Are coffee and tea consumption associated with urinary tract cancer risk? A systematic review and meta-analysis.

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Are coffee and tea consumption associated with urinary tract cancer risk? A systematic review and meta-analysis

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Background	Narrative reviews have concluded that there is a small association between coffee consumption and an increased risk of urinary tract cancer, possibly due to confounding by smoking. No association for tea consumption has been indicated. This systematic review attempts to summarize and quantify these associations both unadjusted and adjusted for age, smoking and sex.
Method	Thirty-four case-control and three follow-up studies were included in this systematic review. Summary odds ratios (OR) were calculated by meta-regression analyses.
Results	The unadjusted summary OR indicated a small increased risk of urinary tract cancer for current coffee consumers versus non-drinkers. The adjusted summary OR were: 1.26 (95% CI : 1.09–1.46) for studies with only men, 1.08 (95% CI : 0.79–1.46) for studies with only women and 1.18 (95% CI : 1.01–1.38) for studies with men and women combined. Neither unadjusted nor adjusted summary OR provided evidence for a positive association between tea consumption and urinary tract cancer. Even though studies differed in methodology, the results were rather consistent. We did not perform dose-response analyses for coffee and tea consumption due to sparse data.
Conclusions	In accordance with earlier reviews, we found that coffee consumption increases the risk of urinary tract cancer by approximately 20%. The consumption of tea seems not to be related to an increased risk of urinary tract cancer.

Keywords	Coffee, tea, urological neoplasms, bladder neoplasms, meta-analysis, epidemiology
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Over the last four decades, a number of epidemiological studies have been conducted to investigate determinants of urinary tract cancer.[1–5] These studies suggested that bladder cancer is influenced by environmental factors, such as cigarette smoking and exposure to industrial chemicals (e.g. aromatic amines), and by chronic infections with *Schistosoma haematobium*. The impact of coffee and tea consumption on the risk of urinary tract cancer is less clear, although many case-control studies and several follow-up studies on these associations have been published. Because coffee and tea are two of the most popular beverages consumed worldwide, the relationship between coffee and tea consumption and the incidence of bladder cancer is an important concern. Earlier narrative reviews on coffee consumption concluded that the evidence was consistent with a small positive association.[4,6–8] Viscoli *et al.*[9] quantified this association in 1993 in a meta-analysis based on seven studies and concluded that the best available evidence does not suggest a clinically important association between coffee consumption and cancer of the lower urinary tract. According to four narrative reviews, there is no positive association between tea consumption and urinary tract cancer, although a summary association has never been quantified.[4,6,10,11] The present study aims at reviewing all epidemiological studies up to February 2000 more systematically, to provide quantitative summary estimates of the risk of urinary tract cancer associated with both coffee and tea consumption and to evaluate changes in summary estimates after adjustment for cigarette smoking.

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Material and Methods

Search strategy

The study design has been published previously.[12] Epidemiological studies were identified by the principal investigator through a computerized Medline, Cancerlit and Current Contents search on follow-up and case-control studies of all languages published

until February 2000 using Medical Subjects Headings and free text words. The keywords used were urolo*, bladder, cyst*, vesic*, kidney, glomerul*, nephr*, pyel*, renal, ureteral, urethral, transitional cell, cancer, carcino*, tumo*, neoplasm*, onco*, risk, etiology, epidemiology, and caus*. Citation tracking was performed until no new studies were found. For inclusion in this analysis, the articles had to provide sufficient information to estimate a summary odds ratio (OR) and the associated standard error of incident primary urinary tract cancer for coffee or tea consumers compared to non-drinkers, i.e. exposure frequency distribution, exposure-specific OR or exposure-specific incidence rate ratios. Coffee and tea consumption were defined as ever consumption or current consumption at baseline (for follow-up studies) or in the reference period (for case-control studies).

