Intakes of coffee, tea, milk, soda and juice and renal cell cancer in a pooled analysis of 13 prospective studies.

Int. J. Cancer: **121,** 2246–2253 (2007)

Intakes of coffee, tea, milk, soda and juice and renal cell cancer in a pooled analysis of 13 prospective studies

Jung Eun Lee[1]*, David J. Hunter[1,2,3], Donna Spiegelman[3,4], Hans-Olov Adami[3,5], Leslie Bernstein[6], Piet A. van den Brandt[7], Julie E. Buring[3,8], Eunyoung Cho[1], Dallas English[9], Aaron R. Folsom[10], Jo L. Freudenheim[11], Graham G. Gile[9], Edward Giovannucci[1,2,3], Pamela L. Horn-Ross[12], Michael Leitzmann[13], James R. Marshall[14], Satu Männistö[15], Marjorie L. McCullough[16], Anthony B. Miller[17], Alexander S. Parker[18], Pirjo Pietinen[15], Carmen Rodriguez[16], Thomas E. Rohan[19], Arthur Schatzkin[13], Leo J. Schouten[7], Walter C. Willett[1,2,3], Alicja Wolk[20], Shumin M. Zhang[3,8] and Stephanie A. Smith-Warner[2,3]

[1]*Channing Laboratory, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA*
[2]*Department of Nutrition, Harvard School of Public Health, Boston, MA*
[3]*Department of Epidemiology, Harvard School of Public Health, Boston, MA*
[4]*Department of Biostatistics, Harvard School of Public Health, Boston, MA*
[5]*Department of Medical Epidemiology and Biostatistics, National Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden*
[6]*Department of Preventive Medicine and USC/Norris Comprehensive Cancer Center, University of Southern California, Los Angeles, CA*
[7]*Department of Epidemiology, NUTRIM, Maastricht University, Maastricht, The Netherlands*
[8]*Division of Preventive Medicine, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA*
[9]*Cancer Epidemiology Centre, The Cancer Council Victoria, Melbourne, Australia*
[10]*Division of Epidemiology and Community Health, School of Public Health, University of Minnesota, Minneapolis, MN*
[11]*Department of Social and Preventive Medicine, University at Buffalo, State University of New York, Buffalo, NY*
[12]*Northern California Cancer Center, Fremont, CA*
[13]*Division of Cancer Epidemiology and Genetics, Department of Health and Health Services, National Cancer Institute, National Institute of Health, Bethesda, MD*
[14]*Roswell Park Cancer Institute, Buffalo, NY*
[15]*Department of Health Promotion and Chronic Disease Prevention, National Public Health Institute, Helsinki, Finland*
[16]*Epidemiology and Surveillance Research, American Cancer Society, Atlanta, GA*
[17]*Department of Public Health Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada*
[18]*Department of Urology, Mayo Clinic College of Medicine, Jacksonville, FL*
[19]*Department of Epidemiology and Population Health, Albert Einstein College of Medicine, Bronx, NY*
[20]*Division of Nutritional Epidemiology, National Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden*

Specific beverage intake may be associated with the risk of renal cell cancer through a diluting effect of carcinogens, alterations of hormone levels, or other changes in the renal tubular environment, but few prospective studies have examined these associations. We evaluated the associations between coffee, tea, milk, soda and fruit and vegetable juice intakes and renal cell cancer risk in a pooled analysis of 13 prospective studies (530,469 women and 244,483 men). Participants completed a validated food-frequency questionnaire at baseline. Using the primary data, the study-specific relative risks (RRs) were calculated and then pooled using a random effects model. A total of 1,478 incident renal cell cancer cases were identified during a follow-up of 7–20 years across studies. Coffee consumption was associated with a modestly lower risk of renal cell cancer (pooled multivariate RR for 3 or more 8 oz (237 ml) cups/day versus less than one 8 oz (237 ml) cup/day = 0.84; 95% CI = 0.67–1.05; *p* value, test for trend = 0.22). Tea consumption was also inversely associated with renal cell cancer risk (pooled multivariate RR for 1 or more 8 oz (237 ml) cups/day versus nondrinkers = 0.85; 95% CI = 0.71–1.02; *p* value, test for trend = 0.04). No clear associations were observed for milk, soda or juice. Our findings provide strong evidence that neither coffee nor tea consumption increases renal cell cancer risk. Instead, greater consumption of coffee and tea may be associated with a lower risk of renal cell cancer.

Key words: renal cell cancer; coffee; tea; milk; juice; soda; prospective study

Renal cell cancer incidence rates have been increasing steadily over the past 3 decades.[1] However, the etiology of renal cell cancer remains unclear. Given that the main functions of the kidneys are to regulate water and inorganic-ion balance, and to excrete waste products and foreign chemicals,[2] the risk of renal cell cancer may be affected by the quantity and type of beverages consumed. More specifically, beverages containing caffeine and/or antioxidants may reduce renal cell cancer risk because caffeine has a diuretic effect by blocking anti-diuretic hormone,[2] and antioxidants alleviate oxidative damage to DNA, proteins and other molecules.[3] Moreover, coffee and tea intake may reduce the risk of renal cell cancer by improving insulin sensitivity.[4,5] Beverages high in protein, such as milk, may increase the risk of renal cell cancer because high protein intakes may cause renal hypertrophy or renal damage.[6]

Inconsistent associations with risk of renal cell cancer have been observed in several case-control studies for intakes of coffee and tea,[7–18] soda,[7–9,11,16,18] juice[19] and milk.[9–11,17,19–21] However, very few prospective studies[22–25] have examined these relationships because many prospective studies have a relatively small number of incident renal cell cancer cases. We therefore examined the associations between intakes of coffee, tea, milk, soda and juice and risk of incident renal cell cancer in a pooled analysis of 13 prospective studies including 1,478 renal cell cancer cases. We previously reported a modest inverse association between alcohol intake and renal cell cancer risk.[26]

***Correspondence to:** Channing Laboratory, Brigham and Women's Hospital and Harvard Medical School, 181 Longwood Avenue, Boston, MA 02115, USA. Fax: +1-1-617-525-2008.
E-mail: jung.lee@channing.harvard.edu
Received 15 December 2006; Accepted after revision 3 May 2007
DOI 10.1002/ijc.22909
Published online 21 June 2007 in Wiley InterScience (www.interscience.wiley.com).

Material and methods

Study population

The Pooling Project of Prospective Studies of Diet and Cancer (referred to as the Pooling Project) has been described elsewhere.[27] For the renal cell cancer analyses, each included study met the following prespecified criteria: at least one publication on a diet and cancer association, identification of at least 25 incident renal cell cancer cases, assessment of long-term dietary intake, and validation of the dietary assessment method or a closely related instrument. Studies including both men and women were treated as 2 separate cohorts (1 of men and 1 of women) and the inclusion criteria were applied to each gender-specific cohort. Overall, the renal cell cancer analyses included 530,469 women and 244,483 men from 13 prospective studies. The Canadian National Breast Screening Study and the Netherlands Cohort Study were each analyzed as case-cohort studies.[28] In the Pooling Project, we have divided the person-time of the Nurses' Health Study into 2 segments corresponding to the 1980–1986 follow-up period (part a) and follow-up beginning in 1986 (part b) to take advantage of the increased comprehensiveness of the food-frequency questionnaire (FFQ) completed in 1986 ($n = 131$ food items) compared to the FFQ completed in 1980 ($n = 61$ food items). In the renal cell cancer analyses, we only used data from the Nurses' Health Study (part b) because fewer than 25 cases were identified between 1980 and 1986.

