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Miscellaneous

Coffee and tea consumption and mortality from all causes, cardiovascular disease and cancer: a pooled analysis of prospective studies from the Asia Cohort Consortium

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Abstract

Background: Accumulating evidence suggests that consuming coffee may lower the risk of death, but evidence regarding tea consumption in Asians is limited. We examined the association between coffee and tea consumption and mortality in Asian populations.

Methods: We used data from 12 prospective cohort studies including 248 050 men and 280 454 women from the Asia Cohort Consortium conducted in China, Japan, Korea and Singapore. We estimated the study-specific association of coffee, green tea and black tea consumption with mortality using Cox proportional-hazards regression models and the pooled study-specific hazard ratios (HRs) using a random-effects model.

Results: In total, 94 744 deaths were identified during the follow-up, which ranged from an average of 6.5 to 22.7 years. Compared with coffee non-drinkers, men and women who drank at least five cups of coffee per day had a 24% [95% confidence interval (CI) 17%, 29%] and a 28% (95% CI 19%, 37%) lower risk of all-cause mortality, respectively. Similarly, we found inverse associations for coffee consumption with cardiovascular disease (CVD)-specific and cancer-specific mortality among both men and women. Green tea consumption was associated with lower risk of mortality from all causes, CVD and other causes but not from cancer. The association of drinking green tea with CVD-specific mortality was particularly strong, with HRs (95% CIs) of 0.79 (0.68, 0.91) for men and 0.78 (0.68, 0.90) for women who drank at least five cups per day of green tea compared with non-drinkers. The association between black tea consumption and mortality was weak, with no clear trends noted across the categories of consumption.

Conclusions: In Asian populations, coffee consumption is associated with a lower risk of death overall and with lower risks of death from CVD and cancer. Green tea consumption is associated with lower risks of death from all causes and CVD.

Key words: Coffee, tea, mortality, Asian

Key Messages

- In a pooled analysis of 12 prospective cohort studies from the Asia Cohort Consortium conducted in China, Japan, Korea and Singapore, coffee consumption was associated with a lower risk of death overall and lower risks of death from cardiovascular disease and cancer.
- Green tea consumption was associated with lower risks of death from all causes and cardiovascular disease.
- Green tea consumption did not decrease the risk of cancer-specific deaths.

Introduction

Coffee and tea are the two most commonly consumed beverages in the world. Coffee consumption has increased considerably over the past few decades in Asia. Food-balance data from the United Nations Food and Agricultural Organization (FAO) have shown an increase in coffee supply per capita per day available for human consumption, which increased from 1.93 g in 1970 to 10.65 g in 2013 in Japan and 0.07 g in 1970 to 3.06 g in 2013 in Korea.[1] Asia has a long tradition of drinking tea, with green tea being one of the most popular types of tea consumed. China and Japan accounted for >90% of the worldwide green tea production in 2015–2017.[2] The potential health benefits associated with drinking coffee and tea have drawn the attention of both researchers and the general public because coffee and tea are rich sources of antioxidants.[3,4]

Coffee consumption has been inversely associated with several chronic diseases, including type 2 diabetes,[5] cardiovascular disease (CVD),[6] stroke,[7] Parkinson's disease,[8] advanced prostate cancer,[9] endometrial cancer[10] and liver cancer.[11] Moreover, cohort studies in the USA[12–15] and Europe[16] have consistently found that coffee consumption was associated with lower risk of both all-cause and cause-specific mortality. A recent dose–response meta-analysis of three Japanese cohort studies reported that the largest reduction in the all-cause mortality was noted in the group consuming four cups of coffee per day but that there was no further reduction in the groups that consumed more than four cups per day.[17] Comparatively, few cohort studies have explored the association of green tea consumption with all-cause or chronic disease-specific mortality. In Japanese populations, green tea consumption has been associated with a lower risk of gastric cancer in women but not in men.[18] Five prospective Asian cohort studies, including three that were included in our analysis, evaluated the association between green tea consumption and mortality, but the results were not consistent for cause-specific mortality.[19–23]

The objective of this study was to evaluate the association of coffee, green tea and black tea consumption with all-cause and cause-specific mortality in 12 ethnically diverse Asian cohorts and these cohorts included nearly half a million men and women, involved considerable follow-up times and were used to study a broad range of dietary and other lifestyle exposures.