Data collection

A criteria list for the assessment of quality items (study characteristics) in observational cancer research was developed (Appendix 1). The criteria list was used to provide co-variables for meta-regression to explore reasons for observed heterogeneity in results and is available upon request. The criteria list was developed through consensus meetings with experts in the fields of cancer and meta-analysis. The list comprised items felt to be important for the quality of observational research, including study design (follow-up or case control study), measuring instrument (interview or self-administered questionnaire) and anatomical site of the neoplasm (total urinary tract, bladder, renal pelvis or ureter). For case-control studies, additional information was gathered on the sources of the cases and controls. Case-control studies that used controls obtained from the general population or from hospitals were defined as population-based or hospital-based case control studies, respectively. If case-control studies used both population- and hospital-based controls, population-based controls were used for further analysis. Data were extracted to permit the calculation of both unadjusted and adjusted OR to estimate the association between coffee and tea consumption and the risk of urinary tract cancer. Two-way contingency tables for each study were constructed, based on exposure frequency distributions, in order to calculate the unadjusted OR. Adjusted OR were extracted directly from the original reports. Because we considered age, smoking and sex to be the most important confounding variables, the authors of the original articles had to have adjusted for at least these three variables for inclusion in the calculation of adjusted summary estimates. If studies reported sex-stratified age- and smoking-adjusted OR, we combined these estimates by calculating age-, smoking- and sex-adjusted OR.[13] In such calculations, the inverse of the variance was used to weight the reported sex-stratified estimates. For studies that reported separate adjusted OR for several consumption strata, we estimated a total OR for current or ever use weighted by the exposure specific prevalence of the non-cases.[14]

Statistical analysis

To detect publication or related biases, we explored asymmetry in funnel plots, i.e. plots of effect estimates against their estimated precision.[15] This is examined visually and the degree of asymmetry is measured using Egger's unweighted regression asymmetry test.[16,17] If a study appeared in more than one publication, data from the last publication were used for statistical analysis. We estimated the summary OR and corresponding 95% CI with random effects meta regression analysis using the Stata statistical software.[18,19] The between-study variance was estimated iteratively, using the empirical Bayes method.[19,20] Summary OR were calculated for total coffee consumption (current drinker versus non-drinker and ever drinker versus never-drinker), decaffeinated coffee (drinker versus non-drinker) and total tea consumption (current drinker versus non-drinker and ever drinker versus never-drinker). We did not perform subgroup analyses by beverage type other than decaffeinated coffee or by the number of cups consumed per day due to sparse data. Data were analysed separately or combined for men and women, depending on data availability in the original studies. Furthermore, we evaluated the influence of the type of adjustment for cigarette smoking in the component studies on the summary association between current coffee and tea consumption and bladder cancer risk. This analysis might give some insight into the existence of residual confounding from inadequate adjustment of cigarette smoking in the component studies. To explore reasons for observed heterogeneity, sensitivity analyses were performed on the study characteristics measuring instrument, anatomical site of the neoplasm and source of cases and controls, and their influence on the association between coffee or tea consumption and urinary tract cancer was tested.

Results

Study characteristics

We identified 69 articles reporting follow-up or case-control studies on coffee and tea consumption and urinary tract cancer published between 1968 and 1999.[21–89] Generally, the association between coffee or tea consumption and urinary tract cancer was not the main research hypothesis. Twenty articles were excluded because they did not provide sufficient information to estimate a summary OR and corresponding standard error[21–29,33–39] or did not use incident cases.[30–32,87] The remaining 49 articles described three follow-up studies[40,41,84,88] and 34 case-control studies with incident cases.[42–83,85,86,89] One case-control study that provided separate associations for parts of the study performed in the US, the UK and Japan was considered as three separate studies.[45] The case-control studies were population-based (n = 12),[42–56,83,89] hospital-based (n = 18)[57–78,85,86] or neighbourhood-based (n = 3).[79–81] One case-control study used both population- and hospital-based controls.[82] The hospital controls in most case-control studies did not have any diet- or smoking-related disease. The case-control studies also varied with regard to their criteria of case selection. Seven case-control studies identified cancer cases in defined populations,[44,46,47,49,51,52,55,56,79,80,83,89] 22 case-control studies selected cases from hospitals[42,43,45,53,58–63,65–78,81,82,85,86] and five case-control studies used both sources.[48,50,54,57,64] Information on coffee and tea consumption was obtained by interview,[40,42–58,61,62,64–83,86,89] self-administered questionnaire[41,59,60,85,88] or both techniques.[63,84] Some studies included all neoplasms of the urinary tract as cases, of which more than 90% were found to involve bladder cancer,[42,45,48,53,60,73,84,85] while others selected only bladder carcinomas,[40,41,44,46,47,49–52,54–59,62–72,74–79,81–83,86,88] carcinomas of the renal pelvis[61,89] or carcinomas of renal pelvis and ureter combined.[80] Most studies used histologically confirmed cases with urothelial cell cancer (Table 1).

