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Nutrition and Cancer

Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/hnuc20>

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Published online: 18 Nov 2009.

To cite this article: Jianjun Zhang , Zijin Zhao & Hans J. Berkel (2003) Egg Consumption and Mortality From Colon and Rectal Cancers: An Ecological Study, Nutrition and Cancer, 46:2, 158-165, DOI: [10.1207/S15327914NC4602_08](https://doi.org/10.1207/S15327914NC4602_08)

To link to this article: http://dx.doi.org/10.1207/S15327914NC4602_08

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Egg Consumption and Mortality From Colon and Rectal Cancers: An Ecological Study

Jianjun Zhang, Zijin Zhao, and Hans J. Berkel

Abstract: *The relation between egg consumption and mortality from colon and rectal cancers remains unclear and was investigated in this study. Colon and rectal cancer mortality data, mostly around 1993–94 and egg consumption data in nine time periods (1964–94) in 34 countries were derived from World Health Organization and Food and Agriculture Organization, respectively. Egg consumption was significantly and positively correlated with mortality from colon and rectal cancers in both sexes in most of the nine time periods. The correlations were generally stronger for colon cancer ($r = 0.39$ to 0.63 in men and $r = 0.33$ to 0.65 in women) than for rectal cancer ($r = 0.18$ to 0.49 in men and $r = 0.08$ to 0.45 in women). After adjustment for confounding factors, egg consumption was still significantly and positively associated with mortality from colon cancer in the earliest five time periods (1964–84) ($P = 0.046$ to 0.017 in men and $P = 0.034$ to 0.014 in women) and rectal cancer in the latest five time periods except for the last time period (1982–91) ($P = 0.046$ to 0.024 in men and $P = 0.045$ to 0.026 in women). This study suggested that egg consumption was associated with an increased risk of colon and rectal cancers at the population level.*

tions (11,12). Dietary intakes of cholesterol and fat have been associated with an increased risk of colon and rectal cancers in many epidemiological studies (6,7,13,14). Therefore, we hypothesized that egg intake may be involved in the etiology of colon and rectal cancers.

To date, little is known about the potential relation between egg consumption and the risk of colon and rectal cancers. Epidemiological studies that have examined this relation yielded inconsistent and controversial results (15,16). Positive, null, or inverse relations have been reported, although a positive, insignificant relation was found in most studies (15,16). The primary objective of the current study, using data on mortality from colon and rectal cancers from the latest available 3 yr and egg consumption data during nine time periods, was to investigate whether egg consumption is associated with the risk of cancers of the colon and rectum at the population level. Another objective of this study was to explore the temporal trends in this association over an extended period of 30 yr. To our knowledge, this is the first ecological study that focuses on clarifying the relation between egg consumption and colon and rectal cancers, which has important public health implications.

Introduction

Cancers of the colon and rectum are among the leading causes of cancer death in developed countries and are an emerging public health problem in developing countries (1). The International Agency for Research on Cancer (IARC) estimates that 498,754 men and 445,963 women receive diagnoses of colon or rectal cancer and 254,816 men and 237,595 women die from these diseases each year worldwide (2). A rapid increase in colon and rectal cancer incidence or mortality rates within a relatively short period of time among Asian immigrants to North America (3,4) and populations in Eastern European countries and Russia (1,5) suggests that environmental factors, especially nutrition, play a major role in the etiology of colon and rectal cancers (6–10). Eggs are frequently consumed and are a substantial source of cholesterol, protein, and fat intake, especially in Western popula-

Materials and Methods

Data Sources

Age- and sex-specific colon and rectal cancer mortality rates (per 100,000/yr) (International Classification of Disease, 9th revision, 093 for colon cancer and 094 for rectal cancer) in three age classes, 45–54, 55–64, and 65–74 yr, for the latest available 3 yr, mostly around 1993–94, were derived from the World Health Statistics Annual, World Health Organization (WHO) (1). The mortality rates were averaged over 3 yr to minimize random fluctuations in individual years and then age-standardized to 45–74 yr using the European Standard Population (1). The mortality rates analyzed in this study were truncated to 45–74 yr because only a small proportion of the patients with colon and rectal cancers occur outside this age range (1,5). The mortality data were obtained

from 34 countries, including eight countries of the Americas, 21 European countries, and five Western Pacific countries. The selection of the countries was based primarily on the availability of relatively reliable data on mortality from colon and rectal cancers and consumption of eggs, other food groups or nutrients, and cigarettes.

