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Dietary pattern and odds of lung cancer: a large case-control study in Iran

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Abstract

Background Lung cancer is known as the second main fatal cancer in the world. Besides smoking, the effect of other lifestyle factors, especially dietary habits, on the risk of this cancer has not been established yet. The current study is designed to assess the association between various dietary patterns and the odds of lung cancer in Iran.

Methods This large case-control study was conducted on 608 cases and 3397 controls enrolled in the IROPICAN study in Iran. Dietary intakes were reported using a 171-item validated food frequency questionnaire. Data on the participants' dietary consumption and demographic characteristics was collected by performing face-to-face interviews. Factor analysis was carried out to extract the main nutritional patterns. Multi-model adjusted logistic regression was conducted to evaluate the association between extracted dietary patterns and the risk of lung cancer.

Results Three dietary patterns were derived. Significantly higher odds of small cell carcinoma were observed with higher adherence to the "Pesco vegetarian" dietary pattern, rich in fruits, vegetables, legumes and nuts, olives and olive oil, honey, and fish ($OR_{T3\ vs.\ T1}$ = 1,81, 95% CI 1.05, 3.11, P = 0.04). We found no significant association between the odds of total or subtypes of lung cancer with the "animal and sugar" dietary pattern, full of red and processed meat, dairy, sugar, coffee, tea, and chicken, and the "carbohydrate, fat, and egg" dietary pattern, rich in grains, eggs, fat, coffee and tea, and salt, and poor in dairy and red meat.

Conclusion While there was no association between dietary intake and the odds of lung cancer, adherence to the "pesco vegetarian dietary pattern" might be associated with an increase in the odds of small-cell carcinoma lung cancer.

Keywords Dietary pattern, Lung cancer, Case-control, Iran

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Introduction

Lung cancer is the second most prevalent cancer worldwide [1] and the fifth most diagnosed cancer in Iran [2]. With a 5-year survival rate of 19% and a mortality rate of 24%, lung cancer is also known as the main cancer death cause in the world [1, 2]. While smoking is considered the leading risk factor for lung cancer [3], opioid usage [4], alcohol consumption [5], genetic history of lung cancer [6], air pollution [7], and dietary factors [8] Now have been shown to influence the risk of lung cancer effectively.

Dietary items have been suggested to play an important role in the incidence of lung cancer. For instance, higher consumption of fruits and vegetables has been proposed to be adversely associated with the risk of lung cancer [9]. Moreover, a large meta-analysis of observational studies has suggested a protective role against lung cancer for fish consumption [10]. In Addition, consuming fermented dairy products has been observed to be adversely correlated with the risk of lung cancer [11]. On the other hand, red and processed meat, sodium, and whole milk intakes have been shown to increase lung cancer risk [11–13].

However, various foods and nutrients are usually consumed together in an individual's diet which might have unseen interactions with each other, influence the bioavailability of some nutrients, and affect their association with various conditions [14]. This illustrates the necessity of investigating their relationship with the risk of various diseases as specific patterns rather than studying their role solely [15]. The association between following priory dietary patterns and the risk of lung cancer has been evaluated previously. For example, higher adherence to Mediterranean dietary patterns [16] and Dietary Approaches to Stop Hypertension (DASH) [17] have shown to be protective against the risk of lung cancer.

Although posteriorly dietary patterns derived by factor analysis might play a crucial role in predicting the risk of chronic diseases and related mortality [18], few studies have estimated the relationship between factor analysis-derived dietary patterns and the risk of lung cancer. For example, following a healthy dietary pattern, rich in fruits, vegetables, and low-fat foods has been shown to reduce the risk of lung cancer in non-smokers [19]. In contrast, no significant association was observed between the "processed meat and potatoes" dietary pattern and the risk of lung cancer among current smokers in a cohort study [20]. However, adherence to a "Western dietary pattern" was associated with an increase in lung cancer risk among men in a case-control investigation [21].

Despite these observations, the World Cancer Research Fund suggested no established association between various dietary patterns and the risk of lung cancer yet, except for the inverse association between arsenic and high-dose supplements of beta-carotene and the risk of lung cancer [22]. Moreover, the dietary patterns are different in each specific region, which makes it necessary for this investigation to be conducted in every country [23]. Although a previous study has investigated this association in Iran [24], it has only been conducted in two hospitals in Tehran, whereas our study encompasses several provinces across different parts of Iran. This broader scope provides a more comprehensive understanding of our country's dietary patterns and other risk factors, which vary significantly between provinces. Therefore, we aimed to assess the association between dietary-derived patterns and the odds of lung cancer among the Iranian population.

