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LIFELONG VEGETARIANISM AND RISK OF BREAST CANCER: A POPULATION-BASED CASE-CONTROL STUDY AMONG SOUTH ASIAN MIGRANT WOMEN LIVING IN ENGLAND

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To investigate the role of lifelong vegetarianism on the aetiology of female breast cancer, we conducted a population-based case-control study among South Asian migrant women from the Indian subcontinent resident in England. A total of 240 South Asian breast cancer cases were identified from 2 cancer registries during 1995–1999. For each case, 2 age-matched South Asian controls were randomly selected from the age-sex register of the case practice. Lifelong vegetarians had a slight reduction, although not statistically significant, in the odds of breast cancer relative to lifelong meat-eaters, which persisted after adjustment for socio-demographic and reproductive variables [odds ratio (OR)=0.77; 95% confidence interval (CI)=0.50–1.18]. Analysis by food group revealed no linear trend in the odds of breast cancer with increasing consumption of meat (p=0.10) but the odds were higher for women in the top 75%. In contrast, there were strong inverse trends in the odds of breast cancer with increasing intake of vegetables (p=0.005), pulses (p=0.007) and fibre [non-starch polysaccharides, NSP (p=0.02)], with women in the highest 25% of intake of these foods having about 50% of the odds of those in the lowest ones. Adjustment for intake of vegetables and pulses reverted the odds of breast cancer in lifelong vegetarians relative to lifelong meat-eaters (OR=1.04; 95% CI=0.65–1.68) and attenuated the quartile-specific estimates for meat intake, whereas the inverse trends in the odds of breast cancer with intake of vegetables and pulses remained after adjustment for type of diet or meat intake. These findings suggest that lifelong vegetarianism may be associated with a reduction in the risk of breast cancer through its association with a higher intake of vegetables and pulses. Although it is not possible to exclude the possibility that lifelong meat abstention may also play a role, the findings provide evidence that a diet rich in vegetables and pulses, such as those typically found in South Asian diets, may be protective against this cancer.

Key words: *breast cancer; diet; vegetarianism; migrants; South Asians; England*

Migrant[1,2] and ecological[3] studies have supported the hypothesis that diet may play a role in the aetiology of female breast cancer. However, results from cohort and case-control studies have been inconsistent. Deficiencies in study design or inaccuracies of dietary assessment methods that introduce non-differential misclassification of exposure leading to relative risk estimates biased towards unity could have contributed to the conflicting results. In addition, a common difficulty in investigating relationships between dietary factors and breast cancer risks with case-control or cohort studies, especially if they are likely to be weak associations, is the relative homogeneity of the diet of Western populations where most such epidemiological studies have been carried out. South Asian populations such as those in India, Pakistan and Bangladesh are characterised by a large variability in dietary intakes with most of them influenced by strong religious and regional variations. Most Hindus do not eat any type of meat nor eggs but consume milk and its products, whereas Muslims are predominantly meat-eaters, although they do not consume pork. However, in contrast to Western vegetarians who usually stop meat consumption only in adult life, Hindus are vegetarians from early life. We report here findings on the role of lifelong vegetarianism in the aetiology of breast cancer from a population-based case-control study conducted among women of South Asian ethnicity who have migrated to England.

METHODS

The study was carried out in the catchment areas of the Thames and West Midlands population-based cancer registries, which cover some of the areas in England with the largest numbers of residents of South Asian origin.[4] Within each registry, we restricted, for logistic reasons, the study to health authorities with reasonable numbers of South Asian patients, that is, essentially those in Greater London, Birmingham, Coventry and Wolverhampton. The study began initially as a pilot in Greater London and was later extended to the other study areas. Thus, cases were identified through the Thames registry from December 1995 to March 1999 and through the West Midlands registry from July 1997 to May 1999. The study was approved by all relevant ethics committees.

Selection of cases and controls

Cases were women of South Asian ethnic origin, under 75 years, with a newly diagnosed breast cancer, who were born in the Indian subcontinent or in East Africa, resided in 1 of the study areas, were reported to the Thames and West Midlands cancer registries during the study period and were still alive at the time of reporting. Cases registered more than 2 years after diagnosis were excluded. For each case, 2 population-based controls, individually matched to the case on year of birth (within 5 years), were randomly selected from all South Asian female patients born in the Indian subcontinent or East Africa who were registered with the same general practitioner (GP) as the case at the time of diagnosis. Occasionally, a neighbouring GP practice was used if no eligible controls were available from the case GP's list. Cases and controls with a previous diagnosis of any cancer, suffering from conditions requiring strict diets (*e.g.*, insulin-dependent diabetes mellitus) or from mental or psychiatric disorders that would reduce the accuracy of the information elicited in an interview were excluded.

