kilograms) by height squared (meters).[15]

Seven-Day Physical Activity Recall (PAR)

The validated Seven-Day Physical Activity Recall (Seven-Day PAR) questionnaire was used to measure physical activity levels. Seven-Day PAR is a questionnaire that focuses on a participant's recall of the usual time spent doing a physical activity over a seven-day period.[16] The scores of the physical activity were calculated according to Thompson et al.[17]

Statistical Analysis

SPSS version 22.0 (IBM SPSS Statistics for Windows, IBM Corporation) was used to perform all statistical analyses. For descriptive statistics, mean±standard deviation (SD) and percentages were used.

Dietary patterns were derived using principal component analysis (PCA) from factor analysis. Consumption frequency was used to identify the dietary patterns. The foods in the FFQ were separated into 51 food items based on their similarity of nutrient content and culinary usage or their reported relationship with GC (Table 1). These factors explained 30.34 of the total variance in the original data set. Only the magnitude of each loading was used to name the factors. A Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity were used to assess the suitability of using factor analysis for this exercise. Sampling adequacy and inter-correlation of factors were supported by KMO value >0.577 and Bartlett's test of sphericity <0.001, respectively. Factors were retained based

Table 1 Factor Loading Matrix for the Four Major Dietary Patterns Identified in a Representative Sample

Food Items	Dietary Patterns in Gastric Cancer Patients			
	Mediterranean	Prudent	Unhealthy	High-Fruit
Tomato Juice		0.436		
Orange Juice		0.471		
Natural Fruit Juice				−0.354
Artificial Fruit Juice			0.368	
Total Low Fat Milk		0.668		
Beer				0.589
Wine				0.705
Tea	0.350			
Apple				0.479

(*Continued*)

Table 1 (Continued).

Food Items	Dietary Patterns in Gastric Cancer Patients			
	Mediterranean	Prudent	Unhealthy	High-Fruit
Pear				0.364
Dried Fruit		0.356		
Peach	0.518			0.367
Grape	0.378			0.320
Melon	0.461			
Water Melon	0.399			
Orange	0.364			
Grape Fruit	0.317			0.528
Dates	0.305			
Other Fruit	0.498	0.324		
Cooked Vegetables			0.415	
Fresh Vegetables	0.351	0.312		
Grape Leaves	0.484			
Stuffed Vegetables	0.394			
Cabbage Salad			0.418	
Vegetable Salad	0.376	0.378		
Carrot				0.334
Peas		0.375		
Corn			0.330	
Broccoli		0.456		
Cauliflower	0.374			
Mixed Vegetables	0.356	0.353		0.308
Olives Pickles	0.411			
Fried Vegetables	0.492			
Pepper				0.360
Tomato	0.352			
Lettuce		0.451		
Fried Potato			0.338	−0.337
Boiled Potato	0.380			
White Bread		−0.362		−0.347
Whole Wheat Bread		0.363		
Rice	0.420			

(*Continued*)

Table 1 (Continued).

Food Items	Dietary Patterns in Gastric Cancer Patients			
	Mediterranean	Prudent	Unhealthy	High-Fruit
Pasta With Meat			0.474	
Pasta With Cheese			0.523	
Whole Wheat Cereals		0.603		0.320
Yogurt	0.429			
White Cheese	0.447			
Low-Fat White Cheese		0.707		
Free-Fat White Cheese		0.576		
Beef Mortadella			0.312	
Tuna Canned In Oil			0.314	
Burger			0.752	
Minced Meat	0.481			
Cooked Lamb Meat	0.468			
Chicken Sandwich			0.666	
Fried Chicken Without Skin			0.359	
Liver	0.344			
Sausage			0.492	
Fried Fish			0.359	
Baked Fish		0.376		
Fried Egg			0.359	
Boiled Egg	0.359			
Cooked Beans	0.353			
Lentil Soup	0.300	0.360		
Mushroom Soup		0.746		
Vegetable Soup		0.466		
Vermicelli Soup		0.456		
Pizza With Meat			0.524	
Biscuit			0.334	
Chips			0.372	
Popcorn			0.367	
Ice Cream		0.595	0.333	
Cake			0.577	
Ma'mmol			0.358	

(*Continued*)

Table 1 (Continued).