Methods

Study design and population

The current study was analyzed based on the data of the large case-control multi-centered Iranian Opioid and Cancer study. The IROPICAN (the Iranian Study of Opium and Cancer) project was carried out to evaluate the association between opioid usage and the risk of four types of cancers, including lung, bladder, colorectal, and head and neck cancers in ten provinces of Iran (Tehran, Fars, Kerman, Golestan, Mazandaran, Kermanshah, Khorasan-Razavi, Hormozgan, Sistan-Baluchestan, and Bushehr). The case group ($n=608$) was selected from the patients hospitalized in the cancer wards between May 2017 and July 2020 with the exclusion of those who did not have an approval report of pathologic cancer or ones suffering from pleura cancer. The visitors of non-oncology wards or people who went to the hospital for non-treatment reasons were the control group ($n=3397$). The detailed information on the study protocol has been explained elsewhere [25]. The protocol of the current study was confirmed by the Ethics Committee of Imam Khomeini Hospital, Tehran University of Medical Sciences.

Dietary assessment

During a face-to-face interview, a 171-item food frequency questionnaire (FFQ), consisted of 153 dietary items, categorized into eight food groups, including bread and cereal, fruit and vegetable, dairy, meat, sugar, oils, and other groups, 17 dietary supplementations, and water was applied to assess the dietary intakes of participants [26]. The validity and reliability of the mentioned questionnaire have been proved previously in the Persian Cohort Study [26]. The dietary intakes of the patients and the healthy group were assessed in the year before being diagnosed with cancer and during the last year of the interview, respectively [27]. They could answer questions about the frequency of their consumption in specific

phrases of daily, weekly, monthly, and yearly [27]. Household measurements were used to calculate the grams per day of each food item. The data of the USDA (United States Department of Agriculture) food composition was applied to compute the overall daily intakes of energy, macro, and micronutrients [28]. Those with a daily energy intake of higher than 4500 or lower than 500 calories or ones with an incomplete FFQ of more than two-thirds were excluded from the study. We analyzed the intake of various food groups previously associated with lung cancer risk using factor analysis of dietary patterns [19–21, 29, 30]. We made minor modifications based on our FFQ items and the frequency of intake in the Iranian population. The final list of food groups included energy, grains, vegetables, fruits, fish, chicken, red meat, processed meat, eggs, dairy, nuts and legumes, fats and oils, olive and olive oil, honey, sugar, coffee, tea, and salt.

Assessment of other factors

The participants' height was measured when recruiting for both the case and control groups. The case group's weights were either derived from their medical reports if were not able to stand or were measured at the time of the interview same as the control group. Body Mass Index (BMI) was then calculated by dividing weight as kilograms by height as meter squared. Lifestyle factors, including educational status, age, gender, opium consumption, smoking cigarettes or pipes, medical history, socioeconomic status (SES), and use of nonsteroidal anti-inflammatory drugs (NSAIDs) were evaluated by holding face-to-face interviews between the participants and trained specialists. Socioeconomic status (SES) was defined by conducting a principal component analysis which combined various factors, including education, income, and home appliances. The Finnish Job Exposure Matrix (FINJEM) was applied to assess the subjects' physical activity [31, 32].

Statistical analysis

To calculate the number or percentage of participants in each case and control group based on their categorical properties, we conducted descriptive statistics. Mean ± SD of dietary intakes of energy, grains, vegetables, fruits, fish, chicken, red meat, processed meat, egg, dairy, nuts and legumes, fats and oils, olive and olive oil, honey, sugar, coffee, tea, and salt across the case and control groups was then reported. Factor analysis was performed to extract the main dietary patterns after including 16 food groups. The distribution of the food groups was evaluated by performing the Kaiser-Meyer-Olkin (KMO) test before using principal components. To extract the main dietary patterns, we performed varimax rotation. The association between tertiles of the derived dietary patterns and the odds of overall and subtypes of lung cancer (small-cell carcinoma, adenocarcinoma, and squamous cell carcinoma) was evaluated in two models. Age (30–39, 40–49, 50–59, 60–69, ≥ 70), energy intake (continues, Kcal/d), gender (Male/Female), and province (10 provinces) were controlled in the first model. This association was further adjusted for SES (low, medium, high), opium use (never user, user), cigarette smoking (no, yes), water pipe use (no, yes), regular alcohol consumption (no, yes), workload physical activity (sedentary, moderate, heavy), and BMI (continues, kg/m^2) in the second model. Assuming an interaction between smoking and dietary patterns on the risk of lung cancer, we performed a stratified analysis and assessed the association between dietary patterns and the odds of lung cancer among smokers and non-smokers. The analysis of the current study was carried out using the software Stata (STATA 14.1, College Station, Texas 77845 USA).