Table 1 Study characteristics of published epidemiological studies concerning coffee and tea consumption and cancer of the urinary tract, ordered by year of publication

Ref.	First author	Publication year	Country	Anatomical site of urinary tract	Study design			Coffee/Tea assessment
						Case-control study		
					Follow-up study	Case source	Control source	
57	Dunham	1968	US	bladder	–	both	hospital	interview
42	Cole[a]	1971	US	urinary tract	–	hospital	population	interview
58	Bross	1973	US	bladder	–	hospital	hospital	interview
59	Morgan	1974	Canada	bladder	–	hospital	hospital	questionnaire
43	Schmauz[a]	1974	US	urinary tract	–	hospital	population	interview
60	Simon	1975	US	urinary tract	–	hospital	hospital	questionnaire
61	Armstrong	1976	UK	renal pelvis	–	hospital	hospital	interview
44	Miller[b]	1977	Canada	bladder	–	population	population	interview
62	Wynder[c]	1977	US	bladder	–	hospital	hospital	interview
63	Mettlin	1979	US	bladder	–	hospital	hospital	both
79	Howe[b]	1980	Canada	bladder	–	population	neighbour	interview
64	Cartwright	1981	UK	bladder	–	both	hospital	interview
45	Morrison	1982	US	urinary tract	–	hospital	population	interview
45	Morrison	1982	UK	urinary tract	–	hospital	population	interview
45	Morrison[d]	1982	Japan	urinary tract	–	hospital	population	interview
65	Najem	1982	US	bladder	–	hospital	hospital	interview
46	Hartge[e]	1983	US	bladder	–	population	population	interview
47	Marrett[e]	1983	US	bladder	–	population	population	interview
89	McLaughlin	1983	US	renal pelvis	–	population	population	interview
48	Ohno[d]	1985	Japan	urinary tract	–	both	population	interview
66	Rebekalos	1985	Greece	bladder	–	hospital	hospital	interview
85	Bravo	1986	Spain	urinary tract	–	hospital	hospital	questionnaire
40	Heilbrun[f]	1986	US	bladder	yes	–	–	interview
49	Jensen	1986	Denmark	bladder	–	population	population	interview
67	Kabat[c]	1986	US	bladder	–	hospital	hospital	interview
83	Piper	1986	US	bladder	–	population	population	interview
68	Iscovich	1987	US	bladder	–	hospital	hospital	interview
69	Ciccone	1988	Italy	bladder	–	hospital	hospital	interview
50	Risch	1988	Canada	bladder	–	both	population	interview
52	Slattery[e]	1988	US	bladder	–	population	population	interview
51	Slattery[e]	1988	US	bladder	–	population	population	interview
70	LaVecchia[g]	1989	Italy	bladder	–	hospital	hospital	interview
80	Ross	1989	US	renal pelvis[h]	–	population	neighbour	interview
71	Clavel	1991	France	bladder	–	hospital	hospital	interview
41	Mills	1991	US	bladder	yes	–	–	questionnaire
53	Nomura	1991	US	urinary tract	–	hospital	population	interview
72	d'Avanzo[g]	1992	Italy	bladder	–	hospital	hospital	interview
73	Kunze	1992	Germany	urinary tract	–	hospital	hospital	interview
74	LaVecchia[g]	1992	Italy	bladder	–	hospital	hospital	interview
84	Chyou[f]	1993	US	urinary tract	yes	–	–	both
82	Pujolar	1993	Spain	bladder	–	hospital	both	interview
81	Vena	1993	US	bladder	–	hospital	neighbour	interview
75	Barbone[g]	1994	Italy	bladder	–	hospital	hospital	interview
76	Hours	1994	France	bladder	–	hospital	hospital	interview
54	Momas	1994	France	bladder	–	both	population	interview
55	Sturgeon[e]	1994	US	bladder	–	population	population	interview
77	d'Avanzo[g]	1995	Italy	bladder	–	hospital	hospital	interview
56	Bruemmer	1997	US	bladder	–	population	population	interview
78	Donato[h]	1997	Italy	bladder	–	hospital	hospital	interview
86	Donato[h]	1998	Italy	bladder	–	hospital	hospital	interview
88	Michaud	1999	US	bladder	yes	–	–	questionnaire