Since information on ethnicity and country of birth in cancer registry data or in GPs' lists was very incomplete, potential South Asian cases and controls were identified on the basis of their names and subsequent confirmation of ethnicity and country of birth was obtained from the GPs and the patients themselves. The validity of name analyses to identify people of South Asian ethnicity in Britain has been widely demonstrated.[5,6] After obtaining

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permission from her GP, a letter (in English and in the most likely language spoken by the subject) was sent to the woman explaining the aim of the study. To avoid motivation and recall biases, the study was described as a general survey on women's health and no mention was made of breast cancer. Failure in tracing a woman was only accepted after at least 2 home visits.

Cases and controls were interviewed at their home in English (48% of cases and 52% of controls) or in their mother tongue by trained interviewers. A structured questionnaire was developed to obtain data on socio-demographic, reproductive and general health variables. Dietary data were collected through a food-frequency questionnaire (FFQ) specifically designed for South Asian populations resident in England (see below). Although it was not always possible to keep the interviewers blind to the case-control status of the subjects throughout the whole interview, dietary questions were always completed before the section on general health. Measurements of weight, standing and sitting heights and hip and waist circumferences were taken at the end of the interview using standard procedures. The median time between case diagnosis and interview was 15 months (inter-quartile range: 12–19 months). For each matched triplet, events that occurred after the date on which the corresponding case was diagnosed were excluded from the analysis.

Food-frequency questionnaire (FFQ)

The interviewer-administered FFQ was developed to assess the habitual dietary intake of the participants 2–3 years prior to an interview. The development of this FFQ has been described in detail elsewhere.[7] Briefly, the FFQ was organised in sections according to food groups. The foods/dishes included were those that covered the range consumed by the various South Asian ethnic subgroups and were likely to contribute to inter-individual variation in energy and macronutrient intake.[7] The FFQ included 24 questions on meat dishes, 40 questions on vegetables, 21 on pulses, lentils and dhals and 23 on fruits. Frequency of consumption was ascertained by asking women how often they ate the particular quantity of food per day/week/month or never. For seasonal foods, such as mangoes, women were asked to estimate their average intake when the food was in season. Portion sizes were estimated on the basis of "natural" units (*e.g.*, 1 egg), or by asking the women to select from previously validated sets of 8 colour photographs that represent different portion sizes[8,9] or by using average portion sizes derived from published sources.[10–13] Additional questions ascertained the main eating habits (*e.g.*, consumption of alcohol, meat and fish and type of fat used in cooking) and changes throughout life. Nutrient intakes were computed on the basis of the frequency of consumption of each unit of food and nutrient content of the specified portions. Data on the nutrient composition of traditional South Asian foods/dishes were available from recent publications.[14–16] Nutrient analyses were conducted in COMP-EAT.[17]

This FFQ was validated against the average of 12 monthly 24 hr dietary recalls collected from each of a subset of 100 controls who participated in the present case-control study (Sevak et al., personal communication). The agreement between the 2 methods was 100% for type of diet (vegetarian/meat-eater) and high for food and nutrient intake. The percentage of women classified in the same $\pm$ 1 quartile by the 2 methods was 74% for total energy and 85%, 85%, 96% and 90% for energy-adjusted fat, carbohydrates, proteins and non-starch polysaccharides (NSP), respectively. Spearman correlation coefficients for total energy and energy-adjusted fat, carbohydrates, protein and NSP, were 0.45, 0.59, 0.56, 0.76 and 0.71, respectively. Similar results were observed for vegetarians and meat-eaters. The percentage of vegetarians who were classified in the same $\pm$1 quartile by the 2 methods was 69%, 90%, 90%, 96% and 87% for total energy, total fat, carbohydrates, proteins and NSP, respectively. The equivalent figures for meat-eaters were 79%, 79%, 79%, 96% and 94%, respectively.