Results

An overall number of 608 cases and 3397 controls participated in the current study (Table 1). Men constituted a larger proportion of participants in both groups (77% of the case and 69% of the control group, P-value < 0.001). Socioeconomic status was low among the highest percentage of the case group (43%) and the lowest number of the control group (28%), P-value < 0.001. BMI was slightly higher in the controls (26.7 ± 4.7) than in the cases (25.3 ± 5.3), P-value < 0.001. The proportion of smokers was significantly higher in the case group (63%) than in the control group (28%), P-value < 0.001). Water-pipe smoking was also higher in the patients (11%) than in the control group (7%), P-value < 0.001. Energy consumption was significantly higher in the control group than in the cases (1854.0 vs. 1777.8 kcal/d, P-value = 0.01). However, the difference between the case and control groups was not significant in the intake of other food groups (Table 2). Sixteen food groups, including grains, vegetables, fruits, fish, chicken, red meat, processed meat, eggs, dairy, legumes and nuts, oil and fat, olive, honey, sugar, coffee, and tea were included in the factor analysis (Appendix 1). Three dietary patterns were derived through factor analysis (Appendix 2). The first dietary pattern, associated with higher values of vegetables, olives, honey, fruits, legumes, nuts, and fish, was called the "pesco-vegetarian" dietary pattern. Greater consumption of sugar, dairy, red meat, processed meat, coffee and tea, and chicken was observed in the second dietary pattern. This pattern was named the "animal and sugar" dietary pattern. The third dietary pattern, rich in oil and fat, salt, grain, coffee and tea, and eggs, and poor in dairy and red meat was called the "carbohydrate, fat, and egg" dietary pattern. No significant association was observed between adherence to the Pesco-vegetarian dietary pattern (OR = 1.02, 95% CI (0.81–1.29), P trend = 0.84),

Table 1 Characteristics of lung cancer patients and controls in a large case/control study in Iran[1]

Characteristics		Cases (*n* = 608)	Controls (*n* = 3,397)	*P*-value
Gender	male	468(77)	2344(69)	< 0.001
	female	140(23)	1053(31)	
Age category	30–39	13(2)	250(7)	< 0.001
	40–49	71(12)	547(16)	
	50–59	199(33)	1048(31)	
	60–69	210(35)	1069(32)	
	≥ 70	115(19)	483(14)	
Province	Tehran	129(21)	813(24)	< 0.001
	Fars	190(31)	931(27)	
	Kerman	103(17)	518(15)	
	Golestan	46(8)	359(11)	
	Mazandaran	33(5)	131(4)	
	Kermanshah	38(6)	249(7)	
	Khorasan-Razavi	6(1)	162(5)	
	Bushehr	33(5)	67(2)	
	Hormozgan	16(3)	73(2)	
	Systan-Baluchestan	14(2)	94(3)	
Socioeconomic status	Low	261(43)	950(28)	< 0.001
	Median	219(36)	1136(33)	
	High	128(21)	1311(39)	
Opium use	No	315(52)	2948(87)	< 0.001
	Yes	293(48)	449(13)	
Cigarette smoking	No	226(37)	2440(72)	< 0.001
	Yes	382(63)	957(28)	
Water pipe use	No	542(89)	3172(93)	< 0.001
	Yes	66(11)	225(7)	
Regular alcohol use	No	549(90)	3256(96)	< 0.001
	Yes	59(10)	141(10)	
Work physical activity	Sedentary	174(29)	1102(32)	< 0.001
	Moderate	132(22)	740(22)	
	Heavy	194(32)	744(22)	
	Unknown	108(18)	811(124)	
BMI (kg/m^2, mean ± SD)		25.3 ± 5.3	26.7 ± 4.7	< 0.001

[1]reported figures are number and percent unless indicated

animal and sugar dietary pattern (OR = 0.97, 95% CI (0,77,1.23), P trend = 0.83), and carbohydrate, fat, and egg dietary pattern (OR = 0,81, 95% CI (0,64,1,02), P trend = 0.08) and odds of lung cancer overall (Table 3). However, the odds of small cell carcinoma significantly increased in the third tertile compared to the first tertile of the pesco-vegetarian dietary pattern (OR = 1.81, 95% CI (1.05,3.11), P trend = 0.04). The linear association was insignificant between each dietary pattern and the odds of overall and various types of lung cancer in crude and controlled models. Stratified analysis (Supplementary Table 1) showed no significant interaction between smokers and non-smokers in each dietary pattern (P-interaction $_{\text{animal and sugar pattern}}$ = 0.41, P-interaction $_{\text{carbohydrate, fat, and egg pattern}}$ = 0.29).