[a,b,c,d,e,f,g] same study has appeared in more than one publication, [h] and ureter

Risk estimation

Funnel plots showed no asymmetry, neither visually nor in terms of statistical significance (*P*-values ≥0.51 and ≥0.12 for current coffee and tea consumption, respectively)(Figure 1). Table 2 summarizes the unadjusted and adjusted results of observational studies reporting the association between coffee and tea consumption. Almost all included articles provided some information to estimate an association between coffee consumption and urinary tract cancer.[41–73,75–86,88,89] The study specific effect estimates are available upon request. The unadjusted summary OR for current coffee drinkers compared to non-drinkers were 1.30 (95% CI: 1.15–1.47) for 25 studies with only men, 1.18 (95% CI: 0.96–1.44) for 23 studies with only women and 1.26 (95% CI: 1.11–1.43) for 25 studies with men and women combined. The adjusted summary OR for current coffee consumption were somewhat lower after adjustment for age, smoking and sex. The adjusted summary OR for current coffee consumption were 1.26 (95% CI: 1.09–1.46), 1.08 (95% CI: 0.79–1.46) and 1.18 (95% CI: 1.01–1.38) for 16 studies with men, 12 studies with women and 14 studies with men and women combined. The adjusted summary associations between ever versus never coffee consumption and urinary tract cancer also showed small increased risks, although the unadjusted summary estimates were higher. The consumption of decaffeinated coffee also appeared to be associated with bladder cancer risk, although it was not statistically significant (Table 2).

Twenty articles provided sufficient information to estimate a summary association of tea consumption.[40,46,48–53,56,59,60,68,71–74,79,84,88,89] Neither the unadjusted nor the age-, smoking-, and sex-adjusted summary associations provided evidence for a positive association between current tea consumption and the risk of urinary tract cancer (Table 2). The sex-specific adjusted summary OR for current tea consumers compared to non-drinkers were 1.08 (95% CI: 0.94–1.24) for seven studies with men and 0.99 (95% CI: 0.81–1.20) for six studies with women. Seven studies allowed calculation of adjusted summary OR for men and women combined: 1.01 (95% CI: 0.92–1.10). Very few studies reported an effect estimate for ever versus never tea consumption. Both unadjusted and adjusted summary associations for ever tea consumption did not indicate a positive association between tea consumption and bladder cancer risk. All summary associations were around unity (Table 2).