The data on consumption of eggs, fat, meat, vegetables, fruit, and alcohol during nine time periods (1964–66, 1969–71, 1974–76, 1979–81, 1982–84, 1984–86, 1987–89, 1989–91, and 1992–94) were obtained from the Food Balance Sheet, Food and Agriculture Organization (FAO) (11). Fat consumption is calculated as the sum of fat derived from all vegetal and animal food sources. Meat includes chicken but not fish. The food consumption data from FAO were obtained from the same 34 countries as the mortality data from WHO. The consumption of eggs, fat, meat, and alcohol was expressed

in percent of total energy (% E) because it has been reported that % E is more appropriate than absolute units for FAO food consumption data (17). However, in view of the fact that egg consumption is the focus of this study, data on the absolute amount of egg consumption (g/day) are also provided in Table 1. As vegetables and fruits are not a major source of energy intake, they are treated as g/day in this study. Cigarette consumption data in 1970, 1980, and 1990 were also taken from the WHO (18). Romania has missing data on cigarette consumption in 1970 and 1980, and only the data from 1990 were used for our analysis.

Statistical Analysis

The purposes of the statistical analyses in this study were to investigate whether egg consumption was associated with co-

Table 1. Egg, Fat, Meat, Vegetable, Fruit, and Alcohol Consumption, Mean of the Nine Periods (1964–94), Food Balance Sheets, FAO,^a and Cigarette Consumption, Mean of 1970, 1980, and 1990, WHO^{a,b}

Countries (<i>n</i> = 34)	Egg		Fat (% E)	Meat (% E)	Vegetable (g/day)	Fruit (g/day)	Alcohol (% E)	Cigarette (NAY ^a)
	(% E ^a)	(g/day)						
Israel	2.46	54	32.1	8.4	366	487	1.30	2,175
Japan	2.40	46	22.0	4.3	305	163	4.87	3,126
Hungary	1.94	48	34.2	12.6	237	202	6.49	3,054
Spain	1.86	40	34.0	9.5	395	328	6.25	2,453
Germany	1.80	42	36.7	12.0	192	306	8.43	2,371
USA	1.80	41	36.2	12.2	270	310	4.96	3,329
New Zealand	1.79	40	36.4	15.4	232	252	5.11	2,407
Sweden	1.64	34	36.8	8.9	138	237	4.59	1,773
Hong Kong	1.63	34	33.1	16.0	202	205	1.88	2,413
Austria	1.59	38	38.7	12.0	204	361	7.43	2,390
Canada	1.57	34	36.9	11.9	267	306	4.36	2,976
France	1.57	38	38.3	16.1	326	219	7.64	2,085
Denmark	1.56	38	43.9	18.5	174	182	6.24	1,923
UK	1.54	35	38.8	14.3	223	184	5.86	2,631
Netherlands	1.53	34	38.5	11.5	207	299	4.97	2,014
Belgium	1.50	36	38.6	9.8	253	256	6.97	2,413
Romania	1.40	30	25.2	7.3	338	151	5.03	1,752
Australia	1.34	29	33.0	16.7	187	255	5.61	3,011
Finland	1.30	28	37.1	14.3	106	213	4.79	1,771
Norway	1.29	29	38.4	9.6	147	257	2.76	841
Italy	1.29	31	33.5	9.9	435	357	5.66	2,066
Switzerland	1.29	31	40.4	15.8	233	360	6.09	3,407
Greece	1.24	30	33.7	7.5	560	505	3.27	3,123
Poland	1.22	30	29.1	9.6	304	92	3.36	3,323
Bulgaria	1.18	29	26.8	8.5	282	311	5.98	1,953
Ireland	1.15	29	34.0	11.8	173	173	4.97	2,549
Cuba	0.98	22	23.0	6.7	104	174	1.36	2,502
Venezuela	0.86	17	24.7	6.0	49	336	4.20	1,861
Costa Rica	0.86	17	21.5	4.5	56	255	2.45	1,428
Argentina	0.84	20	31.5	19.6	192	243	0.30	1,742
Colombia	0.81	15	19.2	7.3	106	247	2.29	1,237
Chile	0.78	16	20.7	8.2	237	174	3.94	1,269
Korea	0.76	17	13.2	3.8	424	119	7.78	2,645
Portugal	0.68	15	28.0	7.4	368	205	9.12	1,793
Mean	1.40	31	32.0	10.8	244	257	4.89	2,288
SD	0.44	10	7.2	4.1	113	92	2.12	646

a: Abbreviations are as follows: FAO, Food and Agriculture Organization; WHO, World Health Organization; % E, percentage of total energy; NAY, no./adult/yr.

b: Data shown are ranked by the descending order of egg consumption (% E).