Food Items	Dietary Patterns in Gastric Cancer Patients			
	Mediterranean	**Prudent**	**Unhealthy**	**High-Fruit**
Arabic Sweet			0.470	
Chocolate			0.391	
Tomato Paste	0.304		0.515	
Ketchup			0.432	
Mayonnaise			0.626	
Margarine			0.330	
Butter			0.359	
Olive oil	0.385			
Variance of Intake Explained (%)	**5.10**	**7.25**	**10.15**	**4.63**

on an eigenvalue of >1.25 for the screen plot. Further, Varimax rotation was applied to review the correlations between variables and factors. Food items with absolute factor loadings > 0.25 were considered to have contributed significantly to the pattern. Potential confounders (adjusted for age, gender, BMI, smoking, marital status, total energy intake, education level, family history and physical activity) were chosen based on reported risk factors for GC.[18] Odds ratios (OR) and their 95-confidence intervals (CI) were calculated using a multinomial logistic regression model. The significance level was set at $p \leq 0.05$.

Results

Table 1 shows the different food groups loaded for our four-factor components. The first factor, "Mediterranean", is mainly loaded with vegetables and fruits. The "Prudent" factor is loaded for food groups such as fruit and vegetables, milk, low- and free-fat white cheeses, soup, whole bread and cereal. In comparison, the "Unhealthy" group contained items like artificial fruit juice, cooked vegetables, cabbage salad, fried potato, pasta, burger and different kinds of processed meat. Lastly, "High- fruit" featured mainly fruits. As described by Al-Awwad et al, study on the same GC cases and controls, the pre-diagnosis weight and BMI of GC cases were significantly higher than controls (Table 2). Additionally, Table 2 reveals that the total physical activity metabolic equivalent- min/

Table 2 Characteristics of the Study Participants (n=486)[19]

Variables	Cases (n=172) Mean±SD	Controls (n=314) Mean±SD
Age (y)	54.1 ± 1.0	54.0 ± 0.7
Height (cm)	167.9 ± 0.7	168.0 ± 0.5
Pre-diagnosis Bodyweight (Kg)	85.3 ± 1.6	79.4 ± 1.2
Current Weight (Kg)	70.6 ± 1.3	80.9 ± 0.9
Pre-diagnosis BMI (kg/m^2)	30.1 ± 0.5	28.3 ± 0.4
Current BMI (kg/m^2)	25.0 ± 0.5	28.7 ± 0.3
Total Physical Activity (MET-min/week)	1031.5 ± 42.7	1314.7 ± 45.6

(*Continued*)

Table 2 (Continued).

Variables	Cases (n=172) Mean±SD	Controls (n=314) Mean±SD
	n (%)	n (%)
Gender		
Male	107 (61.8)	191 (60.8)
Female	66 (38.2)	123 (39.2)
Pre-diagnosis BMI Categories		
<18.5	0 (0.0)	6 (2.1)
18.5–24.9	29 (18.6)	73 (25.9)
25–29.9	63 (40.4)	97 (34.4)
>30	64 (41.0)	106 (37.6)
Current BMI Categories		
<18.5	9 (5.8)	0 (0.0)
18.5–24.9	89 (57.1)	85 (27.8)
25–29.9	30 (19.2)	108 (35.3)
>30	28 (17.9)	113 (36.9)
Cancer Stages		
No Cancer	0 (0.0)	314 (100.0)
First Stage	0 (0.0)	0 (0.0)
Second Stage	2 (1.4)	0 (0.0)
Third Stage	43 (30.7)	0 (0.0)
Fourth Stage	95 (67.9)	0 (0.0)
Marital Status		
Married	148 (85.5)	273 (86.9)
Single	8 (4.6)	20 (6.4)
Divorced	3 (1.7)	7 (2.2)
Widow	14 (8.1)	14 (4.5)
Education Level		
Illiterate	10 (5.8)	18 (5.8)
Less than High School	54 (31.4)	80 (25.6)
High school	43 (25.0)	72 (23.0)
Diploma	25 (14.5)	56 (17.9)
Bachelor	34 (19.8)	71 (22.7)
Master's degree	4 (2.3)	13 (4.2)
Doctorate Degree	2 (1.2)	3 (1.0)
Employment Status		
Yes	82 (47.7)	153 (49.0)
No	90 (52.3)	159 (51.0)
Smoking Status		
Total Number of the Smokers	90 (52.0)	124 (39.5)
Current Smoker	56 (32.4)	99 (31.5)
Previous Smoker	23 (13.3)	13 (4.1)
Passive Smoker	11 (6.3)	12 (3.8)
Non-Smoker	83 (48.0)	190 (60.5)
Number of Cigarettes/Day		
< 1	95 (56.2)	206 (65.6)
2–5	6 (3.6)	12 (3.8)
6–10	5 (3.0)	12 (3.8)
11–20	23 (13.6)	42 (13.4)
21–40	28 (16.6)	29 (9.2)
>41	12 (7.1)	13 (4.1)
≥ 2	1 (0.6)	6 (2.0)