Case ascertainment

Cases were ascertained by follow-up questionnaires and subsequent review of medical records,[22,29] linkage to cancer registries,[23,24,30–34] or both.[35–37] Some studies also used linkage to mortality registries to identify outcomes.[22–24,29,30,33–37] We defined renal cell cancer cases as those with histologically confirmed renal cell cancer (ICD-O-2 code = C64.9; ICD-9 = 189.0) using histological codes based on the International Classification of Diseases for Oncology[38,39] or the morphological classification provided by the study investigators. The majority (62%) of cases were classified as renal cell carcinoma, NOS (morphology code = 8312) and clear cell carcinoma was the second most frequent (20%) histologic subgroup. The proportion of renal cell carcinoma, NOS in our database is higher than that reported in surgical series which have reported clear cell carcinoma as the most common type of renal cell cancer.[40] This may be due to, in part, the large number of renal cell cancer cases in our data that were ascertained before a 1997 workshop on the diagnosis and prognosis of renal cell cancer held by the World Health Organization,[40] which prompted more widespread use of the currently used classification system. We have combined all histologically confirmed renal cell cancers together in our analyses due to the insufficient number of cases for histology-specific analyses.

Assessment of beverage and other dietary intake

Each study assessed baseline consumption of several beverages using a validated FFQ or diet history. Each study provided food and beverage intake data as either the number of servings consumed per day or grams consumed per day. For those studies that quantified intake in servings per day, the intake of each beverage was converted to grams per day based on the frequency reported and study-specific serving sizes. Intake of each beverage group was calculated by summing the intake of the related individual beverages listed on each study's FFQ. We excluded from the analyses of coffee and tea 2 studies (Breast Cancer Detection Demonstration Project Follow-Up Study and Cancer Prevention Study II Nutrition Cohort) that did not inquire about coffee and tea consumption at baseline and 1 study (California Teachers Study) that asked a combined question on coffee and tea intake. We were not able to separate caffeinated, decaffeinated and herbal tea because most studies did not assess intakes of specific types of tea. The FFQ used in the Melbourne Collaborative Cohort Study[41] did not assess overall milk consumption and therefore, this study was excluded for the milk analyses. Each study also provided intake data for several nutrients.

Although each study in this analysis conducted a validation study for their diet assessment method,[27] the results for beverage consumption were reported in only a few of the validation studies. In these studies, the correlation coefficients comparing beverage intake from the FFQs to diet records generally exceeded 0.6 for coffee, tea, milk, soda and juice,[42–44] or nonalcoholic beverages.[45]

Assessment of nondietary factors

Information on nondietary factors was collected at baseline in each study using self-administered questionnaires. Age, height and weight were asked in all studies; body mass index (BMI, weight (kg)/height (m^2)) was calculated using height and weight at the start of the follow-up period. All the cohort studies including women assessed parity and age at first birth. Three studies did not measure history of hypertension, and 1 study had a large proportion of missing data on history of hypertension. One study did not measure smoking habits.

Statistical analysis

After applying the study-specific exclusion criteria, we further excluded participants if they consumed an unreasonable energy intake (± 3 SDs from the study-specific $\log_e$-transformed mean energy intake), had a history of cancer except for nonmelanoma skin cancer at baseline, or had missing data on specific beverage intake (if applicable). Each study was analyzed using the Cox proportional hazards model.[46] Age at baseline (in days) and the year that the baseline questionnaire was returned were used as stratification variables, thereby creating a time metric, which simultaneously accounted for age, calendar time and time since entry into the study. Person-years of follow-up time were calculated from the date of the baseline questionnaire until the date of renal cell cancer diagnosis, death, loss to follow-up, if applicable, or end of follow-up, whichever came first.

We categorized the intake of each beverage using uniform cutpoints across studies. We defined 1 serving as 237 g (8 oz) for coffee and tea, 245 g (8 oz) for milk, 186 g (6 oz) for juice and 355 g (12 oz) for soda. If there were no cases in the highest intake category in a study, the relative risk (RR) for the highest category could not be estimated in that study and the noncases in the highest category were included in the second highest category. To calculate the p-value for the test for trend, participants were assigned the median value of their intake category and this variable was treated as a continuous term in the model. In the multivariate analyses, we further adjusted for BMI (continuous), history of hypertension (yes, no), pack-years of smoking (continuous), energy intake (continuous), fruit and vegetable consumption (tertiles), alcohol intake (continuous), and, among women, parity and age at first birth (1 or 2 children and age at first birth <25 years old, 1 or 2 children and age at first birth ≥ 25 years old or nulliparous, ≥ 3 children and age at first birth <25 years old, and ≥ 3 children and age at first birth ≥ 25 years old). Among studies that measured covariates included in the analyses, mean proportion of missing data across studies ranged from 0.2 to 5% for BMI, history of hypertension, pack-years of smoking, and among women, parity and age at first birth. Alcohol intake, and fruit and vegetable intake generally did not have missing responses. For each measured covariate in a study, an indicator variable was used for missing responses, if needed.

After calculating study- and gender-specific RRs for each category, we combined the $\log_e$ RRs using a random effects model.[47,48] The individual study estimates were weighted by the inverse of their variance. We tested for heterogeneity between studies using the Q statistic.[49,50] Two-sided 95% confidence intervals (CIs) were calculated.

To assess whether the associations between intakes of coffee and tea and risk of renal cell cancer were linear, we examined nonparametric regression curves using restricted cubic splines[51,52]. To

TABLE I – BASELINE CHARACTERISTICS OF THE COHORT STUDIES INCLUDED IN THE POOLED ANALYSES OF BEVERAGE INTAKES AND RENAL CELL CANCER RISK