Methods

Study population

The Asia Cohort Consortium is an international collaboration that aims to understand the aetiology of common and rare diseases by combining data from multiple Asian prospective cohort studies.[24,25] The members of the Asia Cohort Consortium include established cohorts or new cohorts that are in the development stage across Asia.[25] The established cohorts include cohorts in Bangladesh, China, Japan, Korea, Singapore and Taiwan. Among these cohorts, the study presented here included data from 12 prospective cohort studies that agreed to participate in this project and represented the four countries that collected baseline information on coffee or tea consumption and follow-up data on mortality. Of these cohorts, seven were conducted in Japan, two in mainland China, two in Korea and one in Singapore. These studies included the Japan Public Health Center-based Prospective Study (JPHC) I,[26] the JPHC II,[26] Miyagi Cohort (Miyagi),[27] the Ohsaki National Health Insurance Cohort Study (Ohsaki),[27] the Life Span Study Cohort (RERF),[28] the 3 Prefecture Miyagi,[29] the 3 Prefecture Aichi,[29] the Seoul Male Cancer Cohort (Seoul Male),[30] the Korean Multi-center Cancer Cohort Study (KMCC),[31] the Shanghai Men's Health Study (SMHS),[32] the Shanghai Women's Health Study (SWHS)[33] and the Singapore Chinese Health Study (SCHS).[34] Among a total of 529 362 participants, we excluded those who were missing data regarding an entry date ($n = 858$). Thus, 248 050 men and 280 454 women were considered for the subsequent analyses. For the coffee analyses, we excluded those who did not provide information on coffee consumption ($n = 198\ 180$), resulting in an analytic sample of 330 324 participants (161 177 men and 169 147 women). For the green tea analyses, we excluded those who did not provide information on green tea consumption ($n = 51\ 312$), resulting in an analytic sample of 477 192 participants (225 622 men and 251 570 women). Pooled analysis of the Asia Cohort Consortium (ACC) cohorts was approved by the ethical committee of the National Cancer Center Japan (number 2014–041) and each study was approved by respective ethic committees overseeing the participating studies. Written or oral consent was obtained from all subjects who participated in the study.

Assessment of coffee and tea intake

Each study assessed the participants' diets at baseline using a self-administered food-frequency questionnaire (FFQ),[34–39] and coffee and tea intake was defined as the number of servings (i.e. one cup) consumed per day. Information on coffee consumption was collected in 10 studies (Supplementary Table S1, available as Supplementary data at *IJE* online). Seven studies (JPHC I, JPHC II, Miyagi, 3 Prefecture Miyagi, Ohsaki, RERF and SCHS) collected data on regular coffee and two studies (KMCC and Seoul Male) collected data on any type of coffee. One study (3 Prefecture Aichi) collected data on both ground coffee and instant coffee. The two Shanghai-based studies (SMHS and SWHS) did not query about coffee consumption due to the low consumption in the population. Information on tea consumption was collected in all 12 studies, with all studies assessing green tea consumption and all but two studies (Seoul Male and KMCC) assessing black tea consumption (Supplementary Table S1, available as Supplementary data at *IJE* online).

Coffee- and tea-consumption data were obtained from the participants using questions of four to nine predefined categories or by using open-ended questions. JPHC, Miyagi, 3 Prefecture Miyagi, Ohsaki and 3 Prefecture Aichi assessed the intake with similar categories: almost never or does not drink, sometimes drink or one or two, or three or four days per week, one to two cups per day, three to four cups per day and five or more cups per day. Korean and Singapore studies provided information on continuous servings or frequencies per day based on their FFQs; e.g. in the KMCC, continuous servings per day were provided based on frequencies written as none, once per month, two or three times per month, once per week, two or three times per week, four to six times per week, once per day, and two or more times per day. SMHS and SWHS asked participants about the types and amounts of tea they consumed. We categorized total coffee, green tea and black tea consumption data from each cohort using the following categories: almost none, less than one cup per day, one to under three cups per day, three to under five cups per day, and five or more cups per day. For black tea, we collapsed the top two categories into one because of an insufficient number of cases and therefore used four frequency categories: almost never, less than one cup per day, one to under three cups per day, and three or more cups per day. Six studies asked whether participants put sugar or milk/cream in their coffee or tea, but the majority of the studies did not ask the amount used.