Confounding by cigarette smoking

Seventeen studies presented adjusted OR for current coffee and tea consumption for men and women combined. Of these, seven studies adjusted for cigarette smoking by incorporating one smoking variable (mostly smoking status) in a regression model.[48,56,62,65,69,77,82] Seven other studies used a combination of cigarette smoking features (mostly amount and duration) to adjust for cigarette smoking.[49,50,52,53,55,73,78] The type of adjustment for three studies remains unclear.[41,66,74] The summary OR for current coffee consumption compared to non-drinkers was larger in studies in which several cigarette smoking features were used to adjust for cigarette smoking compared to studies in which only one smoking variable was used (Table 3). For tea consumption, the type of adjustment for cigarette smoking did not influence the summary associations substantially (Table 3).

Sensitivity analysis

We further examined the crude association of current coffee and tea consumption and urinary tract cancer by measuring instrument, sources of cases and controls and anatomical site of the tumour to explore their influence on the outcome estimates in case-control studies that provided information for men and women combined (Figure 2). Unfortunately, none of the follow-up studies provided sufficient information for men and women combined to contribute to this sensitivity analysis. All tests for multiplicative interaction were statistically non-significant. Most subset-specific summary OR did not differ substantially. Neither selection on anatomical site of the tumour nor selection on the source of cases and controls altered the summary OR. It appeared, however, that the summary associations for studies that used interviewing techniques were higher than for studies that used self-administered questionnaires (Figure 2).

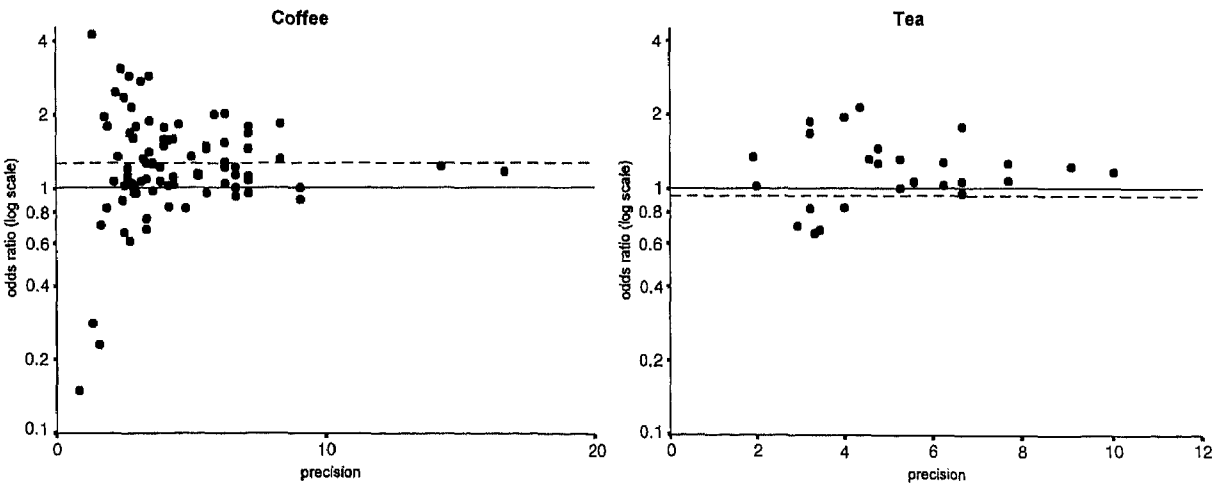

Figure 1 Funnel plots for current coffee and tea drinkers versus non-drinkers, unadjusted

Interrupted and uninterrupted reference lines indicate total summary odds and null effect.

Table 2 Summary odds ratios (OR) for coffee and tea consumption both unadjusted and adjusted for age, smoking and sex calculated from epidemiological studies