Study (Sex[2])	Follow-up period	Baseline cohort size	No. of cases[3]	Median intake among drinkers (g/day) (% of nondrinkers)[1]				
				Coffee	Tea	Milk	Juice	Soda
Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study (M)	1985–1999	26,987	187	600 (2)	157 (64)	654 (0.01)	16 (51)	47 (58)
Breast Cancer Detection Demonstration Project Follow-up Study (W)	1987–1999	42,007	49	–	–	200 (4)	89 (21)	47 (61)
California Teachers Study (W)	1995–2001	100,036	35	231[4] (14)		141 (23)	57 (18)	50 (66)
Canadian National Breast Screening Study (W)	1980–2000	49,613	81	448 (15)	384 (22)	244 (15)	147 (14)	39 (43)
Cancer Prevention Study II Nutrition Cohort (W)	1992–2001	74,138	86	–	–	215 (3)	78 (19)	29 (64)
Cancer Prevention Study II Nutrition Cohort (M)	1992–2001	66,166	220	–	–	232 (3)	91 (16)	77 (45)
Health Professionals Follow-up Study (M)	1986–2000	47,780	116	237 (30)	102 (42)	196 (15)	159 (8)	202 (17)
Iowa Women's Health Study (W)	1986–2000	34,588	117	597 (10)	102 (42)	245 (12)	149 (9)	104 (28)
Melbourne Collaborative Cohort Study (M)	1990–2003	14,908	50	500 (11)	500 (19)	–	79 (20)	86 (37)
Netherlands Cohort Study (W)	1986–1993	62,573	68	500 (4)	375 (11)	180 (7)	25 (41)	29 (54)
Netherlands Cohort Study (M)	1986–1993	58,279	134	500 (3)	375 (15)	179 (7)	23 (55)	54 (47)
New York State Cohort (M)	1980–1987	30,363	62	710 (12)	237 (64)	207 (10)	158 (4)	370 (82)
Nurses' Health Study (W)	1986–2000	68,523	86	592 (26)	102 (37)	210 (12)	152 (9)	159 (19)
Swedish Mammography Cohort (W)	1987–2004	60,604	138	443 (4)	181 (29)	345 (14)	24 (37)	23 (60)
Women's Health Study (W)	1993–2004	38,387	49	592 (14)	102 (33)	196 (12)	111 (11)	284 (13)
Total		774,952	1,478					

[1]For coffee and tea, an 8 oz. serving/day is equivalent to 237 g/day. For milk, an 8 oz. serving/day is equivalent to 245 g/day. For juice, a 6 oz. serving/day is equivalent to 186 g/day. For soda, a 12 oz. serving/day is equivalent to 355 g/day.–[2]W, Women; M, Men.–[3]Histologically confirmed renal cell cancer cases.–[4]One question on coffee and tea consumption was asked.

test for nonlinearity, the model fit including the linear and cubic spline terms selected by a stepwise regression procedure was compared to the model fit with only the linear term using the likelihood ratio test, and by visual inspection of the restricted cubic spline graphs. For these analyses, all studies were combined into a single dataset, and then stratified by age, the year that the questionnaire was returned, and study, and were adjusted for other covariates in the model. For analyses of each beverage, individuals reporting extremely high intake (top 1% of participants in the aggregated dataset) of that beverage were excluded from the analysis to reduce the influence of extreme values.

We examined whether the associations between each beverage and renal cell cancer varied by gender, median age at diagnosis (<68, ≥ 68 years), smoking status (never, past, current smoker), and parity (nulliparous or 1 child, 2 children, ≥ 3 children) using a mixed effects meta-regression model.[53] For evaluation of whether BMI (<25, ≥ 25 kg/m^2), history of hypertension (no, yes), alcohol intake (nondrinkers, drinkers), hormone replacement therapy (ever, never) and oral contraceptive use (user, nonuser) modified the association for each beverage, we used a Wald test of the pooled cross-product term of beverage intake as a continuous variable with the specific modifier variable modeled as a dichotomous variable.

Results

During maximum follow-up periods of 7–20 years across studies, 1,478 incident renal cell cancer cases (709 women and 769 men) were diagnosed among 530,469 women and 244,483 men (Table I).

Consumption of each beverage varied across studies. There were 3- to 5-fold differences in the median intakes of coffee, tea and milk across studies. Coffee was consumed more frequently and in higher quantities than tea. There was more than a 10-fold variation in median soda and juice intake across studies.

Coffee consumption was associated, but not significantly, with a lower risk of renal cell cancer overall (Table II). Inverse association was observed in women, although the difference in the results between women and men was not statistically significant (p value, test for between-studies heterogeneity due to gender for the $\geq$ three 8 oz servings/day category = 0.13). When we alternatively adjusted for smoking habits using categories of never smokers, 2 categories of years smoked among past smokers (<30 years, ≥ 30 years), and 3 levels of amount smoked among current smokers (<15 cigarettes/day, 15 to <25 cigarettes/day, ≥ 25 cigarettes/day), the results (data not shown) did not differ from the multivariate results presented in Table II. The nonparametric regression curve and a formal test showed that the relations between coffee consumption and renal cell cancer risk were consistent with linear associations (p-values, test for curvature = 0.25 for women, 0.55 for men). When coffee consumption was modeled as a continuous variable, an increment of 237 g/day (8 oz or 237 ml) was associated with a 5% lower risk of renal cell cancer among women (pooled multivariate RR = 0.95; 95% CI = 0.90–1.01), but not among men (pooled multivariate RR = 1.00; 95% CI = 0.94–1.06). The multivariable RRs obtained in the aggregated dataset were not different from the pooled multivariable RRs (data not shown). We could not examine the association for regular coffee and decaffeinated coffee separately because too few studies asked separate questions.

For tea, the pooled age-adjusted RRs were similar to the pooled multivariate RRs (Table II). In the multivariate analyses, we found a nonsignificant 15% lower risk of renal cell cancer among participants who consumed 1 or more 8 oz (237 ml) cups of tea per day

TABLE II – POOLED RELATIVE RISKS[1] (RR) AND 95% CONFIDENCE INTERVALS (CI) OF RENAL CELL CANCER ACCORDING TO CATEGORIES OF INTAKE FROM SPECIFIC BEVERAGES