Table 2. Sex-Specific Mortality Rates of Colon and Rectal Cancers (per 100,000/yr), Age-Standardized by the European Standard Population to 45–74 yr, Mean of the Latest Available 3 yr, Mostly Around 1993–94, WHO^a

Countries (<i>n</i> = 34)	Colon Cancer		Rectal Cancer	
	Men	Women	Men	Women
Hungary	52.2	33.4	42.9	20.0
New Zealand	49.5	40.4	32.5	16.4
Ireland	45.4	29.8	18.5	7.9
Australia	43.6	31.5	17.7	8.7
Austria	40.2	25.1	23.5	11.3
Denmark	39.6	35.1	24.6	14.5
Germany	38.4	27.6	20.4	11.8
USA	38.0	26.1	7.9	4.4
Netherlands	36.5	27.9	11.9	7.3
Israel	36.2	27.9	9.8	7.6
Belgium	35.7	25.7	13.3	6.5
UK	34.6	25.5	20.5	9.8
Canada	34.3	23.3	12.6	5.9
Norway	34.3	27.5	23.4	12.1
France	34.0	20.1	13.1	6.3
Switzerland	33.8	19.2	13.4	8.2
Portugal	31.9	20.1	16.9	8.1
Spain	31.1	20.1	12.0	6.4
Hong Kong	30.5	22.6	19.3	10.4
Argentina	29.7	19.4	8.3	4.7
Italy	28.5	18.9	15.0	8.4
Japan	27.3	18.7	20.1	9.0
Poland	23.6	16.3	27.0	16.3
Bulgaria	21.7	14.5	33.6	19.6
Cuba	20.7	24.9	4.8	5.7
Greece	19.0	14.5	2.8	2.1
Sweden	18.4	16.4	11.9	6.8
Romania	17.7	13.2	17.4	11.0
Finland	16.9	14.4	15.5	8.9
Chile	12.6	11.4	6.1	5.2
Costa Rica	12.2	13.5	4.8	3.3
Venezuela	11.2	11.4	4.2	3.7
Korea	10.3	7.5	10.4	6.8
Colombia	10.1	10.2	3.4	3.4
Mean	29.4	21.6	15.8	8.8
SD	11.5	7.8	9.0	4.4

a: Data shown are ranked by the descending order of male colon cancer mortality.

lon and rectal cancer mortality and, if so, whether these associations were similar for colon cancer and rectal cancers. To examine temporal trends in the potential associations between egg consumption and the risk of colon and rectal cancers, we conducted all analyses over nine time periods covering a span of approximately 30 yr. The Pearson correlation analysis was done between egg consumption and mortality from colon and rectal cancers. Multiple linear regression analysis was performed to examine whether egg consumption was independently associated with colon and rectal cancer mortality. Multivariate models were constructed with colon or rectal cancer mortality as a dependent variable and the consumption of total fat, meat, vegetables, fruit, alcohol, and cigarettes as independent variables. All independent variables were retained in the multivariate models regardless of their statistical significance levels. In the multivariate models, total fat, meat, vegetable, fruit, and alcohol consumption data were obtained from the same period as the egg consumption data. For cigarette consumption, the mean of the three time periods, 1970,

1980, and 1990, was calculated and fit into the models. Multiple determination coefficient (R^2), the quantity of which lies between 0 and 1, was used to measure the goodness of fit of a model, that is, what percentage of the variation in a dependent variable is explained by independent variables contained in the model (19). Because dietary factors usually are correlated with each other, the collinearity of covariates in logistic regression models was tested. No apparent collinearity existed in all established multivariate models.

All statistical analyses were performed using the statistical package SAS (The SAS Institute, Inc., Cary, NC), and statistical significance level was set at $P < 0.05$ (two-sided).