Coffee/Tea consumption	Male			Female			Male and Female		
	No.[a]	OR (95% CI)	Q^b (*P*)	No.[a]	OR (95% CI)	Q^b (*P*)	No.[a]	OR (95% CI)	Q^b (*P*)
Unadjusted summary odds ratios									
Coffee consumption									
Current versus non drinker	25	1.30	45.94	23	1.18	35.00	25	1.26	56.36
		(1.15–1.47)	(<0.01)		(0.96–1.44)	(0.04)		(1.11–1.43)	(<0.01)
Ever versus never drinker	7	1.92	13.57	6	1.66	15.47	7	1.85	22.43
		(1.37–2.70)	(0.04)		(0.81–3.38)	(<0.01)		(1.21–2.82)	(<0.01)
Decaffeinated coffee consumption									
Drinker versus non-drinker	4	1.08	3.79	2	0.56	0.01	4	1.01	6.52
		(0.88–1.32)	(0.29)		(0.35–0.91)	(0.91)		(0.74–1.37)	(0.09)
Tea consumption									
Current versus non-drinker	8	1.04	10.11	8	0.97	9.179	0.94	14.59	
		(0.89–1.21)	(0.18)		(0.78–1.20)	(0.24)		(0.82–1.08)	(0.07)
Ever versus never drinker	3	0.94	3.69	2	1.36	14.90	3	0.77	7.16
		(0.66–1.35)	(0.16)		(0.18–10.11)	(<0.01)		(0.47–1.25)	(0.03)
Adjusted summary odds ratios									
Coffee consumption									
Current versus non-drinker	16	1.26	40.15	12	1.08	26.68	14	1.18	30.03
		(1.09–1.46)	(<0.01)		(0.79–1.46)	(<0.01)		(1.01–1.38)	(<0.01)
Ever versus never drinker	6	1.19	6.03	5	1.16	4.25	5	1.18	1.06
		(1.00–1.41)	(0.30)		(0.86–1.56)	(0.37)		(1.03–1.36)	(0.90)
Decaffeinated coffee consumption									
Drinker versus non-drinker	5	1.04	4.47	3	1.18	5.76	4	1.18	2.40
		(0.86–1.25)	(0.35)		(0.63–2.22)	(0.06)		(0.99–1.40)	(0.49)
Tea consumption									
Current versus non-drinker	7	1.08	9.07	6	0.99	6.96	7	1.01	5.47
		(0.94–1.24)	(0.17)		(0.81–1.20)	(0.22)		(0.92–1.10)	(0.49)
Ever versus never drinker	4	1.02	2.97	3	1.00	13.81	3	1.09	9.60
		(0.84–1.25)	(0.40)		(0.27–3.73)	(<0.01)		(0.54–2.17)	(0.15)

[a] Number of analysed studies.

[b] χ^2-test for heterogeneity.

Table 3 Summary odds ratios (OR) for current coffee and tea consumption compared to non-drinkers according to the type of adjustment for cigarette smoking made in the component studies, for men and women combined

Coffee/tea consumption	Adjusted for one cigarette smoking variable[a]			Adjusted for several cigarette smoking features[b]		
	N^c	OR (95% CI)	Q^d (*P*)	N^c	OR (95% CI)	Q^d (*P*)
Coffee consumption						
Current versus non-drinker	7	1.04	8.90	5	1.36	11.74
		(0.89–1.22)	(0.18)		(1.08–2.01)	(0.02)
Tea consumption						
Current versus non-drinker	1	1.02	N/A	5	1.09	3.25
		(0.77–1.33)			(0.96–1.25)	(0.52)

[a] *Adjusted for cigarette smoking status or amount only.*

[b] Adjusted for any combination of cigarette smoking status, amount or duration.

[c] Number of analysed studies.

[d] χ^2-test for heterogeneity.