Assessment of other environmental factors

Age, height, weight, cigarette-smoking history including intensity and duration, and alcohol-consumption data were collected in all 12 studies using structured questionnaires; body mass index [BMI, weight (kg)/height (m^2)] was calculated using the baseline height and weight of the participants. Energy intake was assessed using a structured food-frequency questionnaire in eight of the cohort studies. Educational attainment was also assessed in eight studies. Individual-level data from all participating cohorts were collected and harmonized for the statistical analyses.

Death ascertainment

Data on all-cause and cause-specific mortality were obtained via linkage to death-certificate data or by active follow-ups. Our primary endpoint was death from any cause. Based on the ninth or tenth revision of the International Statistical Classification of Diseases (ICD-9 or 10), outcomes of interest included CVD (using ICD-10 codes I00–I99; ICD-9 codes 390–459) and cancer (ICD-10 codes C00–C97; ICD-9 codes 140–239). Deaths from other causes were defined as all other ICD codes.

Statistical analysis

The means (standard deviation) or proportions of the baseline characteristics based on the coffee or green tea consumption were calculated. Person-years of follow-up were estimated from the baseline entry date until the date of death, loss to follow-up (if applicable) or end of study follow-up, whichever came first. Multivariable Cox proportional-hazards regression models were used to obtain the study-specific hazard ratio (HR) estimates for coffee or tea intake and mortality, adjusting for potential confounding factors, including age at baseline (years; continuous), BMI (kg/m^2; <18.5, 18.5–19.9, 20.0–24.9, 25.0–29.9 and ≥30.0), smoking status (never-smoker, former smoker, current smoker with <20 pack-years of smoking and current with ≥20 pack-years of smoking), alcohol intake (non-drinker, 1–155 g/week and ≥156 g/week), education level (less than secondary, secondary and more than secondary school) and energy intake (kcal/day; continuous). Coffee and tea intakes were mutually adjusted in the multivariable analyses. Because information on the education level was not available for some participants in eight studies that assessed this information, participants with missing data were coded with missing indicator variables. For energy intake, missing data were coded using the sex-specific median values of energy intake. The proportions of missing data observed were 2.4% for education level and 3.4% for energy intake among studies that assessed this information.

After calculating the study- and sex-specific HRs for each coffee and green tea intake category, we combined the $\log_e$ HRs using a random-effects model.[40] The study-specific HRs were weighted by the inverse of their variance. Studies that had no participants in a category were not included in the pooled estimate for that category. We estimated *P*-values for trends using the regression coefficients by treating the category midpoint of each category as an ordinal variable in each individual study and then combined the coefficients using a random-effects model. We tested for and quantified the heterogeneity of the HRs for the highest category across studies using the *Q* statistics.[40]

To evaluate for any potential effect modifiers, we conducted analyses that were stratified by the baseline age (<54 and ≥54 years; the median age of cohorts combined); baseline smoking status (never, former and current for men, never and ever for women); alcohol use (non-drinker and current drinker); BMI level (15–18.4, 18.5–24.9 and ≥25.0 kg/m^2); education level (lower than secondary and secondary education or higher); baseline co-morbidities including diabetes, hypertension, cancer and coronary heart disease (yes and no); and energy intake (<median, ≥median kcal/day). We combined the data sets from each participating cohort into one harmonized data set for subgroup analyses because of the small number of deaths in each stratum per study (aggregated analysis). In the aggregated analysis, the study centre was adjusted as a stratification variable. In the sensitivity analysis, we estimated the HRs of coffee and green tea with the all-cause mortality and excluded participants who died within 3 years of follow-up after baseline.

All statistical tests were two-sided and *P*-values of <0.05 were considered significant. All analyses were carried out using SAS version 9.3 (SAS Institute, Cary, NC) and STATA version 14.0 (Stata Corporation, Texas, USA).

Results

In total, 94 744 deaths were identified during the follow-up periods, which ranged from an average of 6.5 to 22.7 years (Supplementary Table S2, available as Supplementary data at *IJE* online). Of these, 29 968 deaths from CVD and 32 765 deaths from cancer were documented. Participants' mean ages ranged from 49.2 to 60.7 years and the mean BMIs ranged from 21.9 to 23.7 kg/m^2 in men and 21.9 to 24.1 kg/m^2 in women (Table 1).