Results

Egg, fat, meat, vegetable, fruit, alcohol, and cigarette consumption data derived from 34 countries are shown in Table 1, and sex-specific mortality rates for colon and rectal can-

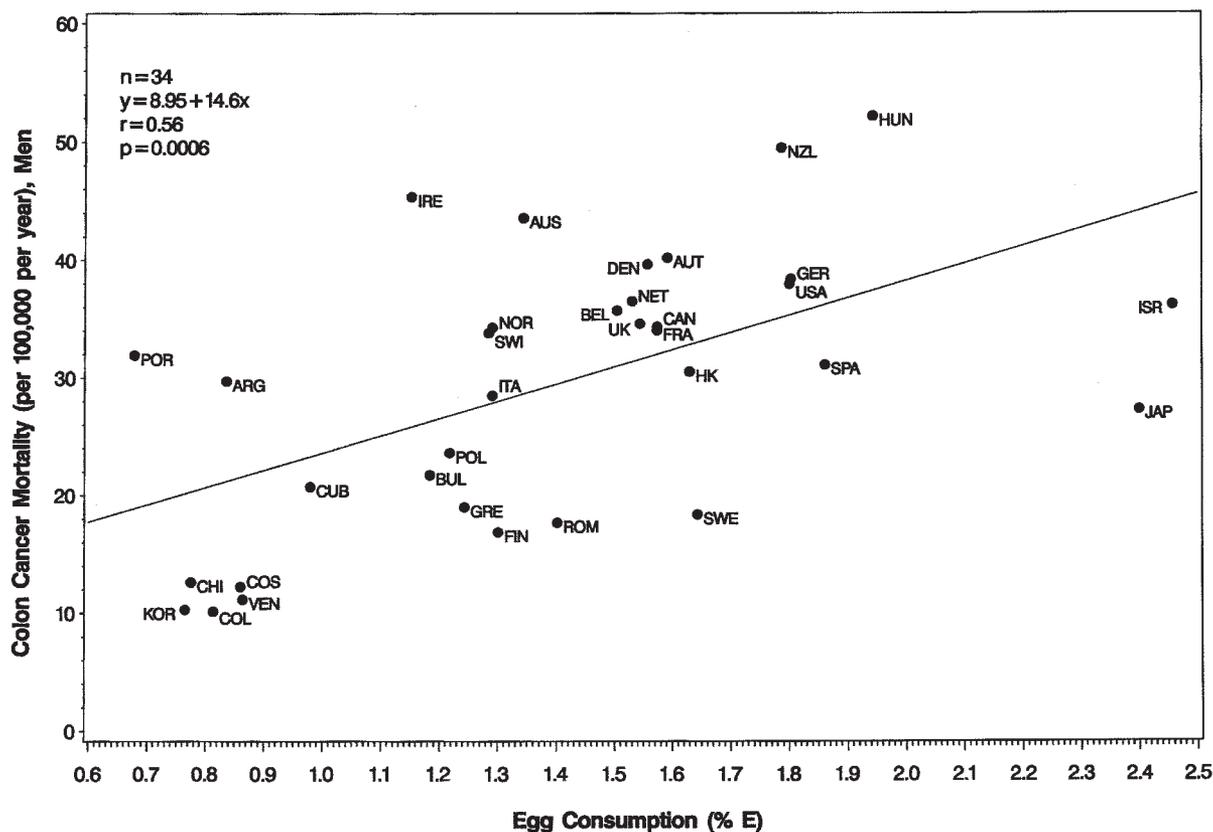


Figure 1. The Pearson correlation between egg consumption (% E), mean of nine periods (1964–94), and male colon cancer mortality, age-standardized by the European Standard population to 45–74 yr, mean of the latest 3 yr, mostly around 1993–94. % E, percentage of total energy; ARG, Argentina; AUS, Australia; AUT, Austria; BEL, Belgium; BUL, Bulgaria; CAN, Canada; CHI, Chile; COL, Colombia; COS, Costa Rica; CUB, Cuba; DEN, Denmark; FIN, Finland; FRA, France; GER, Germany; GRE, Greece; HK, Hong Kong; HUN, Hungary; IRE, Ireland; ISR, Israel; ITA, Italy; JAP, Japan; KOR, Korea; NET, Netherlands; NOR, Norway; NZL, New Zealand; POL, Poland; POR, Portugal; ROM, Romania; SPA, Spain; SWE, Sweden; SWI, Switzerland; UK, United Kingdom; USA, United States; VEN, Venezuela.