Statistical methods

Conditional logistic regression models,[18] with each case and her 2 age- and GP-matched controls being identified in a common set, were used to analyse the data, taking into account potential confounding variables. Nutrient intake, independent of total energy intake, was estimated by using the residuals of the regression of the nutrient on total energy intake (both on a logarithmic scale due to heteroscedasticity of residuals on an untransformed scale).[19] Quartiles of food consumption and nutrient residuals were defined according to the distribution in the controls. The cut-off points that define the energy-adjusted nutrient quartiles shown in the tables correspond to the nutrient range at 1,826 kcal, the median energy intake in controls. Tests for trend in the odds of breast cancer with food/nutrient quartiles were based on the likelihood-ratio test between the models with and without a linear term for food/nutrient's quartiles. To correct attenuation of the odds ratios due to non-differential errors in the measurement of nutrient intakes by the FFQ, corrected odds ratios were calculated using the linear approximation method of regressing 24 hr recall quartile scores on FFQ quartile scores in the validation study.[19,20]

RESULTS

After excluding potential South Asian female breast cancer cases who were found not to be South Asian or not to have been born in the Indian subcontinent or East Africa (77), those who had died (51) or those who did not fulfil the eligibility criteria (23), there were 352 potentially eligible cases. Forty-nine were excluded because the patients and/or their GPs could not be traced. Of those traced, 62 were excluded because the patients or their GPs declined to participate and for 1, it was not possible to obtain appropriate controls. Thus, a total of 240 cases were included in the study, a response rate of 79% among South Asian cases who could be traced. Of the 480 eligible controls initially identified, 365 agreed to participate, which was a response rate of 76%. Second selected controls were interviewed to replace those initially selected who refused to participate. For 3 cases it was only possible to obtain 1 matched control.

Cases and controls had, as expected, similar ages at the time of diagnosis of the cases (matching variable) (Table I). There was no difference between cases and controls in time since migration to the United Kingdom but cases were more likely to have come from Pakistan. Relative to the controls cases had, on average, a higher educational level and a higher current social class, had a younger age at menarche, were older when their first child was born, were less likely to have ever breastfed but more likely to have a positive family history of breast cancer and parents who were first-degree relatives. Only 8.3% of cases and 6.5% of controls reported any intake of alcohol. There were no differences between cases and controls in relation to adult height, current body mass index (BMI), current waist:hip ratio and use of oral contraceptives or hormone replacement therapy.

Lifelong vegetarianism was associated with a slight, although not statistically significant, reduction in the odds of breast cancer relative to lifelong meat-eaters, which persisted after adjusting for socio-demographic and reproductive variables (Table II). Further adjustment for height, current BMI and use of oral contraceptives and hormone replacement therapy did not affect these results. The point estimates for women who changed from being vegetarians to being meat-eaters, or vice-versa, were based on small numbers. There was no evidence of a linear trend in the odds of breast cancer with increasing intake of meat dishes among current meat-eaters (p=0.23), although the odds were higher for the top 75% (Table III). Meat dishes contain meat and varying proportions of vegetables and staples but repetition of the analyses using total meat intake, as estimated from recipe information, gave similar results (p=0.18 for linear trend).

Lifelong vegetarians differed from meat-eaters not only in terms of meat consumption but also in their intake of vegetables and

TABLE I – DISTRIBUTION OF CASES AND CONTROLS BY SOCIO-DEMOGRAPHIC AND REPRODUCTIVE CHARACTERISTICS

		Cases n = 240	Controls n = 477	p-value for heterogeneity
		Numbers (%) unless stated otherwise		
Socio-demographic characteristics				
Age at case's diagnosis	(mean (SD))	51.45 (9.0)	51.87 (9.2)	—
Region/religion of origin	Pakistani Muslim	57 (23.8)	83 (17.4)	0.01
	Gujerati Hindu	73 (30.4)	177 (37.1)	
	Punjabi Sikh	58 (24.2)	105 (22.0)	
	Bangladeshi Muslim	6 (2.5)	30 (6.3)	
	Punjabi Hindu	18 (7.5)	54 (11.3)	
	Other[1]	28 (11.7)	28 (5.9)	
Current household social class[2]	Non-manual	147 (61.3)	252 (52.8)	0.01
	Manual	86 (35.8)	214 (44.9)	
	Unclassified[3]	7 (2.9)	11 (2.3)	
Years of formal education	Median (inter-quartile range)	10 (7–13)	10 (5–13)	0.04
Years in the UK	Mean (SD)	23.7 (8.4)	23.2 (8.6)	0.64
Reproductive-related characteristics				
Age at menarche	Mean (SD)	13.6 (1.8)	13.8 (1.7)	0.10
Age at first full-term birth[4]	Mean (SD)	24.1 (4.9)	23.5 (4.5)	0.11
Parity	Mean (SD)	3.0 (1.8)	3.2 (2.0)	0.13
Family history of breast cancer	%	6.3	3.8	0.08
% post-menopausal	%	57.9	52.0	0.11
Years since menopause[5]	Median (inter-quartile range)	6.7 (3.1–14.7)	9.2 (4.5–14.5)	0.14
% who breastfed[4]	%	74.1	80.4	0.04
Parents who were first-degree relatives	%	9.6	8.0	0.37