The proportions of coffee drinkers and green tea drinkers ranged from 55.6% to 84.2% and 1.5% to 97.8%, respectively (Supplementary Table S1, available as Supplementary data at *IJE* online). Frequent coffee and green tea drinkers were more likely to smoke cigarettes

Table 1 Major characteristics of participating cohorts

Cohort (sex)	Baseline cohort size	Age, years, mean (sd)	BMI, kg/m^2, mean (sd)	Total energy intake, kcal/day, mean (sd)	Current smoker, %	Current alcohol drinker, %	Educational level (more than secondary), %
JPHC I (M)[26]	20 464	49.5 (5.9)	23.6 (2.8)	2188.1 (694.7)	53.2	79.3	12.7
JPHC I (F)[26]	22 307	49.7 (5.9)	23.6 (3.1)	1430.8 (388.0)	5.8	23.2	10.5
JPHC II (M)[26]	26 417	54.0 (8.8)	23.5 (2.9)	1748.5 (587.0)	51.1	74.7	–
JPHC II (F)[26]	29 293	54.4 (8.8)	23.4 (3.2)	1102.0 (291.4)	6.4	19.7	–
Miyagi Cohort Study (M)[27]	21 504	51.7 (7.6)	23.5 (2.8)	1590.0 (444.2)	61.4	77.0	14.2
Miyagi Cohort Study (F)[27]	23 363	52.2 (7.4)	23.7 (3.1)	1560.5 (448.3)	9.0	25.8	12.9
3-Prefecture Miyagi (M)[29]	13 297	56.5 (11.0)	23.1 (3.3)	–	54.1	76.5	–
3-Prefecture Miyagi (F)[29]	16 257	57.1 (11.2)	23.4 (3.6)	–	9.3	32.5	–
Ohsaki (M)[27]	23 000	59.5 (10.6)	23.3 (3.1)	1687.1 (442.1)	54.8	72.1	7.6
Ohsaki (F)[27]	24 710	60.7 (9.9)	23.8 (3.5)	1281.4 (316.4)	8.6	22.8	8.0
RERF (M)[28]	19 523	52.4 (11.1)	21.9 (3.2)	–	78.9	83.9	18.8
RERF (F)[28]	29 448	51.8 (15.1)	22.0 (3.8)	–	13.8	27.7	6.5
3-Prefecture Aichi (M)[29]	15 271	55.7 (11.0)	22.3 (2.8)	–	55.0	78.9	–
3-Prefecture Aichi (F)[29]	16 941	56.6 (11.4)	21.9 (3.1)	–	12.7	42.9	–
Seoul male (M)[30]	13 953	49.2 (5.2)	23.4 (2.4)	2020.4 (931.4)	50.4	66.7	53.7
KMCC (M)[31]	5324	54.9 (12.7)	23.0 (2.9)	–	58.0	63.6	–
KMCC (F)[31]	7958	55.1 (12.0)	24.1 (3.4)	–	7.5	17.9	–
SMHS (M)[32]	61 343	55.3 (9.7)	23.7 (3.1)	1909.0 (484.7)	58.7	29.3	59.8
SWHS (F)[33]	74 874	52.6 (9.1)	24.0 (3.4)	1680.8 (402.8)	2.4	1.9	41.5
SCHS (M)[34]	27 954	56.7 (8.0)	23.0 (3.2)	1749.5 (608.8)	36.2	31.1	8.0
SCHS (F)[34]	35 303	56.3 (8.0)	23.2 (3.3)	1398.8 (472.0)	6.3	9.0	2.9
Total	528 504*	54.3 (10.0)	23.3 (3.3)	1645.0 (561.1)	30.2	26.6	25.0

M, men; F, women; JPHC, Japan Public Health Center-based Prospective Study; Miyagi, Miyagi Cohort Study; Ohsaki, Ohsaki National Health Insurance Cohort Study; RERF, Radiation Effects Research Foundation Life Span Study; Seoul Male, Seoul Male Cohort Study; KMCC, Korean Multi-center Cancer Cohort Study; SMHS, Shanghai Men's Health Study; SWHS, Shanghai Women's Health Study; SCHS, Singapore Chinese Health Study; BMI, body mass index.