(*Continued*)

Table 2 (Continued).

Variables	Cases (n=172) Mean±SD	Controls (n=314) Mean±SD
Health Problem		
No	95 (54.9)	151 (48.1)
Yes	78 (45.1)	163 (51.9)
Type of Health Problem		
No	95 (54.9)	151 (48.1)
Diabetes mellitus	33 (19.1)	81 (25.8)
Cardiovascular diseases	10 (5.8)	19 (6.1)
Hypertension	30 (17.3)	40 (12.7)
Others	5 (2.9)	23 (7.3)
Family History of Cancer		
Yes	84 (48.6)	100 (31.8)
No	89 (51.4)	214 (68.2)
Cancer Type for Patient's Family		
NO	89 (51.4)	214 (68.2)
Gastric	7 (9.8)	10 (3.2)
Colon and/or Rectal	9 (5.2)	13 (4.1)
Gastric	1 (0.6)	1 (0.3)
Bone cancer	4 (2.3)	6 (1.9)
Lung	5 (2.9)	11 (3.5)
Leukaemia	3 (1.7)	10 (3.2)
Breast	16 (9.2)	13 (4.1)
Liver	6 (3.5)	5 (1.6)
Prostate	2 (1.2)	4 (1.3)
Other	21 (12.1)	27 (8.6)
Stomach Pain		
Yes	49 (28.3)	14 (4.5)
No	124 (71.7)	300 (95.5)
Stomach Ulcer		
Yes	77 (44.8)	5 (1.6)
No	95 (55.2)	309 (98.4)
Physical Activity Levels		
Inactive	50 (29.1)	46 (14.6)
Minimally Active[¥]	122 (70.9)	251 (79.9)
HEPA Active[Φ]	0 (0.0)	17 (5.4)

Notes: [¥]Minimally Active: at least 600 MET-min/week. [Φ]HEPA Active: more than 3000 MET-min/week.
Abbreviations: BMI, body mass index; HEPA, health-enhancing physical activity.

week (MET-min/week) was 1031.5 ±42.7 for GC cases and 1314.7±45.6 for controls. However, most of them were considered minimally active.[19]

Table 3 shows the risk of GC across quartiles of the dietary patterns among study participants, the identified dietary patterns include "Mediterranean", "High-Fruit", "Unhealthy" and "Prudent". The "Mediterranean" dietary pattern presents a diet rich in fresh fruits, vegetables, milk, yogurt, and lentils. This dietary pattern was associated with a significant decrease in the odds of GC at the third and fourth quartiles (OR, CI: 0.394 (0.211–0.736); 0.212 (0.107–0.419), respectively) after adjustment. While the "Unhealthy" and "Prudent" dietary patterns enhance the risk of developing GC, this risk was insignificant at any quartile. Additionally, the "High-Fruit" dietary pattern shows an insignificant protective effect against the risk of GC.