cers are presented in Table 2. Large differences in egg consumption and mortality from colon and rectal cancers existed among the populations compared. The correlation between mean egg consumption in the nine time periods and colon cancer mortality is displayed in Fig. 1 for men and Fig. 2 for women. A significant, positive correlation was found in both men ($r = 0.56$, $P = 0.0006$) and women ($r = 0.53$, $P = 0.0014$). Table 3 shows the Pearson correlation coefficients between egg consumption and mortality from colon and rectal cancers separately for the nine time periods in both sexes. Both colon and rectal cancers were positively correlated with egg consumption in all nine time periods, with most correlation coefficients being statistically significant. The correlation between egg consumption and colon cancer was generally stronger than the correlation between egg consumption and rectal cancer. The correlation coefficients ranged from 0.39 to 0.63 in men and from 0.33 to 0.65 in women for colon cancer and from 0.18 to 0.49 in men and from 0.08 to 0.45 in women for rectal cancer. The correlation coefficients between egg consumption and colon cancer mortality in the nine time periods were inversely correlated with the lag in time between egg consumption and mortality in both men ($r = -0.88$, $P = 0.002$) and women ($r = -0.92$, $P = 0.0004$), whereas the opposite results were observed for rectal cancer

($r = 0.95$, $P < 0.0001$ for men and $r = 0.95$, $P = 0.0001$ for women).

The results of multiple regression analysis are given in Table 4 for colon cancer and Table 5 for rectal cancer. The findings obtained from the correlation analysis generally were confirmed by the multiple regression analysis. After adjustment for fat, meat, vegetable, fruit, alcohol, and cigarette consumption, egg consumption was still significantly and positively associated with colon cancer mortality in the earliest five time periods (1964–84) ($P = 0.046$ to 0.017 in men and $P = 0.034$ to 0.014 in women). However, a positive association with rectal cancer mortality was only found in the latest five time periods except for the last period (1982–91) ($P = 0.046$ – 0.024 in men and $P = 0.045$ – 0.026 in women). The further adjustment for protein and milk consumption in all the analyses performed did not materially change the observed results.

Discussion

In the current study, we demonstrated that egg consumption was significantly and positively associated with mortality from colon and rectal cancers in both sexes in most of the