Beverage, serving size (weight)	Categories						Per one serving/day	
	RR	RR (95% CI)	RR (95% CI)	RR (95% CI)	*p*-value, test for trend	*p*-value, test for between-studies heterogeneity due to sex[2]	RR (95% CI)[3]	*p*-value, test for between-studies heterogeneity due to sex
Coffee, 8 oz (237 g)[4,5]	<1/d	1–<2/d[6]	2–<3/d	≥3/d[3]				
No. of cases (W, M)[7]	(148, 119)	(124, 94)	(174, 174)	(76, 157)				
Age-adjusted								
Women	1.00	0.86 (0.67–1.11)	1.00 (0.79–1.27)	0.73 (0.54–0.98)	0.08		0.95 (0.90–1.01)	
Men	1.00	0.92 (0.58–1.45)	1.25 (0.82–1.91)	1.15 (0.83–1.61)	0.21		1.04 (0.98–1.01)	
Combined	1.00	0.86 (0.70–1.06)	1.07 (0.89–1.28)	0.91 (0.74–1.12)	0.78	0.04	1.00 (0.96–1.04)	0.03
Multivariate								
Women	1.00	0.89 (0.69–1.16)	1.03 (0.81–1.31)	0.71 (0.53–0.97)	0.07		0.95 (0.90–1.01)	
Men	1.00	0.84 (0.55–1.28)	1.17 (0.75–1.83)	1.00 (0.73–1.37)	0.83		1.00 (0.94–1.06)	
Combined	1.00	0.86 (0.70–1.06)	1.05 (0.87–1.27)	0.84 (0.67–1.05)	0.22	0.13	0.97 (0.93–1.01)	0.29
Tea, 8 oz (237 g)[4,5]	Nondrinker	1/mo–< 1/d[8]	≥1/d[3]					
No. of cases (W, M)[7]	(151, 256)	(207, 136)	(164, 152)					
Age-adjusted								
Women	1.00	1.14 (0.92–1.41)	0.99 (0.78–1.27)		0.47		1.00 (0.92–1.09)	
Men	1.00	0.93 (0.74–1.17)	0.70 (0.54–0.91)		0.08		0.90 (0.77–1.03)	
Combined	1.00	1.04 (0.89–1.21)	0.84 (0.71–1.01)		0.05	0.06	0.96 (0.70–1.03)	0.15
Multivariate								
Women	1.00	1.15 (0.93–1.42)	0.98 (0.77–1.26)		0.33		0.99 (0.91–1.08)	
Men	1.00	0.98 (0.77–1.23)	0.72 (0.55–0.94)		0.10		0.89 (0.77–1.04)	
Combined	1.00	1.07 (0.91–1.25)	0.85 (0.71–1.02)		0.04	0.09	0.96 (0.89–1.03)	0.24
Milk, 8 oz (245 g)[9]	<2/wk	2/wk–<4/wk	4/wk–<1/d	≥1/d[3,8]				
No. of cases (W, M)[7]	(183, 127)	(91, 106)	(103, 134)	(320, 352)				
Age-adjusted								
Women	1.00	0.92 (0.70–1.20)	0.93 (0.72–1.20)	0.97 (0.80–1.18)	0.82		1.00 (0.93–1.07)	
Men	1.00	1.03 (0.79–1.35)	0.91 (0.70–1.17)	1.02 (0.80–1.28)	0.89		1.01 (0.95–1.08)	
Combined	1.00	0.97 (0.81–1.17)	0.92 (0.77–1.09)	0.99 (0.85–1.15)	0.79	0.78	1.00 (0.96–1.05)	0.81
Multivariate								
Women	1.00	0.91 (0.69–1.19)	0.92 (0.70–1.19)	0.95 (0.78–1.16)	0.99		0.98 (0.90–1.06)	
Men	1.00	1.05 (0.81–1.38)	0.92 (0.70–1.21)	1.03 (0.81–1.31)	0.73		1.02 (0.94–1.11)	
Combined	1.00	0.98 (0.81–1.18)	0.92 (0.76–1.10)	0.98 (0.84–1.14)	0.82	0.61	1.00 (0.94–1.06)	0.45
Soda, 12 oz (355 g)[10]	Nondrinker	1/mo–<3/wk[8]	≥3 /wk[3]					
No. of cases (W, M)[7]	(299, 352)	(259, 280)	(140, 136)					
Age-adjusted								
Women	1.00	1.15 (0.97–1.37)	1.17 (0.85–1.62)		0.09		1.01 (0.95–1.07)	
Men	1.00	1.08 (0.91–1.28)	1.23 (0.86–1.76)		0.31		1.05 (0.99–1.10)	
Combined	1.00	1.12 (0.99–1.26)	1.21 (0.95–1.51)		0.06	0.80	1.04 (1.00–1.08)	0.76
Multivariate								
Women	1.00	1.11 (0.93–1.32)	1.05 (0.78–1.41)		0.42		1.01 (0.95–1.07)	
Men	1.00	1.10 (0.93–1.31)	1.17 (0.83–1.64)		0.45		1.03 (0.97–1.09)	
Combined	1.00	1.11 (0.98–1.25)	1.11 (0.89–1.38)		0.24	0.48	1.02 (0.98–1.06)	0.56
Juice, 6 oz (186 g)[11]	Nondrinker	1/mo–<4/wk	4/wk–<1/d	≥ 1/d[3,12]				
No. of cases (W, M)[7]	(145, 221)	(281, 307)	(119, 148)	(143, 93)				

TABLE II – POOLED RELATIVE RISKS[1] (RR) AND 95% CONFIDENCE INTERVALS (CI) OF RENAL CELL CANCER ACCORDING TO CATEGORIES OF INTAKE FROM SPECIFIC BEVERAGES (CONTINUED)

Beverage, serving size (weight)	Categories						Per one serving/day	
	RR	RR (95% CI)	RR (95% CI)	RR (95% CI)	*p*-value, test for trend	*p*-value, test for between-studies heterogeneity due to sex[2]	RR (95% CI)[3]	*p*-value, test for between-studies heterogeneity due to sex
Age-adjusted								
Women	1.00	0.99 (0.80–1.21)	0.89 (0.64–1.23)	1.08 (0.78–1.50)	0.62		1.00 (0.89–1.13)	
Men	1.00	0.97 (0.74–1.28)	0.89 (0.68–1.15)	1.05 (0.69–1.60)	0.51		1.07 (0.93–1.22)	
Combined	1.00	0.99 (0.85–1.16)	0.89 (0.74–1.08)	1.07 (0.85–1.35)	0.61	0.94	1.03 (0.94–1.12)	0.50
Multivariate								
Women	1.00	1.00 (0.81–1.24)	0.91 (0.66–1.25)	1.09 (0.78–1.53)	0.68		1.00 (0.89–1.13)	
Men	1.00	1.00 (0.76–1.33)	0.92 (0.71–1.20)	1.09 (0.68–1.74)	0.40		1.09 (0.94–1.25)	
Combined	1.00	1.01 (0.86–1.20)	0.92 (0.76–1.11)	1.10 (0.85–1.43)	0.47	0.98	1.03 (0.95–1.13)	0.38

[1]Multivariate models were adjusted for age, history of hypertension (yes/no), body mass index (continuous), pack-years of smoking (continuous), combination of parity and age at first birth (age at first birth <25 years and parity of 1 or 2; age at first birth ≥25 years and parity of 1 or 2, or nulliparous; age at first birth <25 years and parity of ≥3; and age at first birth ≥25 years and parity of ≥3), fruit and vegetable consumption (tertiles), alcohol intake (continuous) and total energy intake (continuous).–[2]For the highest category.–[3]*p* value, test for between-studies heterogeneity > 0.1.–[4]The Breast Cancer Detection Demonstration Project Follow-Up Study, the Cancer Prevention Study II Nutrition Cohort, and the California Teachers Study were excluded from the analyses of coffee and tea because coffee and tea intake was not assessed in the Breast Cancer Detection Demonstration Project Follow-Up Study and the Cancer Prevention Study II Nutrition Cohort, and one combined question on coffee and tea was asked in the California Teachers Study. In the remaining studies, participants who did not report coffee and tea intake were excluded ($n = 22$).–[5]Further adjusted for tea (continuous) for the coffee analysis and coffee (continuous) for the tea analysis.–[6]The Melbourne Collaborative Cohort Study was excluded from this category because there was no one in this category due to the way that frequency of intake was assessed on this study's FFQ.–[7](W): Women, (M): Men.–[8]The New York State Cohort was excluded from this category because there was no one in this category due to the way that frequency of intake was assessed on this study's FFQ.–[9]The Melbourne Collaborative Cohort Study did not assess overall milk consumption and was excluded from this analysis. In the remaining studies participants who did not report milk intake were excluded ($n = 12$).–[10]Participants who did not report soda intake were excluded ($n = 12$).–[11]The model did not include fruit and vegetable consumption. Participants who did not report juice intake were excluded ($n = 21$).[12]The Breast Cancer Detection Demonstration Project Follow-Up Study was excluded from the highest category because no cases were included in this category. The participants who would have been in the highest category were included in the next highest category.