Table 2 Intake of food groups of lung cancer patients and controls in a large case/control study in Iran[1]

	patients (*n* = 608)	Controls (*n* = 3,397)	*P*-value
Energy	1777.8(742.3)	1854.0 (674.6)	0.01
Grains	469.9(269.8)	474.7(270.8)	0.69
Vegetables	440.7(404.9)	421.1(265.9)	0.13
Fruits	315.1(276.8)	321.6(312.5)	0.63
Fish	5.4(16.4)	4.7(14.2)	0.31
Chicken	25.1(21.0)	25.7(26.3)	0.56
Red meat	16.2(24.5)	17.3(27.3)	0.36
Processed meat	0.9(15,6)	0.9(16.9)	0.95
Eggs	16.4(21.8)	17.2(23.4)	0.41
Dairy	315.0(235.8)	299.4(220.9)	0.11
Nuts & legumes	29.1(31.7)	29.1(31.7)	0.19
Fats & oils	11.9(13.5)	12.0(13.5)	0.77
Olive & olive oil	0.5(4.6)	0.4(4.4)	0.36
Honey	1.1(4.6)	0.9(5.2)	0.45
Sugar	44.8(144.6)	35.7(11.6)	0.08
Coffee& tea	710.9(822.8)	704.1(871.1)	0.86
Salt	2.9(3.3)	3.0(3.3)	0.56

[1]reported figures are mean ± SD of gram/day of intakes for food group and kcal/day for energy

Discussion

Three major dietary patterns, including the "pesco vegetarian" dietary pattern, the "animal and sugar" dietary pattern, and the "carbohydrate, fat, and egg" dietary pattern, were found in the current case-control study. Adherence to the first dietary pattern showed a significant increase in the risk of small-cell carcinoma. The association between other dietary patterns and the risk of overall or subtypes of lung cancer was not statistically significant.

Previous studies have evaluated the relationship between various dietary factors and the risk of lung cancer. For instance, our findings were consistent with a large meta-analysis of prospective cohort studies, which did not suggest any significant association between fruit and vegetable consumption, highly found in our first dietary pattern, and the risk of lung cancer in non-current smokers [9]. However, our results were not in line with previous investigations, in which higher consumptions of legumes, nuts, and fish, dietary groups highly consumed in "The pesco vegetarian" dietary pattern in our study, were associated with a decrease in lung cancer risk [10, 33], However, the mean daily intake of nuts and legumes in the current study (29.1 g/d) was lower than the lowest amounts shown in the previous studies for reducing the risk of lung cancer (legumes ≥ 135 g/week, nuts ≥ 15 g/d). Plus, while the average fish intake of 4.5 g/d has been estimated in the present study, it has been shown that a daily increase of at least 10 g/d of fish intake is required for reducing lung cancer risk in a nine-year follow-up prospective cohort study [34]. Plus, high contents of

Table 3 Risk of subtype of lung cancer according to tertiles of dietary patterns scores in a large case/control study in Iran