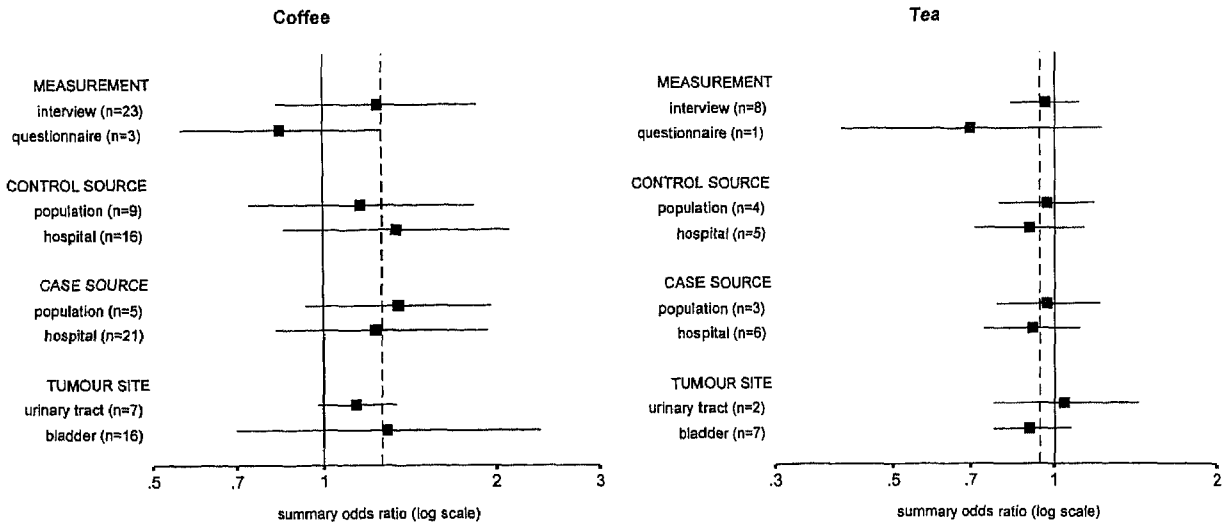

Figure 2 Forest plots of crude summary odds ratios and 95% confidence intervals of urinary tract cancer for current coffee and tea consumers compared to non-drinkers, by measuring instrument, source of cases and controls and tumour site for case-control studies with men and women combined

Interrupted and uninterrupted reference lines indicates total summary odds and null effect.

Discussion

We were able to retrieve 49 articles reporting follow-up or case-control studies on coffee and tea consumption and the risk of human urinary tract cancer in the present meta-analysis. These observational studies can be considered as the best available epidemiological evidence, because no human experimental studies have been conducted. The available evidence suggests a small increased risk for coffee consumers remaining after adjustment for age, smoking and sex. The consumption of tea seems not to be related to an increased risk of urinary tract cancer.

We did not attempt to uncover unpublished observations and excluded studies that did not meet the predetermined criteria. The excluded studies showed inconsistent results for coffee consumption. The estimated associations of coffee consumption ranged from moderately inverse,[27,32,38] through no association[24–26,28,29,31,90] to moderately positive.[22,23,30,33–37,39,91] Although three of the excluded studies on tea consumption have presented positive associations,[34,37] most studies could not confirm these findings.[21,23,27,33,35,90] Publication bias might arise by excluding these studies. However, we did not identify funnel plot asymmetry in our meta-analysis, either visually or in terms of statistical significance.

The definition of 'current drinker' at baseline (follow-up studies) or in the reference period (case-control studies) might have caused heterogeneity between studies, because the follow-up period and the reference date varied between the included studies. Therefore, results have to be interpreted with caution. Because of potential additional heterogeneity in populations, designs and analyses of various studies, we assumed that the true effects being estimated would vary between the studies in addition to the usual sampling variation in the estimates (within studies), even if the test for heterogeneity could not identify heterogeneity. To account for both sources of variation we used a random effects meta regression analysis to combine the results from the primary studies.[20] The random effect approach provides some allowance for heterogeneity in studies beyond sampling error.

The summary OR were similar across sources of the cases and controls in the case-control studies. It appeared that the anatomical site of the tumour did not modify the association between coffee/tea consumption and urinary tract cancer risk. Because the overwhelming majority of urinary tract tumours occurred in the urinary bladder and, since the renal pelvis and urether are covered by the same urothelium as the urinary bladder, no biologically plausible difference would be expected. Although we could not find statistically significant interaction effects, it appeared that the summary estimates of coffee and tea consumption were higher for studies that used interviewing techniques than for studies that used self-administered questionnaires. This contrast can be a consequence of response bias due to different assessment techniques or to chance alone.