TABLE III – POOLED MULTIVARIATE RELATIVE RISKS (RRS) AND 95% CONFIDENCE INTERVALS (CIS) OF RENAL CELL CANCER FOR AN INCREMENT OF ONE 8 oz. (237 g) CUP OF COFFEE AND TEA PER DAY STRATIFIED BY BODY MASS INDEX, SMOKING STATUS AND HISTORY OF HYPERTENSION

Beverages	Body mass index[1]		Smoking Status[2]			History of hypertension[3,4]	
	<25 kg/m^2	≥25 kg/m^2	Never[5]	Past[1]	Current[1,6]	No	Yes
Coffee							
No. of cases (W, M)[7]	(217, 208)	(296, 330)	(216, 69)	(97, 175)	(69, 285)	(195, 335)	(115, 147)
Women	0.99 (0.85–1.14)	0.96 (0.89–1.03)	0.89 (0.82–0.98)	1.00 (0.88–1.13)	0.97 (0.81–1.15)	0.92 (0.84–1.02)	1.01 (0.90–1.13)
Men	0.98 (0.86–1.11)	1.00 (0.92–1.09)	0.95 (0.80–1.13)	0.96 (0.86–1.08)	1.00 (0.89–1.12)	1.04 (0.96–1.12)	0.99 (0.87–1.12)
Combined	0.98 (0.89–1.07)	0.98 (0.93–1.04)	0.91 (0.84–0.98)	0.98 (0.90–1.06)	0.98 (0.90–1.08)	0.99 (0.92–1.06)	1.00 (0.92–1.09)
p value, test for interaction (W, M, C)[7]	(0.89, 0.85, 0.95)			(0.34, 0.78, 0.40)		(0.10, 0.59, 0.84)	
Tea							
No. of cases (W, M)[7]	(217, 208)	(296, 330)	(216, 69)	(97, 175)	(69, 285)	(195, 335)	(115, 147)
Women	1.00 (0.88–1.13)	1.00 (0.89–1.13)	1.00 (0.87–1.14)	0.80 (0.54–1.20)	1.05 (0.89–1.25)	0.89 (0.75–1.06)	1.08 (0.90–1.29)
Men	0.95 (0.77–1.18)	0.84 (0.66–1.06)	0.73 (0.40–1.32)	0.89 (0.65–1.21)	0.97 (0.81–1.15)	0.95 (0.82–1.10)	0.93 (0.76–1.13)
Combined	0.99 (0.90–1.09)	0.94 (0.84–1.06)	0.97 (0.83–1.12)	0.87 (0.70–1.09)	1.01 (0.90–1.14)	0.93 (0.84–1.03)	1.01 (0.88–1.15)
p value, test for interaction (W, M, C)[7]	(0.98, 0.41, 0.57)			(0.86, 0.47, 0.66)		(0.10, 0.92, 0.30)	

[1]Models were adjusted for age, history of hypertension (yes/no), body mass index (continuous), pack-years of smoking (continuous), combination of parity and age at first birth (age at first birth <25 years and parity of 1 or 2; age at first birth ≥25 years and parity of 1 or 2, or nulliparous; age at first birth <25 years and parity of ≥3; and age at first birth ≥25 years and parity of ≥3), fruit and vegetable consumption (tertiles), alcohol intake (continuous) and total energy intake (continuous). Coffee intake and tea intake were mutually adjusted in the models.–[2]The Swedish Mammography Cohort was excluded from these analyses because data on smoking habit were not available at baseline. The Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study was included in only the current smoking group status because the cohort included only current smokers.–[3]Models were adjusted for all covariates listed in footnote 1 except history of hypertension.–[4]The Breast Cancer Detection Demonstration Project Follow-Up Study, the Canadian National Breast Screening Study, the New York State Cohort, and the Swedish Mammography Cohort were excluded from these analyses because history of hypertension was not available at baseline.–[5]Models were adjusted for all covariates listed in footnote 1 except pack-years of smoking. The Netherlands Cohort Study was excluded from the analysis of never smoker due to small case numbers ($n < 10$).–[6]The Women's Health Study was excluded from the analysis of current smoker due to small case numbers ($n < 10$).–[7]W, Women; M, Men; C, Combined.

compared with nondrinkers (pooled multivariate RR = 0.85; 95% CI = 0.71–1.02) (Table II). The inverse association was limited to men (pooled multivariate RR = 0.72; 95% CI = 0.55–0.94), and the difference in the results between women and men was marginally significant (p value, test for between-studies heterogeneity due to gender = 0.09). When we additionally adjusted for multivitamin use (user, nonuser) and physical activity (low, medium, high), the results did not differ (data not shown). The multivariable RRs obtained in the aggregated dataset were not different from the pooled multivariable RRs (data not shown). For both women and men, the nonparametric regression curve and a formal test showed that the relations between tea consumption and renal cell cancer risk were consistent with linear associations (p-values, test for curvature = 0.36 for women, 0.66 for men). In the continuous analyses, we found a nonsignificant 4% lower risk of renal cell cancer for an increment of one 8 oz (237 ml) cup of tea per day (pooled multivariate RR = 0.96; 95% CI = 0.89–1.03), but the inverse association was limited to men.

No significant associations with renal cell cancer risk were observed for intakes of milk, soda and fruit and vegetable juice (Table II). When we examined whole milk and reduced fat milk separately in the 11 studies that assessed the intake of these items separately, there were no clear associations for either type of milk but the consumption of whole milk was uncommon in most studies (data not shown). Neither fruit juice (13 studies) nor vegetable juice (7 studies) was associated with risk of renal cell cancer (data not shown). We were not able to examine artificially sweetened and sugar-sweetened soda consumption separately because only a few studies asked separate questions for these beverages.

Overall, the associations between coffee or tea intakes and renal cell cancer risk were not significantly modified by BMI, history of hypertension, smoking habits (Table III), alcohol intake (nondrinkers, drinkers; data not shown) or age at diagnosis ($<$68, and $\geq$ 68 years old, the median age at diagnosis; data not shown). Because there were suggestions that associations for coffee and tea consumption varied by gender, we also examined whether the associations for coffee and tea intake varied by hormone-related variables. We found a marginally significant difference by oral contraceptive use (user, nonuser; p value, test for interaction = 0.09) in women, but no clear differences in risk of renal cell cancer by parity ($\leq$1 child, 2 children, $\geq$3 children), and hormone replacement therapy use (ever, never) (p values, test for interaction $\geq$0.11).