			OR and 95% CI by tertile of dietary patterns				
			First tertile	Second tertile	Third tertile	P Trend	OR and 95%CI (continuous)
Pesco vegetarian pattern	Total	Control	1133	1132	1132	-	-
		Case	202	197	209	-	-
		Model A[1]	Reference	0.98(0.79 – 1.21)	1.05(0.85 – 1.30)	0.64	1.03(0.97 – 1.09)
		Model B[2]	Reference	0.98(0.77 – 1.24)	1.02(0.81 – 1.29)	0.84	1.01(0.95 – 1.08)
	Small cell carcinoma	Case	22	42	39	-	-
		Model A[1]	Reference	1.90(1.12 – 3.22)	1.79(1.06 – 3.06)	0.04	1.04(0.91 – 1.18)
		Model B[2]	Reference	1.91(1.12-3.27)	1.81(1.05 – 3.11)	0.04	1.02(0.89 – 1.16)
	Adenocarcinoma	Case	81	75	73	-	-
		Model A	Reference	0.93(0.67 – 1.29)	0.93(0.66 – 1.29)	0.64	1.03(0.94 – 1.12)
		Model B	Reference	0.95(0.67 – 1.34)	0.95(0.67 – 1.34)	0.76	1.02(0.93 – 1.12)
	Squamous cell carcinoma	Case	62	45	62	-	-
		Model A	Reference	0.72(0.48 – 1.07)	1.03(0.71 – 1.48)	0.89	1.05(0.96 – 1.16)
		Model B	Reference	0.72(0.48 – 1.09)	1.00(0.67 – 1.48)	0.99	1.03(0.93 – 1.14)
animal and sugar dietary pattern	Total	Control	1134	1132	1131	-	-
		Case	200	207	201	-	-
		Model A[1]	Reference	1.03(0.83 – 1.28)	0,99(0,79 – 1,23)	0.94	1.02(0.96 – 1.09)
		Model B[2]	Reference	0,99(0,79 – 1,26)	0.97(0.77-1.23)	0.83	1.00(0.93 – 1.08)
	Small cell carcinoma	Case	40	34	29	-	-
		Model A	Reference	0.84(0.52 – 1.34)	0.73(0.45 – 1.19)	0.20	0.93(0.79-1.11)
		Model B	Reference	0.81(0.49 – 1.30)	0.74(0.45 – 1.22)	0.23	0.92(0.78 – 1.09)
	Adenocarcinoma	Case	71	70	88	-	-
		Model A	Reference	0.97(0.68 – 1.36)	1.21(0.87 – 1.68)	0.24	1.09(0.99 – 1.19)
		Model B	Reference	0.92(0.64 – 1.33)	1.19(0.85 – 1.69)	0.29	1.08(0.98 – 1.19)
	Squamous cell carcinoma	Case	53	59	57	-	-
		Model A	Reference	1.2(0.76 – 1.64)	1.06(0.72 – 1.55)	0.79	1.02(0.91 – 1.15)
		Model B	Reference	1.09(0.73 – 1.65)	1.05(0.7 – 1.59)	0.81	1.00(0.89 – 1.13)
Carbohydrate, fat, and egg pattern	Total	Control	1133	1132	1132	-	-
		Case	220	200	188	-	-
		Model A[1]	Reference	0.91(0.74 – 1.13)	0.85(0.69-1.06)	0.14	0.97(0.91 – 1.05)
		Model B[2]	Reference	0,92(0.73 – 1.16)	0.81(0.64 – 1.02)	0.08	0.98(0.90 – 1.06)
	Small cell carcinoma	Case	43	31	29	-	-
		Model A	Reference	0.72(0.45 – 1.15)	0.67(0.41 – 1.08)	0.09	0.87(0.73 – 1.04)
		Model B	Reference	0.77(0.47 – 1.24)	0.66(0.40 – 1.07)	0.09	0.88(0.73 – 1.06)
	Adenocarcinoma	Case	77	80	72	-	-
		Model A	Reference	1.03(0.74 – 1.43(	0.93(0.67 – 1.30)	0.68	1.02(0.91 – 1.13)
		Model B	Reference	1.06(0.75 – 1.50)	0.89(0.62 – 1.26)	0.51	1.02(0.91 – 1.15)
	Squamous cell carcinoma	Case	62	45	62	-	-
		Model A	Reference	1.02(0.70 – 1.49)	0.93(0.63 – 1.36)	0.70	0.98(0.86 – 1.11)
		Model B	Reference	1.11(0.75 – 1.66)	0.92(0.61 – 1.38)	0.70	0.99(0.87 – 1.14)

[1]Adjusted for energy (continues, Kcal/d), age (five categories), sex (female, male), and provinces (nine provinces of Iran)

[2]Further adjusted for SES (low, medium, high), opium use (never user, user), cigarette smoking (no, yes), water pipe use (no, yes), regular alcohol use (no, yes), workload physical activity (sedentary, moderate, heavy) and BMI (continues, kg/m^2)

The association between different lung cancers with Mediterranean like ($p=0.99$), animal ($p=0.22$), vegetable ($p=0.41$) dietary patterns are not significantly different

There is no significant difference between the association of lung cancers with different dietary patterns is not significant ($p=0.89$)

arsenic in fish consumed by Iranians might prevent the protective role of fish on the odds of lung cancer [22, 35].

The association between various dietary patterns and the risk of small-cell lung cancer has not been evaluated previously. However, higher intakes of non-oily fish and dried fruits were correlated with a reduction in small-cell carcinoma risk in a meta-analysis of observational studies [36]. The current study showed a direct association between following the "pesco vegetarian" dietary pattern, rich in fruits, vegetables, and fish, and the odds of small-cell carcinoma. This might be correlated with the high arsenic contamination of seafood highly consumed in Iranian food [35], which have been proven to increase the odds of lung cancer, significantly [22].

The current study found an inverse insignificant association between following the "animal and sugar" dietary pattern, rich in higher intakes of red meat, processed meat, chicken, dairy, sugar, coffee, and tea, and lung cancer risk. This finding was contrary to the previous studies, which showed a negative role of red and processed meat and coffee consumption on the risk of lung cancer [12, 37].