[1]Includes Gujerati Muslims, East African Ismaili Muslims and Bengali Hindus.–[2]Measured as either the social class of the woman or of her partner, whichever was the highest.–[3]Includes work in the armed forces, unemployed and missing information on occupation.–[4]Parous women only (n = 672).–[5]Post-menopausal women only.

TABLE II – ODDS RATIOS (AND 95% CONFIDENCE INTERVALS) FOR BREAST CANCER BY DIETARY GROUP

Adjusted for age at case's diagnosis (through matching) and the following potential confounders[1]	Life-long meat-eater	Meat-eater in childhood, vegetarian in adulthood	Vegetarian during childhood, meat-eater in adulthood	Life-long vegetarians
		OR (95% CI)	OR (95% CI)	OR (95% CI)
Number of cases/controls	134/247	16/32	10/17	79/179
—	1	0.86 (0.43, 1.73)	0.89 (0.36, 2.23)	0.77 (0.53, 1.13)
Age at menarche	1	0.86 (0.43, 1.75)	0.92 (0.37, 2.32)	0.81 (0.55, 1.19)
Age at first full-term birth	1	0.82 (0.41, 1.66)	0.83 (0.33, 2.10)	0.76 (0.51, 1.13)
Parity	1	0.84 (0.42, 1.68)	0.93 (0.37, 2.31)	0.74 (0.50, 1.09)
Family history of breast cancer	1	0.83 (0.41, 1.68)	0.90 (0.36, 2.27)	0.77 (0.52, 1.13)
Menopausal status and years since menopause	1	0.85 (0.42, 1.72)	0.96 (0.38, 2.43)	0.76 (0.52, 1.12)
Ever breast-fed	1	0.80 (0.40, 1.62)	0.81 (0.32, 2.03)	0.74 (0.50, 1.09)
Adult socio-economic group	1	0.79 (0.39, 1.61)	0.96 (0.38, 2.46)	0.83 (0.56, 1.24)
Years of education	1	0.91 (0.45, 1.83)	0.92 (0.37, 2.30)	0.77 (0.52, 1.13)
Years in the UK	1	0.83 (0.41, 1.69)	0.87 (0.35, 2.19)	0.77 (0.53, 1.13)
Adjusted for all of the above variables	1	0.66 (0.31, 1.44)	0.84 (0.31, 2.26)	0.77 (0.50, 1.19)

[1]Categorisation of the potential confounders are as follows: age at menarche: <13, 13, 14, ≥15 years; age at first birth: <20, 20–24, 25–29, ≥30 years; parity: 0, 1–2, 3–4, ≥5; family history of breast cancer: yes/no; menopausal status: pre/peri/post; time since menopause: <5 years, 5–9, 10–14, ≥15 years; ever breast-fed: yes/no; adult socio-economic group: measured as either the social class of the woman or of her partner, whichever was the highest; years of formal education: 0, 1–7, 8–13, ≥14; years in the UK: continuous.

fruits. Among controls lifelong vegetarians had a much higher median daily intake of vegetables (332 g *vs.* 249 g) and pulses, lentils and dhals (92 g *vs.* 46 gr.) than meat-eaters but similar consumption of fruit (1.6 servings *vs.* 1.6 servings) and bread (184 g *vs.* 175 g). Analysis by food groups (Table III) exhibited strong inverse linear trends in the odds of breast cancer with increasing intake of vegetables (p=0.005) and pulses (p=0.007) but no clear trend with increasing intake of breads or fruits.