Discussion

In our pooled analysis of 13 prospective studies, we found that neither coffee nor tea intake was associated with increased renal cell cancer risk, but rather our results suggest that frequent coffee or tea consumption may be associated with a modestly lower risk of renal cell cancer. Consumption of milk, soda and fruit and vegetable juice was not associated with the risk of renal cell cancer. We found suggestive differences in the apparent benefits of coffee and tea consumption on risk of renal cell cancer between women and men which were unexpected. These gender-differences could be due to chance but it is possible that associations between lifestyle factors such as diet and renal cell cancer risk vary by hormone-related variables. The incidence of renal cell cancer is more than twice as common in men compared to women, but it remains uncertain whether this difference in the association observed is due to differences in endogenous estrogen levels, smoking habits or some other factors. Caffeine metabolism has been shown to be slower among women who received exogeneous estrogens compared to women who did not[54,55] partly because estrogens and caffeine compete for the CYP1A2 isoenzyme of the P450 family.[54] Although we did not find clear differences in the association between coffee and tea intake and renal cell cancer risk by several hormone-related variables, we had a limited number of cases for these analyses.

Ecological studies have found strong positive correlations between per capita consumption of coffee and renal cell cancer mortality[56] and incidence.[57] Because coffee drinking is positively correlated with smoking, a positive correlation between coffee consumption and renal cell cancer risk at the ecological level could be confounded by smoking habits. In our data, the inverse association for coffee was stronger among never smokers compared to past or current smokers, which may suggest that residual confounding by smoking habits could obscure an inverse association of coffee intake if the effects of smoking are not completely controlled for. The majority of case-control studies of renal cell cancer have found no significant associations[9–14,16,17] for coffee consumption. Only a few prospective studies,[22,24,58,59] 3 of which[22,24] (2 studies were reported in 1 paper; Lee *et al.*[22]) are included in our analysis, have examined the association between coffee intake and risk of renal cell cancer. In the 2 cohort studies that were not included in our analysis because they did not meet the prespecified criteria (described in Material and Methods section), significant association in women and men combined[58] or non-significant inverse association in men[59] were found for coffee consumption. Our data suggested the inverse association was limited to women, although the difference in the risk estimates between women and men was not statistically significant.

For tea, most, but not all[16,17] case-control studies have found no significant association with renal cell cancer risk in men,[7,12,13] women[7,12,13] or both genders combined.[7,9–11,14,15,18] Among 4 prospective studies[22,24,25] (2 studies were reported in Lee *et al.*[22]) that examined the association between tea consumption and renal cell cancer risk, 3[22,24] were included in our analyses. The prospective study that was not included in our analyses found that black tea consumption appeared to increase the risk of kidney cancer death, but that green tea did not.[25] However, the authors postulated that, in this Japanese population, drinking black tea may be a surrogate for a westernized diet, which may be associated with an increased risk of renal cell cancer. In contrast, the studies in our analysis, tea consumption was positively correlated with healthy behaviors. Inadequate control for these healthy behaviors could result in a spurious inverse association. However, we found little difference between our age-adjusted results and those adjusted for smoking habits, history of hypertension, BMI, physical activity and multivitamin use.

Milk consumption has been associated with an increased risk of renal cell cancer in some case-control studies[9–11,20], but, as observed in our prospective analysis, other case-control studies have not seen an association for milk intake.[17,19,21] Our finding of no association between soda intake and renal cell cancer risk agrees with the results from the few case-control studies that have examined associations with either total soda intake[7,11,18] or low calorie soda intake.[7] Information on intakes of milk, soda and juice in relation to renal cell cancer risk from prospective studies is limited.

There are several possible mechanisms by which coffee and tea consumption might reduce the risk of renal cell cancer. First, coffee and tea may improve insulin sensitivity. A possible link between insulin sensitivity and renal cell cancer risk is suggested by the strong positive association between obesity and renal cell cancer risk.[60] Furthermore, renal cell cancer incidence rates have been shown to be higher in individuals with diabetes,[61,62] which is usually characterized by impaired insulin sensitivity, and in individuals with elevated fasting glucose levels.[63] Coffee consumption has been associated with improved insulin sensitivity,[4] inversely associated with the risk of diabetes,[64] and inversely correlated with C-peptide levels, a marker of insulin secretion.[65] Tea consumption also has been shown to improve insulin sensitivity in experimental studies,[5,66] but has not been associated with risk of Type 2 diabetes mellitus in prospective cohort studies.[67,68]

Second, the diluting effect caused by coffee and tea could reduce the risk of renal cell cancer by decreasing the time that carcinogenic solutes are in contact with renal epithelial cells.

However, a pooled analysis of the Nurses' Health Study and the Health Professionals Follow-up Study, both of which were included in our analyses, reported that total fluid intake was not associated with a lower risk of renal cell cancer.[22] In this pooled analysis, we were not able to examine if total fluid intake was associated with risk of renal cell cancer because the FFQs of 7 of the 13 studies did not assess water consumption, an important contributor to total fluid intake.

Third, coffee and tea also contain phenolic compounds and bioactive flavonoids,[69,70] which may reduce the risk of renal cell cancer by removing oxidized carcinogenic agents, reducing lipid peroxidation, reducing cell proliferation, or promoting apoptosis.[3,71]

This pooled analysis has limitations. We used only a baseline measure of beverage intake for each study therefore we could not investigate the effects of changes in beverage intake during follow-up, or consumption of specific beverages during earlier age periods or over the lifetime. Also, we only had a baseline measure for confounding factors and potential effect modifiers, so that changes in these variables during follow-up could not be taken into consideration in our analyses. Even though our study included a large number of cases, we could not examine the effects of high intake of each beverage due to the small number of cases with high intakes. Also, we could not examine regular or decaffeinated coffee separately, types of tea, or types of soda. We were not able to examine if the associations differed by ethnicity because over 90% of the participants in our study were Caucasian. We did not have sufficient power to examine associations separately by histological type of renal cell cancer. Smoking habits or history of hypertension, important risk factors for renal cell cancer, were measured in most studies, but not in all. However, in those studies that measured smoking habits and history of hypertension, the pooled RRs from the multivariate model presented were similar to the pooled RRs where we did not adjust for smoking habits and history of hypertension (data not shown).

Our analysis has several strengths. Because of the prospective design of the studies, recall bias and selection bias do not account for our findings. In addition, because of the large number of cases in our study, which has not been possible in any single prospective study, we were able to achieve better precision in our risk estimates relative to the individual prospective studies. Although we did not have information on some risk factors for renal cell cancer, including family history of renal cell cancer, environmental exposures such as asbestos, medications such as phenacetin, or advanced kidney disease, and thus were not able to control for these factors in our analyses, the associations that we observed are not likely to be fully explained by these factors because these factors would need to be both common and strongly associated with each beverage intake. Because we analyzed the primary data from each study, we were able to model beverage intake and confounding factors uniformly across studies to remove potential sources of heterogeneity in the results across studies.

In conclusion, our results suggest that coffee and tea consumption may be associated with a modestly lower risk of renal cell cancer, whereas intakes of milk, juice and soda were not associated with risk. Further studies are needed to explore possible mechanisms and the suggestive gender-difference in risk for coffee and tea.

Acknowledgements

The authors thank Ruifeng Li, Christine C. Rivera, and Shiaw-Shyuan Yaun for assistance in data management.