Higher consumptions of oils and fat and salt, and lower intakes of red meat and dairy were observed in the third pattern, called the "carbohydrate, fat, and egg" dietary pattern. Our findings were not in line with the results of previous studies, which showed a negative influence of total fat and salt intake on the risk of lung cancer [38, 39]. However, lower amounts of red meat in this pattern, along with the direct association between red meat intake and the odds of lung cancer suggested in previous studies [12], might have led to an insignificant decrease in the odds of lung cancer in higher tertiles of this dietary pattern.

The association between dietary patterns and the odds of lung cancer also have been investigated previously. For instance, the non-significant adverse association observed between the "carbohydrate, fat, and egg" pattern and the odds of lung cancer in the current study was in line with the results of a nine-year prospective cohort study in the Netherlands [20]. The mentioned study found an insignificant inverse association between the "salad" dietary pattern, rich in pasta, rice, and oil, and overall lung cancer risk (OR = 0.75, 95% CI = 0.55–1.01). However, the insignificant adverse association found between the "animal and sugar" pattern and the odds of lung cancer in our study was not consistent with the non-significant increase in the odds of lung cancer (OR = 0.75; 95% CI = 0.55–1.01) by adhering to the "pork, processed meat, and potato" in the mentioned investigation.

Although various studies have investigated the role of dietary patterns on the risk of lung cancer before, no confirmed association was suggested between any specific pattern and the risk of lung cancer [40, 41]. The negative influence of high doses of arsenic and beta-carotene on the odds of lung cancer is the only proven association between dietary intake and lung cancer risk [22]. In a meta-analysis of 92 articles investigating the arsenic contamination of Iranian food, high contents of arsenic in consumed seafood have been estimated, which might explain the significant direct association between adherence to the "pesco vegetarian" dietary pattern, rich in fish, and the risk of lung cancer.

The association between dietary patterns and the risk of lung cancer in Iran has only been estimated in one study [24]. While the previous investigation was conducted on a small sample size of 372 participants in one province of Iran, the current investigation was carried out on a large population all over the country in seven provinces. Factor-analysis-derived dietary patterns have been evaluated in the current study, rather than studying each food item individually. Considering the usual compound consumption of foods, this method can assess the association between dietary factors and the odds of lung cancer more specifically. Applying validated questionnaires along with conducting interviews for collecting dietary and socioeconomic status information, and controlling the findings for a variety of covariates are also the main strengths of this study. Of the limitations of the study, we can mention the recall bias, which is unavoidable due to the case-control nature of the study and the fact that we asked about the patients' dietary intakes during the previous year of cancer diagnosis. Although holding interview sessions between specialists and participants highly reduced this bias in our study. Moreover, the control group was chosen from a specific group of people in the present study (the healthy visitors of non-oncology wards and people referring to the hospitals for non-treatment reasons) and the population-based approach was not applied to selecting them, which makes selection bias possible. The changes in dietary habits between the case group during their disease are also probable, which was modified by asking them to report their intakes before cancer diagnosis.

To conclude, three dietary patterns, including the "pesco vegetarian" dietary pattern, the "animal and sugar" dietary pattern, and the "carbohydrate, fat, and egg" dietary pattern emerged in the present study. Adherence to the "pesco vegetarian" dietary pattern, rich in vegetables, fruits, legumes and nuts, olives and olive oil, honey, and fish was associated with a significant increase in the odds of small cell carcinoma. The associations between adhering to other patterns and the odds of overall or subtypes of lung cancer were not significant.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40795-025-01092-4.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

FT and KZ designed the research. MSS and MH supervised the primary data collection and cleaning. AA and MB conducted the study in different provinces and were involved in collecting data. FT analyzed the data and performed the statistical analysis. BS, SN, and HR consulted FT in statical analysis. FD wrote the draft. PB reviewed the paper and provided substantial comments. KZ was primarily responsible for the final content; All authors read and approved the final manuscript.

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Data availability
Data from this study are available on a reasonable request by KZ. The ethics committee of Tehran University of Medical Sciences approved this study (no. IR. TUMS.IKHC.REC.1400.314.). No data containing the names of participants has been published.

Declarations

Ethical approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the ethics committee of Tehran University of Medical Sciences (no. IR. TUMS.IKHC.REC.1400.314). Written informed consent was obtained from all subjects.