Table 2 Pooled hazard ratios (HRs)[a] and 95% confidence intervals (CIs) of all-cause and cause-specific mortality according to coffee consumption

	Coffee consumption						
	Almost never	Less than 1 cup/day	1 to <3 cups/day	3 to <5 cups/day	≥5 cups/day[b]	*P* for trend	*P* for heterogeneity[c]
Men							
No. of participants	35 409	47 369	62 696	11 537	4166		
Total person-years	434 288	603 860	786 344	133 874	48 269		
All-cause-specific mortality (no. of cases)	10 216	10 605	11 580	1797	706		
HR (95% CI)	1.00 (Ref.)	0.83 (0.79–0.87)	0.78 (0.73–0.83)	0.76 (0.67–0.85)	0.76 (0.71–0.83)	<0.001	0.934
CVD-specific mortality (no. of cases)	2843	2858	3286	430	180		
HR (95% CI)	1.00 (Ref.)	0.80 (0.75–0.85)	0.77 (0.68–0.87)	0.67 (0.55–0.81)	0.73 (0.62–0.85)	<0.001	0.818
Cancer-specific mortality (no. of cases)	3561	3994	4633	776	291		
HR (95% CI)	1.00 (Ref.)	0.88 (0.84–0.93)	0.86 (0.81–0.92)	0.88 (0.79–0.97)	0.85 (0.75–0.97)	0.004	0.544
Other cause-specific mortality (no. of cases)	3812	3753	3661	591	235		
HR (95% CI)	1.00 (Ref.)	0.81 (0.75–0.87)	0.73 (0.67–0.80)	0.66 (0.55–0.81)	0.72 (0.62–0.84)	<0.001	0.296
Women							
No. of participants	44 709	50 860	61 960	8623	2995		
Total person-years	565 582	683 414	802 334	104 830	36 053		
All-cause-specific mortality (no. of cases)	9461	7444	7253	639	265		
HR (95% CI)	1.00 (Ref.)	0.86 (0.82–0.90)	0.80 (0.72–0.89)	0.65 (0.54–0.78)	0.72 (0.63–0.81)	<0.001	0.686
CVD-specific mortality (no. of cases)	3359	2385	2250	172	75		
HR (95% CI)	1.00 (Ref.)	0.83 (0.76–0.92)	0.75 (0.63–0.89)	0.61 (0.48–0.79)	0.73 (0.58–0.92)	<0.001	0.452
Cancer-specific mortality (no. of cases)	2607	2466	2764	282	110		
HR (95% CI)	1.00 (Ref.)	0.91 (0.86–0.97)	0.90 (0.81–1.00)	0.75 (0.57–0.98)	0.81 (0.63–1.04)	0.039	0.208
Other cause-specific mortality (no. of cases)	3495	2593	2239	185	80		
HR (95% CI)	1.00 (Ref.)	0.85 (0.79–0.91)	0.75 (0.67–0.84)	0.60 (0.50–0.72)	0.68 (0.54–0.85)	<0.001	0.870

CVD, cardiovascular disease.

[a]Pooled HRs (95% CIs) were calculated using a random-effects model after study-specific HRs (95% CIs) were obtained using Cox proportional-hazards regression models. Multivariate models were adjusted for baseline age (years; continuous), body mass index (BMI, kg/m^2; <18.5, 18.5–19.9, 20.0–24.9, 25.0–29.9 and ≥30.0) and smoking status (never-smoker, former smoker, current with <20 pack-years of smoking and current with ≥20 pack-years of smoking), alcohol intake (non-drinker, 1–155 and ≥156 g/week), educational level (less than secondary, secondary and more than secondary school graduate), energy intake (kcal/day; continuous) and green tea consumption (almost never, <1, 1 to <3, 3 to <5 and ≥5 cups/day).

[b]The RERF (Radiation Effects Research Foundation Life Span Study), KMCC (Korean Multi-center Cancer Cohort Study) and Seoul male cohort were excluded from the 3 to <5 and ≥5 cups/day categories because there was no one in these categories due to the way that frequency of intake was assessed in these studies (the highest category was >2 cups/day).

[c]*P* for heterogeneity for the highest category was calculated using the Q statistic.

than non-drinkers (Supplementary Table S3, available as Supplementary data at *IJE* online). A lower proportion of men and women who almost never drank coffee vs those who drank more than five cups per day were current smokers (43.1% vs 74.6% and 5.9% vs 23.7%, respectively). Similarly, a lower proportion of men and women who almost never drank green tea vs those who drank more than five cups per day were current smokers (45.9% vs 59.1% and 4.1% vs 9.9%, respectively). Women, but not men, who reported drinking coffee were more likely to drink alcohol, and both women and men who reported drinking green tea were more likely to drink alcohol. Among women, regular coffee drinkers were more educated than non-drinkers, but this trend was not found in men. Participants who drank green tea had completed less education on average than non-drinkers.