References

1. Mathew A, Devesa SS, Fraumeni JF, Jr, Chow WH. Global increases in kidney cancer incidence, 1973–1992. Eur J Cancer Prev 2002; 11:171–8.
2. Vander A, Sherman J, Luciano D. Human physiology: The mechanisms of body function, 6th edn. New York: McGraw-Hill, 1994.
3. Kehrer JP, Smith CV. Free radicals in biology: sources, reactivities, and roles in the etiology of human diseases. In: Frei B, ed. Natural antioxidants in human health and disease. San Diego, CA: Academic Press, 1994. 25–62.
4. Arnlov J, Vessby B, Riserus U. Coffee consumption and insulin sensitivity. JAMA 2004;291:1199–201.
5. Anderson RA, Polansky MM. Tea enhances insulin activity. J Agric Food Chem 2002;50:7182–6.
6. Chow WH, Gridley G, McLaughlin JK, Mandel JS, Wacholder S, Blot WJ, Niwa S, Fraumeni JF, Jr. Protein intake and risk of renal cell cancer. J Natl Cancer Inst 1994;86:1131–9.
7. Goodman MT, Morgenstern H, Wynder EL. A case-control study of factors affecting the development of renal cell cancer. Am J Epidemiol 1986;124:926–41.
8. Asal NR, Risser DR, Kadamani S, Geyer JR, Lee ET, Cherng N. Risk factors in renal cell carcinoma: I. Methodology, demographics, tobacco, beverage use, and obesity. Cancer Detect Prev 1988;11:359–77.
9. Maclure M, Willett W. A case-control study of diet and risk of renal adenocarcinoma. Epidemiology 1990;1:430–40.
10. McCredie M, Ford JM, Stewart JH. Risk factors for cancer of the renal parenchyma. Int J Cancer 1988;42:13–6.
11. Talamini R, Baron AE, Barra S, Bidoli E, La Vecchia C, Negri E, Serraino D, Franceschi S. A case-control study of risk factor for renal cell cancer in northern Italy. Cancer Causes Control 1990;1:125–31.
12. Benhamou S, Lenfant MH, Ory-Paoletti C, Flamant R. Risk factors for renal-cell carcinoma in a French case-control study. Int J Cancer 1993;55:32–6.
13. Kreiger N, Marrett LD, Dodds L, Hilditch S, Darlington GA. Risk factors for renal cell carcinoma: results of a population-based case-control study. Cancer Causes Control 1993;4:101–10.
14. Yuan JM, Gago-Dominguez M, Castelao JE, Hankin JH, Ross RK, Yu MC. Cruciferous vegetables in relation to renal cell carcinoma. Int J Cancer 1998;77:211–6.
15. Bianchi GD, Cerhan JR, Parker AS, Putnam SD, See WA, Lynch CF, Cantor KP. Tea consumption and risk of bladder and kidney cancers in a population- based case-control study. Am J Epidemiol 2000; 151:377–83.
16. McLaughlin JK, Mandel JS, Blot WJ, Schuman LM, Mehl ES, Fraumeni JF, Jr. A population-based case-control study of renal cell carcinoma. J Natl Cancer Inst 1984;72:275–84.
17. Yu MC, Mack TM, Hanisch R, Cicioni C, Henderson BE. Cigarette smoking, obesity, diuretic use, and coffee consumption as risk factors for renal cell carcinoma. J Natl Cancer Inst 1986;77:351–6.
18. Wolk A, Gridley G, Niwa S, Lindblad P, McCredie M, Mellemgaard A, Mandel JS, Wahrendorf J, McLaughlin JK, Adami HO. International renal cell cancer study. VII. Role of diet. Int J Cancer 1996; 65:67–73.
19. Hu J, Mao Y, White K. Diet and vitamin or mineral supplements and risk of renal cell carcinoma in Canada. Cancer Causes Control 2003; 14:705–14.
20. Mellemgaard A, McLaughlin JK, Overvad K, Olsen JH. Dietary risk factors for renal cell carcinoma in Denmark. Eur J Cancer 1996; 32A:673–82.
21. Lindblad P, Wolk A, Bergstrom R, Adami HO. Diet and risk of renal cell cancer: a population-based case-control study. Cancer Epidemiol Biomarkers Prev 1997;6:215–23.
22. Lee JE, Giovannucci E, Smith-Warner SA, Spiegelman D, Willett WC, Curhan GC. Total fluid intake and use of individual beverages and risk of renal cell cancer in two large cohorts. Cancer Epidemiol Biomarkers Prev 2006;15:1204–11.
23. Rashidkhani B, Lindblad P, Wolk A. Fruits, vegetables and risk of renal cell carcinoma: a prospective study of Swedish women. Int J Cancer 2005;113:451–5.
24. Nicodemus KK, Sweeney C, Folsom AR. Evaluation of dietary, medical and lifestyle risk factors for incident kidney cancer in postmenopausal women. Int J Cancer 2004;108:115–21.
25. Washio M, Mori M, Sakauchi F, Watanabe Y, Ozasa K, Hayashi K, Miki T, Nakao M, Mikami K, Ito Y, Wakai K, Tamakoshi A. Risk factors for kidney cancer in a Japanese population: findings from the JACC Study. J Epidemiol 2005;15 (Suppl 2):S203–11.
26. Lee JE, Hunter DJ, Spiegelman D, Adami HO, Albanes D, Bernstein L, van den Brandt PA, Buring JE, Cho E, Folsom AR, Freudenheim JL, Giovannucci E, et al. Alcohol intake and renal cell cancer in a pooled analysis of 12 prospective studies. J Natl Cancer Inst, 2007;99:801–10.
27. Smith-Warner SA, Spiegelman D, Ritz J, Albanes D, Beeson WL, Bernstein L, Berrino F, van den Brandt PA, Buring JE, Cho E, Colditz GA, Folsom AR, et al. Methods for pooling results of epidemiologic studies. Am J Epidemiol 2006;163:1053–64.
28. Prentice RL. A case-cohort design for epidemiologic cohort studies and disease prevention trials. Biometrika 1986;73:1–12.