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

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References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209–49.
2. organization WH. Data visualization tools for exploring the global cancer burden in 2022. Cancer Today. 2022.
3. Malhotra J, Malvezzi M, Negri E, La Vecchia C, Boffetta P. Risk factors for lung cancer worldwide. Eur Respir J. 2016;48(3):889–902.
4. Sheikh M, Shakeri R, Poustchi H, Pourshams A, Etemadi A, Islami F, et al. Opium use and subsequent incidence of cancer: results from the Golestan cohort study. Lancet Glob Health. 2020;8(5):e649–60.
5. Troche JR, Mayne ST, Freedman ND, Shebl FM, Abnet CC. The association between alcohol consumption and lung carcinoma by histological subtype. Am J Epidemiol. 2015;183(2):110–21.
6. O'Brien TD, Jia P, Caporaso NE, Landi MT, Zhao Z. Weak sharing of genetic association signals in three lung cancer subtypes: evidence at the SNP, gene, regulation, and pathway levels. Genome Med. 2018;10(1):16.
7. The burden of cancers. And their variations across the states of India: the global burden of disease study 1990–2016. Lancet Oncol. 2018;19(10):1289–306.
8. Zhang Y, Zhong G, Zhu M, Chen L, Wan H, Luo F. Association between diabetes risk reduction diet and lung cancer risk in 98,159 participants: results from a prospective study. Front Oncol. 2022;12:855101.
9. Vieira AR, Abar L, Vingeliene S, Chan DS, Aune D, Navarro-Rosenblatt D, et al. Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis. Ann Oncol. 2016;27(1):81–96.
10. Song J, Su H, Wang BL, Zhou YY, Guo LL. Fish consumption and lung cancer risk: systematic review and meta-analysis. Nutr Cancer. 2014;66(4):539–49.
11. Đoàn LN, Hu C, Zhang Z, Shannon J, Bobe G, Takata Y. Dairy product consumption and lung cancer risk: a prospective analysis. Clin Nutr ESPEN. 2023;57:423–9.
12. Farvid MS, Sidahmed E, Spence ND, Mante Angua K, Rosner BA, Barnett JB. Consumption of red meat and processed meat and cancer incidence: a systematic review and meta-analysis of prospective studies. Eur J Epidemiol. 2021;36(9):937–51.
13. You D, Zhang M, He W, Wang D, Yu Y, Yu Z, et al. Association between dietary sodium, potassium intake and lung cancer risk: evidence from the prostate, lung, colorectal and ovarian cancer screening trial and the women's health initiative. Transl Lung Cancer Res. 2021;10(1):45–56.
14. De Vito R, Lee YCA, Parpinel M, Serraino D, Olshan AF, Zevallos JP, et al. Shared and study-specific dietary patterns and head and neck cancer risk in an international consortium. Epidemiology. 2019;30(1):93–102.
15. Hashemian M, Farvid MS, Poustchi H, Murphy G, Etemadi A, Hekmatdoost A, et al. The application of six dietary scores to a middle Eastern population: a comparative analysis of mortality in a prospective study. Eur J Epidemiol. 2019;34(4):371–82.
16. Du H, Cao T, Lu X, Zhang T, Luo B, Li Z. Mediterranean diet patterns in relation to lung cancer risk: a meta-analysis. Front Nutr. 2022;9:844382.
17. Zhu Z, Peng L, Gu H, Tang Y, Xiao Y, He H, et al. Association between dietary approaches to stop hypertension eating pattern and lung cancer risk in 98,459 participants: results from a large prospective study. Front Nutr. 2023;10:1142067.
18. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol. 2002;13(1):3–9.
19. Gorlova OY, Weng SF, Hernandez L, Spitz MR, Forman MR. Dietary patterns affect lung cancer risk in never smokers. Nutr Cancer. 2011;63(6):842–9.
20. Balder HF, Goldbohm RA, van den Brandt PA. Dietary patterns associated with male lung cancer risk in the Netherlands cohort study. Cancer Epidemiol Biomarkers Prev. 2005;14(2):483–90.
21. Ronco A, Deneo-Pellegrini H, Correa P, Boffetta P, Acosta G, Mendilaharsu M. Dietary patterns and risk of adenocarcinoma of the lung in males: a factor analysis in Uruguay. Nutr Cancer. 2011;63:699–706.
22. Clinton SK, Giovannucci EL, Hursting SD, The World Cancer Research Fund/American Institute for Cancer Research. Third expert report on diet, nutrition, physical activity, and cancer: impact and future directions. J Nutr. 2020;150(4):663–71.
23. Bennett G, Bardon LA, Gibney ER. A comparison of dietary patterns and factors influencing food choice among ethnic groups living in one locality: a systematic review. Nutrients. 2022;14(5).
24. Mohammadzadeh M, Mamaghanin M, Bahrami A, Paydareh A, Abdi F, Seifi* S, et al. Dietary patterns and the risk of lung cancer; a case-control study in Iran. Iranian-J-Nutr-Sci-Food-Technol. 2025;19(4):1–11.
25. Hadji M, Rashidian H, Marzban M, Gholipour M, Naghibzadeh-Tahami A, Mohebbi E, et al. The Iranian study of opium and cancer (IROPICAN): rationale, design, and initial findings. Arch Iran Med. 2021;24(3):167–76.
26. Eghtesad S, Hekmatdoost A, Faramarzi E, Homayounfar R, Sharafkhah M, Hakimi H, et al. Validity and reproducibility of a food frequency questionnaire assessing food group intake in the PERSIAN cohort study. Front Nutr. 2023;10:1059870.
27. Poustchi H, Eghtesad S, Kamangar F, Etemadi A, Keshtkar AA, Hekmatdoost A, et al. Prospective epidemiological research studies in Iran (the PERSIAN cohort study): rationale, objectives, and design. Am J Epidemiol. 2018;187(4):647–55.
28. Haytowitz DB, Ahuja JKC, Wu X, Somanchi M, Nickle M, Nguyen QA, Haytowitz DB, Ahuja JKC, Wu X, Somanchi M, Nickle M et al. NgUSDA National Nutrient Database for Standard Reference. Human Nutrition Research. 2019.