Limitations in reported data meant that the summary OR could not be quantified by amount or type of tea or coffee, other than decaffeinated coffee. The included studies provided data on coffee or tea consumption within exposure categories with different cut-off points. Therefore, we had to dichotomize coffee and tea consumption in current consumption versus no consumption as well as ever consumption versus never consumption. It should be noted, that a dose-response analysis would give more information about the underlying association of coffee and tea consumption[92,93] with urinary tract cancer. However, the result of a dose-response analysis appears to depend heavily on the choice of assigned dose of the different exposure categories.[92] Hence, for a proper dose-response analysis, the number of exposure levels should be at least equal to four. More than 25% of the component studies reported three exposure levels at the most for coffee[55,57,63–66,73,76,77,84,85,87] and tea consumption.[48,50,52,53,72,74,79,73] Moreover, for more than 25% of the component studies, no dose-response analysis for the adjusted

OR was possible, because no exposure specific confidence intervals were reported. In fact, in only 14 out of 46 studies on coffee consumption and in two out of 14 on tea consumption, was a dose response analysis tolerable. With the above-mentioned considerations in mind, we have decided not to conduct dose-response analyses at all.

Although 49 articles contributed to this meta-analysis, only 30 provided sufficient information to permit calculation of OR, adjusted for at least age, smoking and sex. It was not possible to adjust for a specific set of confounders. The decision of authors to report adjusted effect estimates or not, may have been influenced by the results of the component studies. Similarly, the type of confounders that authors chose to adjust for varied and may to some extent have been driven by the data. Therefore, we also calculated unadjusted OR. Furthermore, focussing entirely on adjusted OR would have resulted in the exclusion of 39% of the studies that also had (crude) information on the association between coffee or tea consumption and cancer of the urinary tract. The presentation of both unadjusted and adjusted OR might give some insight into the potential confounding effect in particular of cigarette smoking. It remains possible that adjustment for smoking in the component studies, and therefore in our summary estimates, may have been inadequate if smoking was not carefully adjusted for. Yet, it appeared that adjustment for several cigarette smoking features in the component studies, compared to adjustment for one smoking variable alone, was not associated with a decreased risk of bladder cancer, as would be expected in the case of residual confounding. However, these results should be carefully interpreted since the comparisons were based on different subsets of studies. To avoid residual confounding, the impact of coffee drinking on bladder cancer risk can be evaluated in lifelong non-smokers.[7] Of all identified articles, four reported no increased risk associated with coffee drinking among non-smokers[23,58,67,79], whereas 11 studies suggested a moderately increased risk.[41,46,50,51,58,60,66,69,71,72,82]

In addition to residual confounding by cigarette smoking, another explanation for a small positive association between coffee consumption and cancer of the urinary tract might be that non-coffee-drinkers are a rather selected population. Non-coffee drinkers may differ also in occupation, the consumption of alcohol, tea, vegetables or fruit, or other lifestyle habits from the general population of coffee drinkers.

The consumption of tea seems not to be related to an increased risk of urinary tract cancer, although the results are based on only a few studies. Evidence from animal experimental studies shows that it is plausible that certain compounds present in tea (e.g. flavonoids) may even protect against the development of cancer.[94] If an inverse association between tea consumption and urinary tract cancer does exist, it is likely to be small. Further research from large epidemiological studies is needed is this area.

In accordance with earlier reviews and based on predominantly case-control data, we found that coffee consumption increases the risk of urinary tract cancer by approximately 20%. The consumption of tea seems not to be related to an increased risk of urinary tract cancer. The risk of urinary tract cancer related to the amount or type of coffee and tea needs further investigation.

KEY MESSAGES

- Based on a meta-analysis of 37 epidemiological studies, we estimated that coffee consumption increases urinary tract cancer risk by approximately 20%.
- The consumption of tea seems not to be related to an increased risk of urinary tract cancer.

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