Table 3 Risk of GC Across Quartiles of the Dietary Patterns Among Study Participants

Dietary Pattern	Quartile 1	Quartile Q2 OR (95% CI)	Quartile Q3 OR (95% CI)	Quartile Q4 OR (95% CI)
Mediterranean	1	0.927 (0.513–1.673)	0.394 (0.211–0.736)	0.212 (0.107–0.419)
Cases/Controls	59/54	54/58	35/78	23/91
Prudent	1	1.107 (0.585–2.092)	1.808 (0.960–3.409)	1.585 (0.847–2.964)
Cases/Controls	35/77	37/76	48/61	50/66
Unhealthy	1	0.674 (0.361–1.259)	0.860 (0.457–1.617)	1.544 (0.810–2.943)
Cases/Controls	40/74	36/77	41/73	55/59
High-Fruit	1	0.699 (0.378–1.293)	0.913 (0.498–1.674)	0.911 (0.485–1.713)
Cases/Controls	42/72	39/72	45/68	44/69

Notes: Adjusted for age, marital status, BMI, education, smoking, physical activity, family history, and energy (Kcal). The control group was considered the reference group for dietary pattern analysis.
Abbreviations: OR, odd ratio; CI, confidence interval.

Discussion

Only a few studies have investigated the role of dietary patterns on GC development among populations living in Middle East countries. Therefore, this study was conducted to explore the possible association between dietary patterns and GC development among Jordanian adults. In the present study, we identified four major dietary patterns and labelled them as "Mediterranean", "Prudent", "Unhealthy", and "High-fruit". The "Mediterranean" diet is loaded with vegetable and fruit items while the "Prudent" pattern mainly included fruit; vegetables, milk, low and fat-free white cheeses, soup, whole bread and cereals, and the "High-fruit" diet featured fruits. In comparison, the "Unhealthy" diet is loaded with artificial fruit juices, cooked vegetables, cabbage salad, fried potato, pasta, burgers and different types of processed meats. However, due to differences in dietary patterns based on ethnicity, culture, religion, geography and other social determinants, the types of foods and dietary patterns identified may not always be comparable across all studies. Researchers may perceive and identify the same patterns, but these patterns may differ to a greater or lesser degree in the loading of each food variable and/or in the number of variables loaded.[20,21] Therefore, dietary patterns should be compared thoroughly between studies, with particular emphasis on the substance of each pattern.[21] In the literature, most of the studies that explore the association between data-driven dietary patterns and GC risk identify two types of dietary patterns: a Western/Unhealthy pattern and a Healthy/Prudent pattern.[7,10]

Our results show that a higher intake of a "Mediterranean" dietary pattern is associated with a lower risk of GC in a case–control study of Jordanian adults. The "Mediterranean" Jordanian diet features characteristics of the Mediterranean diet, such as high fruit and vegetable, olive oil and legume content. This may indicate an overall healthy and anti-carcinogenic eating pattern because of the high concentrations of antioxidant substances, vitamin C, and vitamin E compounds found in some of these foods.[21] Antioxidants eliminate free radicals, decrease DNA oxidation, and interfere in several cancer-related biological processes, including carcinogen bio-activation, cell signaling, cell cycle regulation, angiogenesis, and inflammation.[10] Furthermore, allium vegetables, particularly garlic, might lower the severity of H. pylori-associated gastritis, and bioactive components in fruit may protect against *H. pylori*-induced damage, notably inflammation, which has been linked to the development of GC. Additionally, omega-3 polyunsaturated fatty acids, found in fish and nuts, may have anti-cancer properties by affecting several targets involved in cancer progressions, such as cell proliferation, cell survival, angiogenesis, inflammation, and metastasis.[10] Many previous case–control studies of GC have found inverse associations with vegetable and fruit consumption.[12] Similar to our results, a previous study found that the largest factor loading on a "Mediterranean" pattern with consumption of fruits and vegetables (ie >0.3 KMO for each item) could prevent GC.[10,14] Additionally, the frequent consumption of beans was also found to be significantly inversely associated with GC risk.[22] A 10-year longitudinal study in Japan found an inverse