There were no associations between intakes of total energy, fat, protein and carbohydrates and the odds of breast cancer (Table IV). In contrast, there was a strong inverse association between the odds of this cancer and intake of NSP (p=0.02 for linear trend) with women in the highest 25% having only 61% of the odds of those in the lowest 1 (Table IV). This linear trend corresponded to an odds ratio (OR) of 0.83 [95% confidence interval (CI)=0.70–0.98; p=0.02] per unit increase in NSP quartile. After correcting for non-differential exposure measurement errors associated with the FFQ, the OR became stronger (corrected OR per unit increase in NSP quartile=0.75; 95% CI= 0.59–0.97; p=0.03). There was a marginal statistically significant inverse linear trend in the odds of breast cancer with intake of NSP from vegetables and pulses, but not from cereals or fruits, after adjusting for total energy intake and mutually for each other (Table IV). Among controls, the mean daily intake of NSP was 23.3 g/day (SD=6.8) in vegetarians and 19.3 g/day (6.6) in meat-eaters; these values corresponded to a mean of 11.9 g/1,000 kcal (1.9) and 10.4 g/1,000 kcal (1.9), respectively. The effect of NSP on breast cancer was, however, similar among vegetarians and meat-eaters (test for interaction p=0.47), with vegetarians in the top 25% of NSP intake having only 62% (95% CI=0.26–1.49) of the odds of those in the bottom 25%. Similarly, meat-eaters in the top 25% of NSP intake had only 47% (95% CI=0.24–0.95) of the odds of those in the lowest 25%.

To assess whether the reduction in risk among vegetarians relative to meat-eaters was due to abstinence from meat or to higher intake of vegetables and pulses, 2 separate models were fitted. First, when both type of diet and intake of vegetables and pulses were included in the same model, the odds of breast cancer in lifelong vegetarians relative to lifelong meat-eaters was atten-

TABLE III – ODDS RATIO FOR BREAST CANCER BY INTAKE OF SELECTED FOODS

Food groups	Quartile	Range	OR[1]	95% CI	LRT for linear trend: *p*-value
Meat and meat dishes (servings/week)	Vegetarian	0	0.87	0.48, 1.59	0.10[2]
	1	0.1–2.5	1		
	2	2.6–4.8	1.45	0.75, 2.81	
	3	4.9–6.9	1.52	0.78, 2.95	
	4	≥7.0	1.59	0.79, 3.21	
Breads (g/day)	1	<132	1		0.41
	2	132–184	0.75	0.45, 1.22	
	3	185–264	1.14	0.70, 1.87	
	4	≥265	0.62	0.38, 1.14	
Vegetable dishes (g/day)	1	<210	1		0.005
	2	210–299	0.71	0.44, 1.16	
	3	300–405	0.52	0.31, 0.87	
	4	≥406	0.48	0.27, 0.85	
Pulses, lentils and dhals (g/day)	1	<35.0	1		0.007
	2	35.0–67.5	0.96	0.61, 1.52	
	3	67.6–107.3	0.58	0.35, 0.97	
	4	≥107.4	0.54	0.31, 0.94	
Fruit (servings/day)	1	<0.89	1		0.45
	2	0.89–1.61	1.17	0.72, 1.92	
	3	1.62–2.49	0.97	0.51, 1.47	
	4	≥2.50	0.89	0.50, 1.57	

[1]Odds ratio (OR) adjusted for total energy intake, age at menarche (<13, 13, 14, ≥15 years), age at first birth (<20, 20–24, 25–29, ≥30 years), parous (yes/no), parity (1–2, 3–4, ≥5), breast feeding (never/ever), family history of breast cancer (yes/no), menopausal status (pre/peri/post), time since menopause (<5 years, 5–9, 10–14, ≥15 years) and years of formal education (0, 1–7, 8–13, ≥14).–[2]*p*-value for heterogeneity.

uated (from 0.77 to 1.04), whereas the magnitude of the quartile-specific estimates for vegetables and pulses was little affected and the tests for trend remained of borderline statistical significance (Table V, model A). Second, when both meat intake and intake of vegetables and pulses were included in the same model, the quartile-specific estimates for meat were attenuated, whereas the trend in the odds of breast cancer with intake of vegetables and pulses persisted, although they were no longer statistically significant (Table V, model B).

Because a lifelong type of diet may be a marker of acculturation or other lifestyle habits that are causally associated with breast cancer, we examined the association between type of diet and breast cancer stratified by whether or not they migrated to Britain via East Africa, age at migration and main language spoken at home. The effect of lifelong vegetarianism on breast cancer was slightly stronger among women who migrated to the UK *via* East Africa (OR=0.50; 95% CI=0.11–2.22) than in those who came directly to the UK (OR=0.85; 0.37–1.95), although the test for interaction was not significant (p=0.51) but was similar in women who migrated to the UK when they were under 25 years of age (the median age at migration) and in those who migrated later in life (p for interaction=0.59) and in women who predominantly spoke English at home relative to those who used their mother tongue (test for interaction p=0.52). There was also no evidence that the effect of lifelong vegetarianism was modified by menopausal status (p=0.17), but the power was limited, or by time from diagnosis to interview of the cases (p=0.61).