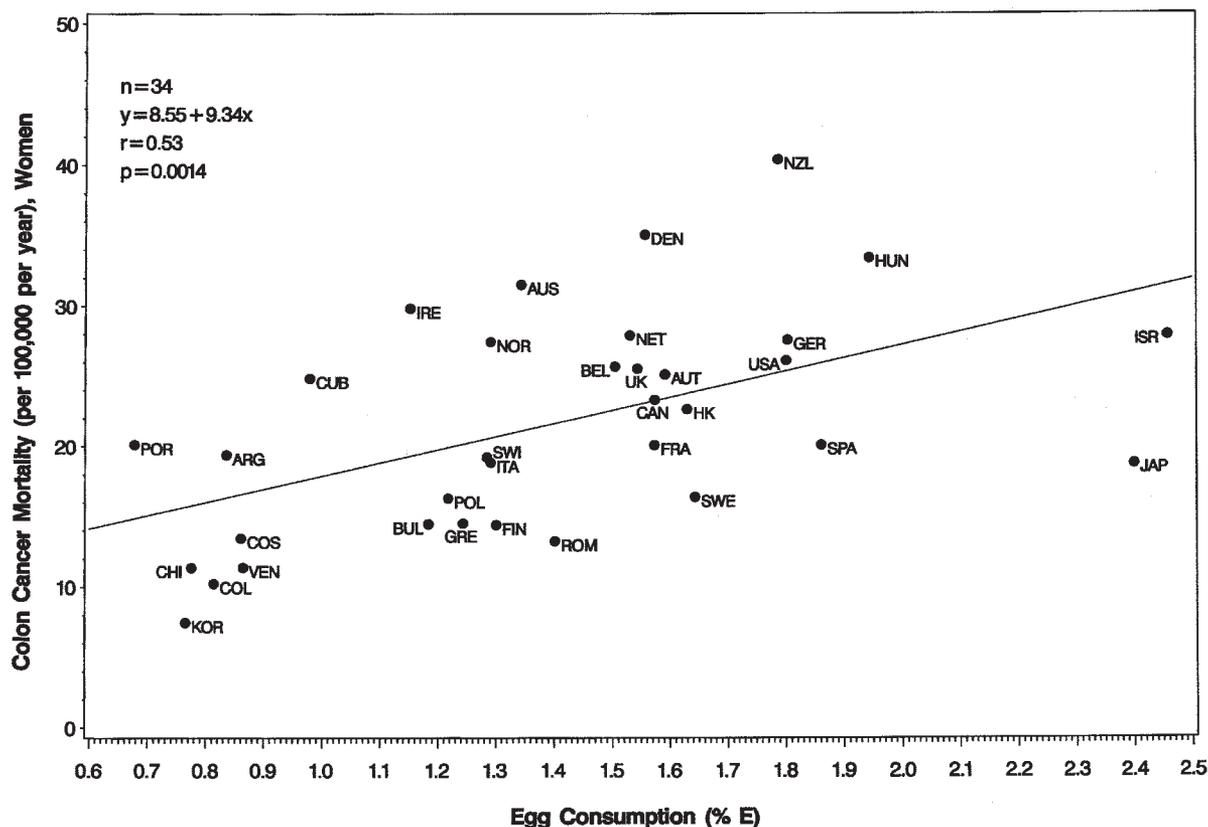


Figure 2. The Pearson correlation between egg consumption (% E), mean of nine periods (1964–94), and female colon cancer mortality, age-standardized by the European Standard population to 45–74 yr, mean of the latest 3 yr, mostly around 1993–94. For abbreviations of countries, see Fig. 1.

nine time periods examined. Egg consumption generally had a stronger correlation with colon cancer than with rectal cancer. After adjustment for consumption of fat, meat, vegetables, fruit, alcohol, and cigarettes, a significant and positive association persisted for colon cancer in the earliest five time periods. In rectal cancer, this association was seen only in the latest five time periods except for the last time period.

The current study is an ecological study. The most important advantage of ecological studies is that they allow researchers to investigate the relation between exposure and disease in many diverse populations for a prolonged period of time (20). The results of this study were obtained on the basis of data collected from 34 populations over a time interval of approximately 30 yr. It may be difficult to investigate the relation between diet and disease in populations with homogenous dietary habits in individual-based epidemiological studies. However, ecological studies are able to achieve a substantial variation in dietary exposure across regions or countries (20). As expected, fat, meat, and alcohol consumption was positively associated with colon and rectal cancer mortality in both sexes in all nine periods examined. An inverse, inconsistent association was observed between vegetable and fruit consumption and colon and rectal cancers. These findings generally are in agreement with those from previous studies (6–10), which indirectly confirms the overall validity of the data analyzed in the current study. The observed positive associations between egg consumption and

colon and rectal cancers were independent of their established and potential risk factors. In this study, all countries with relatively reliable data on food consumption and mortality were included, and the countries selected are well representative of world population.

Whether egg consumption is associated with the risk of colon and rectal cancers remains to be determined. Egg consumption was positively correlated with colon and rectal cancer mortality in two ecological studies (21,22). However, confounding factors were not controlled for, and temporal trends in the correlation between egg consumption and mortality from colon and rectal cancers were not examined in these two studies (21,22). Steinmetz and Potter in 1994 (15) reviewed epidemiological evidence for egg intake as a risk factor for cancers of the colon and rectum. Egg intake was positively associated with the risk of colon cancer in nine (14,15,23–29) of the 11 studies (14,15,23–31) conducted up to that time, but the risk estimates reached statistical significance in only three of these studies (23–25). The odds ratios (OR) or relative risks estimated from these nine studies varied considerably from 1.1 to 8.2 for high versus low intake of eggs (15). An inverse relation between egg intake and colon cancer risk was detected in two case–control studies performed in Northern Italy (30) and in Nagoya, Japan (31). Persons in the highest category of egg intake had a reduced risk of colon cancer compared with those in the lowest category (OR: 0.74 and 0.81 for the Italian study and the Japanese study, respectively).