Coffee consumption and all-cause and cause-specific mortality

We found that a higher coffee consumption was associated with a lower risk of all-cause mortality as well as lower risks of mortality from CVD and cancer among men and women; the HRs [95% confidence intervals (CIs)] for all-cause mortality when comparing participants who drank five or more cups per day to coffee non-drinkers were 0.76 (0.71, 0.83; *P* for trend <0.001) among men and 0.72 (0.63, 0.81; *P* for trend <0.001) among women (Table 2). We observed that the reduction in risk was slightly greater at five or more cups compared with less than one cup per day, but there was a lower risk of mortality among those consuming coffee at both lower and higher levels. The risk of CVD-specific mortality decreased with increasing coffee consumption among both men and women; the HRs (95% CIs) for five or more cups of coffee per day were 0.73 (0.62, 0.85) for men (*P* for trend <0.001) and 0.73 (0.58, 0.92) for women (*P* for trend <0.001) compared with those who did not drink coffee. Both men and women who regularly drank coffee had a lower risk of cancer mortality than non-drinkers. The exclusion of the men and women who died during the first 3 years of follow-up resulted in similar HR estimates for all-cause, CVD- and other cause-specific mortalities, but there was an attenuation in the HR estimates for the cancer-specific mortality (Supplementary Table S4, available as Supplementary data at *IJE* online).

When we stratified by risk factors, including baseline age, smoking status, alcohol use, BMI, education level and history of co-morbidities, the inverse associations for the all-cause mortality were consistent across the strata in both men (Figure 1) and women (Figure 2).

Green tea consumption and all-cause and cause-specific mortality

An increased green tea intake was associated with decreased risk of CVD- and other cause-specific mortality but not cancer-specific mortality (Table 3). The HRs (95% CIs) for CVD-specific mortality when comparing five or more cups per day to green tea non-drinkers were 0.79 (0.68, 0.91; *P* for trend <0.001) among men and 0.78 (0.68–0.90; *P* for trend 0.014) among women. There was no association between green tea consumption and cancer-specific mortality among men. However, women who consumed five or more cups per day had a 12% higher risk of cancer-specific deaths than non-drinkers. The results were similar when we excluded participants who died during the first 3 years of follow-up (Supplementary Table S5, available as Supplementary data at *IJE* online) or in subgroup analyses stratified by baseline age, smoking status, alcohol drinking, BMI, education level and history of co-morbidities in men (Supplementary Figure S1, available as Supplementary data at *IJE* online) and women (Supplementary Figure S2, available as Supplementary data at *IJE* online). The associations did not vary by energy intake (Supplementary Table S6, available as Supplementary data at *IJE* online).

Black tea consumption and all-cause and cause-specific mortality

We evaluated the association of black tea with all-cause and cause-specific mortality (10 studies; 205 783 men and 226 963 women). Because of the limited number of participants who drank black tea, we examined this association in the aggregated data set only. The HRs (95% CIs) for those who consumed fewer than three cups per day, compared with black tea non-drinkers, were generally below 1.0 for both men and women (Supplementary Table S7, available as Supplementary data at *IJE* online).

Discussion

In the Asia Cohort Consortium, we found that coffee consumption was associated with a lower risk of death from all causes, CVD and cancer. Consuming more than five cups of coffee was associated with a 24% and 28% lower risk of death in men and women, respectively. Green tea consumption was also inversely associated with the risk of death from all causes and CVD among both men and women but was associated with an increased risk of cancer death among women. In our study, black tea was less commonly consumed and the associations of black tea with mortality were inconsistent.