DISCUSSION

This is the first study of breast cancer among South Asian first-generation migrant women resident in England and 1 of the few to examine the role of lifelong vegetarianism. One of the strengths of the study derives from the use of population-based controls. Despite this there is still potential for selection bias for various reasons. First, cases were identified from population-based cancer registries to ensure reasonable numbers but case ascertainment by registries was probably incomplete. To minimise possible bias, cases and controls were matched on GP to ensure as much as possible that had a control been diagnosed with breast cancer, she would have had a similar probability as her matched case of being entered into the cancer registry files. In addition, there were delays between diagnosis and registration, with some cases dying before registration or before it was logistically possible to organise a home interview. Examination of breast cancer risks by time since diagnosis did not suggest, however, that the observed associations between dietary factors and breast cancer were due to an underlying association between diet and survival. Second, selection bias might have been introduced even though the response rate among both cases and controls can be regarded as high for a population-based study, but examination of the few variables available from the cancer registration data indicated that untraceable and non-responders were similar to the participants in terms of their age, area of residence and stage. Third, as migrants with similar religious and social origins tend to concentrate in certain geographical areas and controls were selected from the same GP practices as the cases there is a possibility of overmatching, that is, of both groups having similar religious and socio-economic backgrounds and, hence, similar diets. This effect is unlikely to be strong and, if present, would bias odds ratios towards unity. It is reassuring, however, that the distribution of the controls by ethnic origin was similar to that that would have been expected on the basis of the 1991 Census.[4] The observed/expected percentages were 77%/78%, 18%/14% and 6%/9% for Indians, Pakistanis and Bangladeshis, respectively.

Diet plays an important social role in South Asian populations and is largely determined by strong religious and regional influences. Diet and its recall may, therefore, be less influenced by a recent diagnosis of breast cancer than in other populations. Although FFQs are the only feasible method of assessing past dietary intake in case-control studies, there have been concerns with regard to their validity. In particular, it has been argued that the protective effect of fibre observed in some studies could be due to the fact that FFQs usually include a long list of vegetables and fruits that lead to over-reporting of consumption. The findings in the present study did not change when non-differential exposure measurement errors introduced by the FFQ were corrected in relation to an average of 12 monthly 24 hr recalls collected from a subset of the controls. Twenty-four hour recalls agree surprisingly well with weighed records and food diaries[21,22] and multiple 24 hr recalls have been widely used as the reference method in FFQ validation studies[23] but their sources of error may not be