Table 3. Pearson Correlation Coefficients (*P* Value) Between Egg Consumption (% E) in Nine periods, Food Balance Sheets, FAO, and Colon and Rectal Cancer Mortality Rates (per 100,000/yr), Age-Standardized by the European Standard Population to 45–74 yr, Mean of the Latest Available 3 yr, WHO^a

Period of Egg Consumption	Men		Women	
	Colon Cancer	Rectal Cancer	Colon Cancer	Rectal Cancer
1964–66	0.63 (<0.0001)	0.18 (0.31)	0.65 (<0.0001)	0.08 (0.64)
1969–71	0.57 (0.0005)	0.22 (0.22)	0.58 (0.0003)	0.12 (0.49)
1974–76	0.57 (0.0004)	0.32 (0.07)	0.56 (0.0006)	0.23 (0.18)
1979–81	0.59 (0.0002)	0.41 (0.016)	0.57 (0.0005)	0.33 (0.05)
1982–84	0.56 (0.0006)	0.41 (0.017)	0.53 (0.001)	0.36 (0.035)
1984–86	0.48 (0.004)	0.40 (0.018)	0.44 (0.009)	0.38 (0.028)
1987–89	0.39 (0.023)	0.42 (0.013)	0.33 (0.06)	0.40 (0.021)
1989–91	0.42 (0.013)	0.49 (0.003)	0.35 (0.043)	0.45 (0.008)
1992–94	0.41 (0.016)	0.45 (0.008)	0.33 (0.05)	0.37 (0.033)
1964–94 ^b	0.56 (0.0006)	0.38 (0.025)	0.53 (0.001)	0.31 (0.070)

a: *n* = 34.

b: Mean of nine periods.

Table 4. Multiple Regression Analysis of Colon Cancer Mortality Rates (per 100,000/yr), Age-Standardized by the European Standard Population to 45–74 yr, Mean of the Latest Available 3 yr, versus Egg Consumption (% E) in Nine Periods^a

Period of Egg Consumption	Men				Women			
	β^b	SE	<i>P</i>	<i>R</i> ² ^b	β	SE	<i>P</i>	<i>R</i> ²
1964–66	6.75	3.23	0.046	0.69	6.16	2.35	0.014	0.64
1969–71	6.93	3.07	0.033	0.69	5.96	2.29	0.015	0.62
1974–76	8.34	3.28	0.017	0.70	6.71	2.53	0.014	0.60
1979–81	8.49	3.64	0.028	0.66	6.42	2.73	0.026	0.58
1982–84	7.71	3.65	0.045	0.66	6.19	2.77	0.034	0.57
1984–86	5.68	3.72	0.14	0.63	4.38	2.85	0.14	0.52
1987–89	3.14	3.83	0.42	0.59	2.44	2.91	0.41	0.48
1989–91	4.78	4.05	0.25	0.59	3.50	3.09	0.27	0.48
1992–94	5.45	4.05	0.19	0.59	4.15	3.17	0.20	0.45
1964–94 ^c	8.48	3.77	0.033	0.67	6.31	2.90	0.039	0.57

a: Adjusted for fat, meat, vegetable, fruit, alcohol, and cigarette consumption.

b: Abbreviations are as follows: β , partial regression coefficient; *R*²: multiple determination coefficient.

c: Mean of nine periods.

Egg intake has been positively associated with the risk of rectal cancer in most epidemiological studies (14,15,25,26,28). As in colon cancer, the ORs or relative risks were statistically significant in only a few studies (14,28). Some cohort studies (15,29) suggested that the association of egg intake with colon cancer appeared to be slightly stronger than the association with rectal cancer. A few studies performed after the publication of the review mentioned above also yielded inconsistent results (16). The conflicting findings between egg consumption and the risk of colon and rectal cancers may be, in part, caused by differences in sample size, dietary assessment instruments, the reference period of dietary assessment, and the adjustment of confounding factors among different studies. The current study showed a positive relation between egg consumption and the risk of colon and rectal cancers, a finding consistent with most previous studies. However, our study differs from those studies in that we explored the temporal trends in the association between egg consumption

and cancers of the colon and rectum in many populations over a period of approximately 3 decades.

The mechanisms underlying the positive associations between egg consumption and the risk of colon and rectal cancers remain hypothetical. It was found that egg consumption did not have a substantial effect on the development of colorectal polyps (32,33), which might suggest that egg consumption is involved in the promotional, but not in the initiating, phase of colorectal carcinogenesis. Eggs are rich in cholesterol. The content of cholesterol in whole eggs is as high as 425 mg/100 g (12). Eggs are the top contributor of cholesterol in the diets of many populations, for example, Americans and Australians (23). It has been reported that cholesterol promoted colorectal carcinogenesis; animals fed a high-cholesterol diet displayed a high rate of chemically induced tumors (34). Cholesterol is a precursor of the hepatic production of primary bile acids that are converted into secondary bile acids in the large bowel by anaerobic bacteria via enzymatic deconjugation and