relationship between a healthy pattern and the incidence of GC in women (rate ratio for highest quartile (RR) 0.56; 95% CI: 0.32–0.96; p for trend 0.03), but not in men. In contrast, the traditional Japanese dietary pattern, which is rich in salty foods such as miso soup and rice, was linked to an elevated risk of GC in both men and women (RR= 2.88, 95% CI: 1.76–4.72; RR= 2.40, 95% CI:1.32–4.3, respectively). A meta-analysis of the association between fruit and vegetable intake and GC risk has indicated relative risks of 0.81 (95% CI: 0.75–0.87) and 0.74 (95% CI: 0.69–0.81) for each 100-g increase in fruit intake and vegetable intake, respectively.[7] In a recent systematic review and meta-analysis, the combined OR of gastric cancer for the highest Mediterranean diet score vs the referent was found to be 0.42 (95% CI: 0.2–0.86), and the combined HR was 0.89 (95% CI: 0.68–1.17). The combined OR for the dietary inflammatory index was 2.11 (95% CI: 1.41–3.15). Consequently, it was concluded that the consumption of Mediterranean dietary patterns might reduce gastric cancer risk, while inflammatory dietary patterns might enhance gastric cancer risk.[23] Another recent systematic review and meta-analysis of 21 studies showed that a high-quality diet quantified by the Diet Inflammatory Index and Mediterranean Diet Score was significantly associated with a reduced risk of upper gastrointestinal cancer.[24] Moreover, a meta-analysis of a case–control and cohort study was conducted to analyze the association between dietary fiber intake (abundant in fruit and vegetables) and GC risk. The authors found that the dose-response analysis associated a 10-g/day increase in fiber consumption with a significant (44%) reduction in GC risk.[25] Our results reveal that a "High-fruit" dietary pattern shows no association with GC risk.

The Western/Unhealthy patterns are usually high in processed meat, sweets, soft drinks, high-fat dairy, fast food, and sauces and are directly associated with GC risk.[11] On the other hand, other studies reported a null effect of the Western dietary pattern on GC risk.[10] The "Unhealthy" pattern in the present study is comparable to the high-meat and western dietary patterns described previously, which is principally characterized by a high intake of all kinds of red meat, processed meat, fresh fish, fish paste, and salt-preserved fish.[7,14] No association has been detected between the adherence to the "Unhealthy" dietary pattern and GC risk in the present case–control study. Similarly, the Western pattern was not associated with GC risk in Japan.[12] In contrast to our results, it was noticed that higher adherence to the Western pattern in Spain was associated with higher odds of gastric adenocarcinoma even for moderate adherence, going from a 63% increased risk for participants in the second quartile of adherence (OR second vs first quartile (95% CI), 1.63 (1.05; 2.52)), to more than a twofold increased risk for participants in the third and fourth quartiles of adherence (OR third vs the first quartile (95% CI), 2.23 (1.45; 3.43), and OR fourth vs the first quartile (95% CI), 2.09 (1.31; 3.33)).[10] A Canadian case–control study revealed that a Western dietary pattern, strongly correlated with soft drinks, French fries, white bread, hamburger, eggs, bacon, doughnuts, and hot dogs were associated with increased risk in women (OR ¼ 1.86, 95% CI: 1.20, 2.89) and men (OR ¼ 1.44, 95% CI: 1.03, 2.02).[7] The findings of a population-based case–control study conducted in Connecticut, New Jersey, and Western Washington State suggest that meat/nitrite consumption is linked to an increased risk of esophageal and gastric cancer subtypes, while fruit/vegetable consumption lowers the risk of gastric cardia adenocarcinoma.[26] It has been documented that a high amount of salt, nitrates or nitrites, and nitrosamine compounds in processed meat have been linked to an increased risk of GC.[12,14] Salt does not directly act as a carcinogen, but it is considered to enhance the risk of GC by causing direct damage to the gastric mucosa, which causes gastritis, increased DNA synthesis, and cell proliferation.[22] Although there is no evidence that meat increases the risk of GC, cooking techniques such as grilling or frying at high temperatures can produce carcinogenic heterocyclic amines or polycyclic aromatic hydrocarbons.[10,14,22] The iron present in these types of meat might also induce free radicals, which cause DNA double-strand breaks and oncogene activation. Furthermore, saturated fats present in fast food, sauces, and sweets, all of which are part of the Western diet, might induce the production of inflammatory mediators linked to carcinogenesis.[10] Additionally, a positive association between red meat consumption and the risk of gastric cancer, and a reverse relationship between white meat intake and the risk of this malignancy.[11] Another study found that there was approximately a threefold increased risk of GC for frequent consumption (highest quartile) of both fresh meat (odds ratio (OR) = 3.1) and processed meat (OR = 3.2). Odds ratios were also significantly elevated for frequent consumption of dairy products (OR = 2.7) and fish (OR = 2.2).[22] A similar study done in Italy suggested that an increased risk of GC was observed in an "animal product" dietary pattern (OR, 2.13; 95% CI, 1.34–3.40, for the highest versus the lowest quartile of factor score; P trend = 0.0003) and a "starch-rich" pattern (OR, 1.67; 95% CI, 1.01–2.77; P trend = 0.0463). In contrast, the "vitamins and fiber" pattern was inversely associated with GC, with an OR of 0.60