TABLE IV – ODDS RATIOS FOR BREAST CANCER BY INTAKE OF MACRONUTRIENTS AND INTAKE OF NSP FROM DIFFERENT SOURCES

Macronutrients	Quartile	Range[1]	OR (*p*-value for linear trend)	95% CI	Adjusted OR[2] (*p*-value for linear trend)	95% CI
Energy (kcal/day)	1	<1557	1		1	
	2	1557, 1890	1.04	0.67, 1.59	1.12	0.71, 1.77
	3	1891, 2224	1.03	0.65, 1.62	0.96	0.59, 1.56
	4	≥2225	0.99	0.62, 1.58	0.84	0.51, 1.40
			(p = 0.97)		(p = 0.94)	
Fat[3] (g/day)	1	<71	1		1	
	2	71–78	0.90	0.58, 1.40	0.87	0.55, 1.38
	3	79–86	1.02	0.66, 1.58	1.05	0.65, 1.68
	4	≥87	0.76	0.47, 1.24	0.72	0.42, 1.21
			(p = 0.41)		(p = 0.36)	
Protein[3] (g/day)	1	<50	1		1	
	2	50–56	2.07	1.25, 3.41	1.90	1.10, 3.28
	3	57–63	1.59	0.96, 2.63	1.61	0.94, 2.76
	4	≥64	1.07	0.62, 1.85	1.17	0.64, 2.13
			(p = 0.85)		(p = 0.79)	
Carbohydrates[3] (g/day)	1	<220	1		1	
	2	220–238	1.25	0.80, 1.95	1.15	0.72, 1.83
	3	239–254	1.10	0.69, 1.77	1.09	0.65, 1.82
	4	≥255	1.26	0.78, 2.02	1.28	0.77, 2.10
			(p = 0.46)		(p = 0.39)	
NSP[3] (g/day)	1	<17.6	1		1	
	2	17.6–20.4	0.84	0.55, 1.29	0.90	0.56, 1.43
	3	20.5–23.2	0.61	0.38, 0.97	0.60	0.36, 1.00
	4	≥23.3	0.54	0.34, 0.88	0.61	0.36, 1.02
			(p = 0.005)		(p = 0.02)	
NSP from different sources, adjusted for the other 3 NSP sources						
NSP from cereals[3,4] (g/day)	1	<6.7	1		1	
	2	6.7–9.3	1.16	0.76, 1.76	1.15	0.72, 1.85
	3	9.4–11.7	0.48	0.29, 0.78	0.48	0.28, 0.83
	4	≥11.8	0.66	0.41, 1.07	0.87	0.51, 1.49
			(p = 0.006)		(p = 0.10)	
NSP from pulses[3,4] (g/day)	1	<0.9	1		1	
	2	0.9–1.6	1.39	0.88, 2.18	1.18	0.73, 1.91
	3	1.7–2.5	0.91	0.56, 1.48	0.78	0.46, 1.32
	4	≥2.6	0.74	0.45, 1.25	0.66	0.38, 1.15
			(p = 0.10)		(p = 0.06)	
NSP from vegetables[3,4] (g/day)	1	<4.2	1		1	
	2	4.2–5.7	0.91	0.59, 1.39	0.78	0.49, 1.23
	3	5.8–7.4	0.82	0.52, 1.29	0.67	0.41, 1.09
	4	≥7.5	0.67	0.41, 1.11	0.66	0.39, 1.11
			(p = 0.11)		(p = 0.09)	
NSP from fruit[3,4] (g/day)	1	<1.4	1		1	
	2	1.4–2.3	0.84	0.44, 1.63	0.80	0.48, 1.33
	3	2.4–3.5	0.64	0.27, 1.47	0.61	0.36, 1.02
	4	≥3.6	0.97	0.32, 2.92	1.05	0.62, 1.78
			(p = 0.98)		(p = 0.80)	

[1]The nutrient range for each energy-adjusted nutrient quartile corresponds to the appropriate range at the median energy intake in controls of 1826 kcal.–[2]Odds ratio (OR) adjusted for age at menarche (<13, 13, 14, ≥15 years), age at first birth (<20, 20–24, 25–29, ≥30 years), parous (yes/no), parity (1–2, 3–4, ≥5), breast feeding (never/ever), family history of breast cancer (yes/no), menopausal status (pre/peri/post), time since menopause (<5 years, 5–9, 10–14, ≥15 years) and years of formal education (0, 1–7, 8–13, ≥14).–[3]Quartiles of nutrient residuals from regression of nutrient on total energy (both on a log scale).–[4]Each quartile of residual of NSP source is adjusted for total energy and the other 3 NSP sources.

totally independent since both methods rely on memory. The mean intake of vegetables and fruits among South Asians in our study were, however, similar to those reported by others that used different dietary assessment methods.[13,24] After controlling for known breast cancer risk factors, the results were virtually identical to the age-adjusted relative risks, suggesting that residual confounding by known lifestyle factors is unlikely to explain the findings. We cannot exclude unknown lifestyle factors, but they would need to be predictors of breast cancer and also associated with type of diet and intake of vegetables and pulses.

The present study found no clear association between meat intake and breast cancer risk. This finding is consistent with results from a hospital-based case-control study carried out in Bombay (India).[25] It is also consistent with findings from large follow-up studies of Western vegetarians and religious groups who tend to abstain from meat.[26–30] In these studies, however, most subjects cease meat consumption in adult life and therefore it was not possible to exclude the possibility that meat intake might play a role in the causation of breast cancer if pre-adult life is a more critical period. In contrast, the dietary habits of South Asian populations are adopted very early in life and therefore our findings seem to exclude that possibility.

Our study showed that high intakes of vegetables and pulses were associated with protection against breast cancer and that this could potentially account for the reduced breast cancer risk observed among vegetarians. A similar protective effect for vegetable consumption was found in a meta-analysis of 14 case-control and 3 cohort studies.[31] No protective effect was found in a pooled

TABLE V – ODDS RATIOS FOR BREAST CANCER BY DIETARY GROUP AND SERVINGS OF MEAT PER WEEK, ADJUSTED FOR VEGETABLE AND PULSE CONSUMPTION