Table 5. Multiple Regression Analysis of Rectal Cancer Mortality Rates (per 100,000/yr), Age-Standardized by the European Standard Population to 45–74 yr, Mean of the Latest Available 3 yr, versus Egg Consumption (% E) in Nine Periods^a

Period of Egg Consumption	Men				Women			
	β	SE	<i>P</i>	<i>R</i> ²	β	SE	<i>P</i>	<i>R</i> ²
1964–66	0.67	4.05	0.87	0.21	–0.46	2.12	0.83	0.11
1969–71	2.59	3.77	0.50	0.25	0.54	2.00	0.79	0.13
1974–76	6.33	3.70	0.10	0.37	2.51	2.00	0.22	0.24
1979–81	7.62	3.77	0.05	0.42	3.47	2.04	0.10	0.29
1982–84	8.79	3.67	0.024	0.44	4.46	1.98	0.033	0.33
1984–86	8.15	3.49	0.028	0.47	4.39	1.86	0.026	0.37
1987–89	6.94	3.32	0.046	0.50	3.76	1.76	0.042	0.42
1989–91	7.30	3.26	0.034	0.57	3.75	1.78	0.045	0.47
1992–94	5.66	3.45	0.11	0.52	2.45	1.89	0.21	0.40
1964–94 ^b	7.99	3.84	0.047	0.44	3.68	2.09	0.09	0.31

a: Adjusted for fat, meat, vegetable, fruit, alcohol, and cigarette consumption.

b: Mean of nine periods.

dehydroxylation (35). Secondary bile acids were found to promote the proliferation of the colorectal epithelium and tumor formation in animals (35). The cholesterol hypothesis has gained further support from the studies showing that cholesterol intake was positively associated with the risk of colon or rectal cancers (13,14). Because eggs contain a substantial number of other nutrients and vitamins (12), the possibility that factors other than cholesterol contribute to an increased risk of colon and rectal cancers cannot be ruled out.

The current study showed that egg consumption was associated with colon and rectal cancer mortality in a different manner. Our findings suggest that it may take a longer time for egg consumption to exert a significantly promotional effect on colon cancer than on rectal cancer. It remains speculative whether this observation offers a clue that colon and rectal cancers have a different time lag in their associations with egg consumption. In view of the different findings for colon and rectal cancers and their relatively weak correlations ($r = 0.61$ in men and $r = 0.44$ in women), caution should be exercised when colon and rectal cancers are combined and treated as a single cancer entity in the data analysis of epidemiological studies.

Several limitations should be taken into account when interpreting the findings from the current study. Because the data used in ecological studies are based on groups or populations rather than on individuals, the conclusions drawn from studies of this nature may be subject to ecological fallacy (20). The FAO food data refer to food available for human consumption. The amount of food actually consumed by an individual may be lower than the amount reported because of food losses during storage and cooking, waste left on plates, quantities fed to domestic animals or pets, or food that is thrown away. Age- and sex-specific food-consumption data are not provided by the Food Balance Sheets of the FAO (11). The accuracy of diagnosis, the effectiveness of medical treatment, and the completeness of death registration may vary among populations examined, which reduces the comparability of the WHO mor-

tality data (1). The data analyzed in this study are not optimal but are the best available for investigating the relation between egg consumption and the risk of colon and rectal cancers at the population level.

In summary, the current study showed that egg consumption was significantly and positively associated with mortality from colon and rectal cancers in both sexes in many populations worldwide. These associations generally were stronger for colon cancer than for rectal cancer and were independent of almost all established and potential risk factors of these two cancers. Because eggs are consumed regularly and in large amounts in many populations, more epidemiological studies are warranted to clarify the role of egg consumption in the etiology of colon and rectal cancers. If the positive associations between egg consumption and the risk of colon and rectal cancers are confirmed by future studies conducted in various populations with different dietary habits and genetic traits, this may provide an easy and practical intervention measure to reduce the tremendous public health burden of colon and rectal cancers.

Acknowledgments and Notes

We are grateful to Bev Todd, Cindy Wilcox, and Tim Glaze for their technical support. Address correspondence to J. Zhang, Hipple Cancer Research Center, 4100 South Kettering Boulevard, Dayton, OH 45439. Phone: (937) 293-8508. FAX: (937) 293-7652. E-mail: zhang@hipple.org.

Submitted 12 February 2003; accepted in final form 12 May 2003.

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