29. Brennan P, Fortes C, Butler J, Agudo A, Benhamou S, Darby S, et al. A multicenter case–control study of diet and lung cancer among non-smokers. Cancer Causes Control. 2000;11:49–58.
30. De Stefani E, Ronco AL, Deneo-Pellegrini H, Correa P, Boffetta P, Acosta G, et al. Dietary patterns and risk of adenocarcinoma of the lung in males: a factor analysis in Uruguay. Nutr Cancer. 2011;63(5):699–706.
31. Kauppinen T, Toikkanen J, Pukkala E. From cross-tabulations to multipurpose exposure information systems: a new job-exposure matrix. Am J Ind Med. 1998;33(4):409–17.
32. Kauppinen T, Heikkilä P, Plato N, Woldbaek T, Lenvik K, Hansen J, et al. Construction of job-exposure matrices for the nordic occupational cancer study (NOCCA). Acta Oncol. 2009;48(5):791–800.
33. Schoufour JD, Kiefte-de Jong JC, Voortman T. Adherence to the 2015 Dutch dietary guidelines and risk of ten non-communicable diseases and mortality in the Rotterdam study. Ned Tijdschr Geneeskd. 2018;162.
34. Daniel CR, Cross AJ, Graubard BI, Hollenbeck AR, Park Y, Sinha R. Prospective investigation of poultry and fish intake in relation to cancer risk. Cancer Prev Res (Phila). 2011;4(11):1903–11.
35. Hashempour-Baltork F, Hosseini H, Houshiarrad A, Esmaeili M. Contamination of foods with arsenic and mercury in Iran: a comprehensive review. Environ Sci Pollut Res Int. 2019;26(25):25399–413.
36. Yan H, Jin X, Zhang C, Zhu C, He Y, Du X, et al. Associations between diet and incidence risk of lung cancer: a Mendelian randomization study. Front Nutr. 2023;10:1149317.
37. Xie Y, Qin J, Nan G, Huang S, Wang Z, Su Y. Coffee consumption and the risk of lung cancer: an updated meta-analysis of epidemiological studies. Eur J Clin Nutr. 2016;70(2):199–206.
38. Yang JJ, Yu D, Takata Y, Smith-Warner SA, Blot W, White E, et al. Dietary fat intake and lung cancer risk: a pooled analysis. J Clin Oncol. 2017;35(26):3055–64.
39. Behrens G, Gredner T, Stock C, Leitzmann MF, Brenner H, Mons U. Cancers due to excess weight, low physical activity, and unhealthy diet. Dtsch Arztebl Int. 2018;115(35–36):578–85.
40. Gilsing AM, Weijenberg MP, Goldbohm RA, Dagnelie PC, van den Brandt PA, Schouten LJ. Vegetarianism, low meat consumption and the risk of lung, postmenopausal breast and prostate cancer in a population-based cohort study. Eur J Clin Nutr. 2016;70(6):723–9.
41. Parra-Soto S, Ahumada D, Petermann-Rocha F, Boonpoor J, Gallegos JL, Anderson J, et al. Association of meat, vegetarian, pescatarian and fish-poultry diets with risk of 19 cancer sites and all cancer: findings from the UK biobank prospective cohort study and meta-analysis. BMC Med. 2022;20(1):79.

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