	Odds ratio[1]	95% CI		Odds ratio[1]	95% CI
Adjusted for breast cancer risk factors only					
Dietary group			Meat and meat dishes (servings/week)		
Life-long meat-eater	1		0	0.87	0.48, 1.59
Was meat eater, now vegetarian	0.68	0.32, 1.45	0.1–2.5	1	
Was vegetarian, now meat-eater	0.86	0.32, 2.30	2.6–4.8	1.45	0.75, 2.81
Life-long vegetarian	0.77	0.50, 1.18	4.9–6.9	1.52	0.78, 2.95
	($p = 0.57$[2])		≥7.0	1.59	0.79, 3.21
				($p = 0.10$[2])	
Adjusted for breast cancer risk factors and for the other two dietary variables					
	Model A			Model B	
Dietary group			Meat and meat dishes (servings/week)		
Life-long meat-eater	1		0	0.95	0.51, 1.77
Was meat eater, now vegetarian	0.85	0.39, 1.88	0.1–2.5	1	
Was vegetarian, now meat-eater	0.94	0.34, 2.62	2.6–4.8	1.28	0.65, 2.52
Life-long vegetarian	1.04	0.65, 1.68	4.9–6.9	1.35	0.68, 2.66
	($p = 0.97$[2])		≥7.0	1.25	0.60, 2.60
				($p = 0.72$[2])	
Vegetable dishes (g/day)			Vegetable dishes (g/day)		
<210	1		<210	1	
210–299	0.80	0.49, 1.30	210–299	0.77	0.47, 1.27
300–405	0.60	0.35, 1.04	300–405	0.62	0.36, 1.08
≥406	0.64	0.36, 1.12	≥406	0.61	0.33, 2.60
	($p = 0.07$[3])			($p = 0.08$[3])	
Pulses, lentils, dhals (g/day)			Pulses, lentils, dhals (g/day)		
<35.0	1		<35.0	1	
35.0–67.5	0.98	0.61, 1.58	35.0–67.5	0.98	0.61, 1.57
67.6–107.3	0.62	0.36, 1.07	67.6–107.3	0.68	0.40, 1.17
≥107.4	0.64	0.36, 1.15	≥107.4	0.68	0.37, 1.24
	($p = 0.06$[3])			($p = 0.11$[3])	

[1]Odds ratio (OR) adjusted for total energy intake, age at menarche (<13, 13, 14, ≥15 years), age at first birth (<20, 20–24, 25–29, ≥30 years), parous (yes/no), parity (1–2, 3–4, ≥5), breast feeding (never/ever), family history of breast cancer (yes/no), menopausal status (pre-/peri-/post-), time since menopause (<5 years, 5–9, 10–14, ≥15 years) and years of formal education (0, 1–7, 8–13, ≥14).–[2]*p*-value for heterogeneity.–[3]*p*-value for linear trend.

analysis of data from 7 cohorts[32] but, in some, ascertainment of fruit and vegetable intake[33,34] was poor. Moreover, 2 of the cohorts included in this analysis have since reported protective effects for vegetable intake. The inverse trend between NSP intake (a marker of fruit and vegetable consumption) and the odds of breast cancer observed in the present study is also consistent with that from a meta-analysis of case-control studies,[35] which reported a weak, but statistically significant, protective association. Several recent studies, not included in the meta-analysis, have found similar statistically significant protective associations with various components of fibre,[36–38] crude fibre[39] and fibre from vegetables and fruit, but not cereals.[40] No association between total dietary fibre intake and subsequent incidence of breast cancer was reported by 2 prospective studies conducted in the US,[41,42] but a weak protective effect was found in a prospective study conducted in Canada.[43] Intake of vegetables in Western countries is lower than in South Asian populations. The median intake of total vegetables, including pulses, among the controls in our study was 355 g/day, much higher than in the cohorts included in the pooled analysis (range: 77–226 g/day[32]). Thus, the lower intake of vegetables and dietary fibre might have reduced the likelihood of finding associations in studies conducted among Western populations. The type of vegetables typically found in South Asian diets is also different from those found in Western diets with a greater preponderance of pulses.

In short, the findings from the present study seem to suggest that lifelong vegetarianism may be associated with a reduction in the risk of breast cancer through its association with a higher intake of vegetables and pulses. Although it is not possible to exclude the possibility that meat abstention may also play a role, the findings provide evidence that a lifelong diet rich in vegetables, such as those typically found in South Asians diets, may be protective against this cancer. Further studies in these populations will help to identify the precise foods and nutrients associated with this protective effect. In the meantime, these findings suggest that women with a diet rich in vegetables may be protecting themselves not only in relation to cardiovascular diseases[44] and other (mainly digestive) cancers[45] but also in relation to breast cancer.

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