29. Higginbotham S, Zhang ZF, Lee IM, Cook NR, Giovannucci E, Buring JE, Liu S. Dietary glycemic load and risk of colorectal cancer in the Women's Health Study. J Natl Cancer Inst 2004;96:229–33.
30. Giles GG, English DR. The Melbourne Collaborative Cohort Study. IARC Sci Publ 2002;156:69–70.
31. van Dijk BA, Schouten LJ, Kiemeney LA, Goldbohm RA, van den Brandt PA. Vegetable and fruit consumption and risk of renal cell carcinoma: results from the Netherlands cohort study. Int J Cancer 2005;117:648–54.
32. Rohan TE, Jain M, Howe GR, Miller AB. Alcohol consumption and risk of breast cancer: a cohort study. Cancer Causes Control 2000;11: 239–47.
33. Bernstein L, Allen M, Anton-Culver H, Deapen D, Horn-Ross PL, Peel D, Pinder R, Reynolds P, Sullivan-Halley J, West D, Wright W, Ziogas A, et al. High breast cancer incidence rates among California teachers: results from the California Teachers Study (United States). Cancer Causes Control 2002;13:625–35.
34. Bandera EV, Freudenheim JL, Marshall JR, Zielezny M, Priore RL, Brasure J, Baptiste M, Graham S. Diet and alcohol consumption and lung cancer risk in the New York State Cohort (United States). Cancer Causes Control 1997;8:828–40.
35. Mahabir S, Leitzmann MF, Virtanen MJ, Virtamo J, Pietinen P, Albanes D, Taylor PR. Prospective study of alcohol drinking and renal cell cancer risk in a cohort of finnish male smokers. Cancer Epidemiol Biomarkers Prev 2005;14:170–5.
36. Flood A, Caprario L, Chaterjee N, Lacey JV, Jr, Schairer C, Schatzkin A. Folate, methionine, alcohol, and colorectal cancer in a prospective study of women in the United States. Cancer Causes Control 2002;13: 551–61.
37. Calle EE, Rodriguez C, Jacobs EJ, Almon ML, Chao A, McCullough ML, Feigelson HS, Thun MJ. The American Cancer Society Cancer Prevention Study II Nutrition Cohort: rationale, study design, and baseline characteristics. Cancer 2002;94:500–11.
38. Percy C, Van Holten V, Muir C. International classification of diseases for oncology. World Health Organ 1990.
39. Puckett CD. The educational annotation of ICD-9-CM; diseases and procedures tabular lists. Reno, Nevada: Channel Publishing, 1986.
40. Storkel S, Eble JN, Adlakha K, Amin M, Blute ML, Bostwick DG, Darson M, Delahunt B, Iczkowski K. Classification of renal cell carcinoma: workgroup No. 1. Cancer 1997;80:987–9.
41. Baglietto L, Severi G, English DR, Hopper JL, Giles GG. Alcohol consumption and prostate cancer risk: results from the Melbourne collaborative cohort study. Int J Cancer 2006;119:1501–4.
42. Feskanich D, Rimm EB, Giovannucci EL, Colditz GA, Stampfer MJ, Litin LB, Willett WC. Reproducibility and validity of food intake measurements from a semiquantitative food frequency questionnaire. J Am Diet Assoc 1993;93:790–6.
43. Salvini S, Hunter DJ, Sampson L, Stampfer MJ, Colditz GA, Rosner B, Willett WC. Food-based validation of a dietary questionnaire: the effects of week-to-week variation in food consumption. Int J Epidemiol 1989;18:858–67.
44. Pietinen P, Hartman AM, Haapa E, Räsänen L, Haapakoski J, Palmgren J, Albanes D, Virtamo J, Huttunen JK. Reproducibility and validity of dietary assessment instruments. I. A self-administered food use questionnaire with a portion size picture booklet. Am J Epidemiol 1988;128:655–66.
45. Goldbohm RA, van den Brandt PA, Brants HAM, van't Veer P, Al M, Sturmans F, Hermus RJJ. Validation of a dietary questionnaire used in a large-scale prospective cohort study on diet and cancer. Eur J Clin Nutr 1994;48:253–65.
46. Cox DR. Regression models and life-tables. J R Stat Soc 1972;34: 187–220.
47. Laird NM, Ware JH. Random-effects models for longitudinal data. Biometrics 1982;38:963–74.
48. Harville DA. Maximum likelihood approaches to variance component estimation and to related problems. J Am Stat Assoc 1977;72: 320–40.
49. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177–88.
50. Cochran WG. The combination of estimates from different experiments. Biometrics 1954;10:101–29.
51. Smith PL. Splines as a useful and convenient statistical tool. Am Stat 1979;33:57–62.
52. Durrleman S, Simon R. Flexible regression models with cubic splines. Stat Med 1989;8:551–61.
53. Stram DO. Meta-analysis of published data using a linear mixed-effects model. Biometrics 1996;52:536–44.
54. Pollock BG, Wylie M, Stack JA, Sorisio DA, Thompson DS, Kirshner MA, Folan MM, Condifer KA. Inhibition of caffeine metabolism by estrogen replacement therapy in postmenopausal women. J Clin Pharmacol 1999;39:936–40.
55. Balogh A, Klinger G, Henschel L, Borner A, Vollanth R, Kuhnz W. Influence of ethinylestradiol-containing combination oral contraceptives with gestodene or levonorgestrel on caffeine elimination. Eur J Clin Pharmacol 1995;48:161–6.
56. Shennan DH. Letter: renal carcinoma and coffee consumption in 16 countries. Br J Cancer 1973;28:473–4.
57. Armstrong B, Doll R. Environmental factors and cancer incidence and mortality in different countries, with special reference to dietary practices. Int J Cancer 1975;15:617–31.
58. Jacobsen BK, Bjelke E, Kvale G, Heuch I. Coffee drinking, mortality, and cancer incidence: results from a Norwegian prospective study. J Natl Cancer Inst 1986;76:823–31.
59. Stensvold I, Jacobsen BK. Coffee and cancer: a prospective study of 43,000 Norwegian men and women. Cancer Causes Control 1994;5: 401–8.
60. IARC. Weight control and physical activity. In: Vanio H, Bianchini F, eds. IARC handbooks of cancer prevention, Vol. 6. Lyon, France: IARC Press, 2002:120–24.
61. Lindblad P, Chow WH, Chan J, Bergstrom A, Wolk A, Gridley G, McLaughlin JK, Nyren O, Adami HO. The role of diabetes mellitus in the aetiology of renal cell cancer. Diabetologia 1999;42:107–12.
62. Wideroff L, Gridley G, Mellemkjaer L, Chow WH, Linet M, Keehn S, Borch-Johnsen K, Olsen JH. Cancer incidence in a population-based cohort of patients hospitalized with diabetes mellitus in Denmark. J Natl Cancer Inst 1997;89:1360–5.
63. Jee SH, Ohrr H, Sull JW, Yun JE, Ji M, Samet JM. Fasting serum glucose level and cancer risk in Korean men and women. JAMA 2005;293:194–202.
64. van Dam RM, Hu FB. Coffee consumption and risk of type 2 diabetes: a systematic review. JAMA 2005;294:97–104.
65. Wu T, Willett WC, Hankinson SE, Giovannucci E. Caffeinated coffee, decaffeinated coffee, and caffeine in relation to plasma C-peptide levels, a marker of insulin secretion, in U.S. women. Diabetes Care 2005;28:1390–6.
66. Wu LY, Juan CC, Ho LT, Hsu YP, Hwang LS. Effect of green tea supplementation on insulin sensitivity in Sprague-Dawley rats. J Agric Food Chem 2004;52:643–8.
67. van Dam RM, Feskens EJ. Coffee consumption and risk of type 2 diabetes mellitus. Lancet 2002;360:1477–8.
68. Tuomilehto J, Hu G, Bidel S, Lindström J, Jousilahti P. Coffee consumption and risk of type 2 diabetes mellitus among middle-aged Finnish men and women. JAMA 2004;291:1213–9.
69. Arnaud MJ. Metabolism of caffeine and other components of coffee. In: Garattini S, ed. Caffeine, coffee and health. New York: Raven Press, 1993. 43–95.
70. Yang CS, Wang ZY. Tea and cancer. J Natl Cancer Inst 1993;85: 1038–49.
71. Halliwell B. Free radicals, antioxidants, and human disease: curiosity, cause, or consequence? Lancet 1994;344:721–4.