(95% CI, 0.37–0.99; P trend > 0.05) for subjects in the highest quartile as compared with those in the lowest one. The "vegetable unsaturated fatty acids" pattern was not significantly inversely related to gastric cancer.[20]

The results of our study demonstrated that the "Prudent" dietary pattern was not associated with GC risk. A study conducted in Spain, also found that the "Prudent" dietary pattern has no clear effect on gastric adenocarcinoma risk.[10] However, the findings from a Canadian case–control study showed that a prudent dietary pattern rich in vegetables, fruits, and seafood was linked to a lower risk of GC in women (OR ¼ 0.58, 95% CI: 0.37–0.92). Individual scores for vegetables, fiber/whole-grain foods, low consumption of salted/preserved foods, and low intake of sweets/snacks were linked to a lower risk of gastric cancer in women. While, increased fiber/whole grain intake, low salted/preserved food intake, and reduced snack/sweets intake were all linked to a lower risk of GC in men.[7] According to the findings of a systematic review and meta-analysis, the "Prudent/Healthy" diet rich in fruits and vegetables had a beneficial effect on the risk of GC, with an odds ratio (OR) of 0.75 (95% (CI): 0.63–0.90) for the highest vs lowest category.[27] In contrast, the "Western/Unhealthy" diet, which is high in starchy foods, meat, and fats, was found to negatively impact GC, with an OR of 1.51 (95% CI: 1.21–1.89).[27] In the case of dairy products, a collaborative cohort study in Japan found that a high-dairy diet is associated with a lower risk of GC mortality only in males, with multivariate HRs of 0.82 (95% CI: 0.61–1.10), 0.74 (95% CI: 0.54–1.01), and 0.72 (95% CI: 0.52–0.99) for the second, third, and fourth quartiles, respectively.[21]

Our results should be interpreted in the context of the study's limitations. First, recall bias is always a concern in case–control studies, especially when evaluating the effect of self-reported dietary information. Moreover, the subjective decisions involved in the definition of dietary patterns, including the number of factors to retain, the type of rotation (if any), and the interpretation and naming of the factors. A further limitation in this study is the lack of available data on Helicobacter pylori infection among study participants. On the other hand, a major strength of our study was the use of a culturally appropriate food frequency questionnaire, which consists of many food items to capture the usual dietary intake of our study population. Finally, the inclusion of cases and controls recruited from major public hospitals ensures proper representation of the different diets coexisting in Jordan.

In conclusion, our study highlights the protective effect of the "Mediterranean" dietary pattern against gastric cancer risk. While, the "Unhealthy", "Prudent" and "High-fruit" dietary patterns were insignificantly associated at any quartile with the risk of GC in Jordan. This suggests that a diet high in fruits and vegetables and low in processed meat and fat is beneficial to reducing the GC risk.

Data Sharing Statement

Data are available upon request from the corresponding author Reema Tayyem (email: reema.tayyem@qu.edu.qa).

Ethics Approval and Consent to Participate

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of King Hussein Cancer Center (IRB No. 15 KHCC 03, Amman, Jordan), King Abdullah University Hospital, Jordan University Hospital, and Al-Bashir Hospital. A written consent form was obtained from each participant and they were all informed about the purpose of the study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no conflicts of interest.

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