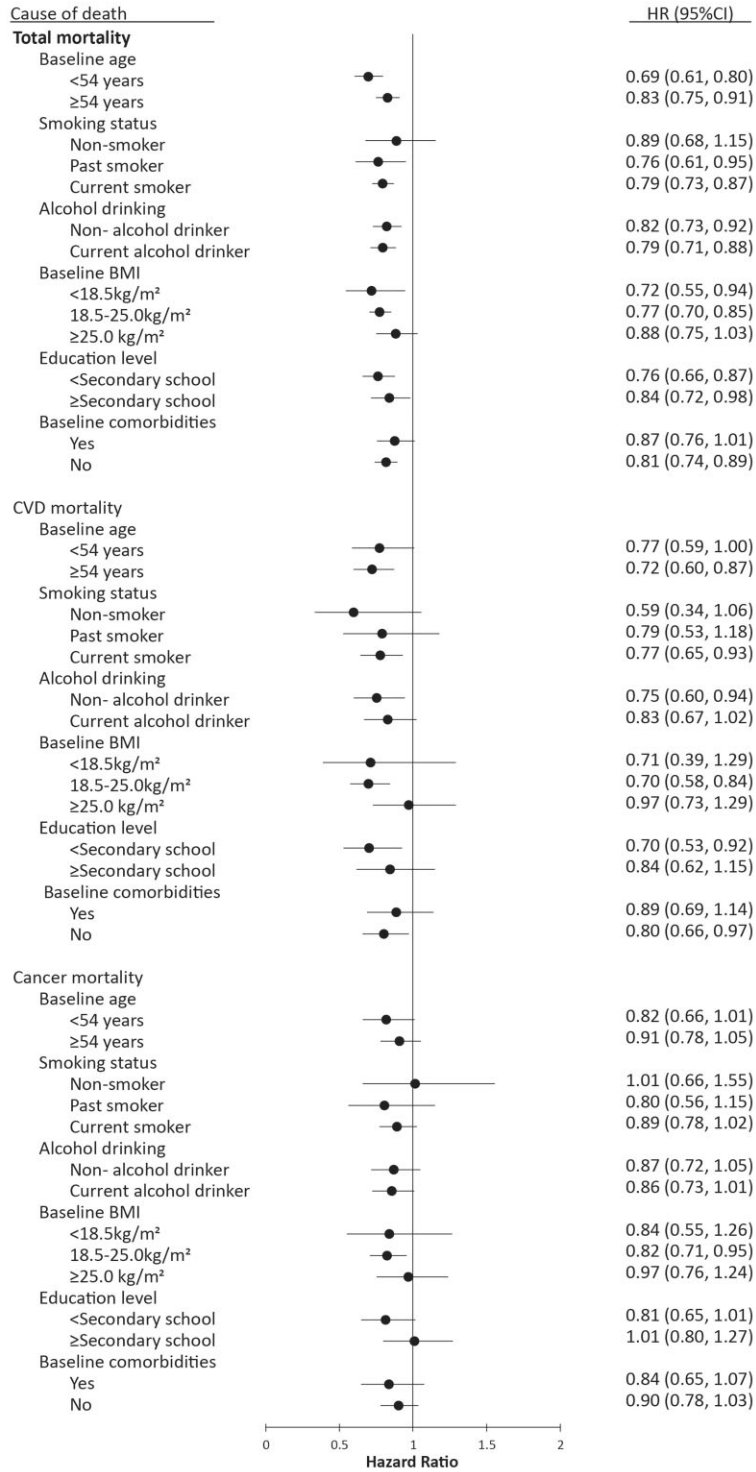

Figure 1 Hazard ratios (HRs) and 95% confidence intervals (CIs) for at least five cups per day coffee consumption vs non-drinkers in relation to mortality by potential interaction factors among men. Aggregated HRs (95% CIs) were calculated using Cox proportional-hazards regression models. The associations between coffee consumption and mortality were analysed in subgroups of baseline age (<54 and ≥54 years; the median age of cohorts combined), baseline smoking status (never, former and current for men), alcohol use (non-drinker and current drinker), body mass index (BMI) level (15–18.4, 18.5–24.9 and ≥25.0 kg/m^2), education level (lower than secondary and secondary education or higher) and baseline co-morbidities including diabetes, hypertension, cancer and coronary heart disease (yes and no). Models were adjusted for baseline age (years; continuous), BMI (kg/m^2; <18.5, 18.5–19.9, 20.0–24.9, 25.0–29.9 and ≥30.0), smoking status (never smoked, former smoker, current with <20 pack-years of smoking and current with ≥20 pack-years of smoking), alcohol consumption (non-drinker and current drinker), educational level (less than secondary, secondary and more than secondary school graduate), energy intake (kcal/day; continuous) and green tea consumption (almost never, <1, 1 to <3, 3 to <5 and ≥5 cups/day). Study centre was adjusted as a stratifying variable.

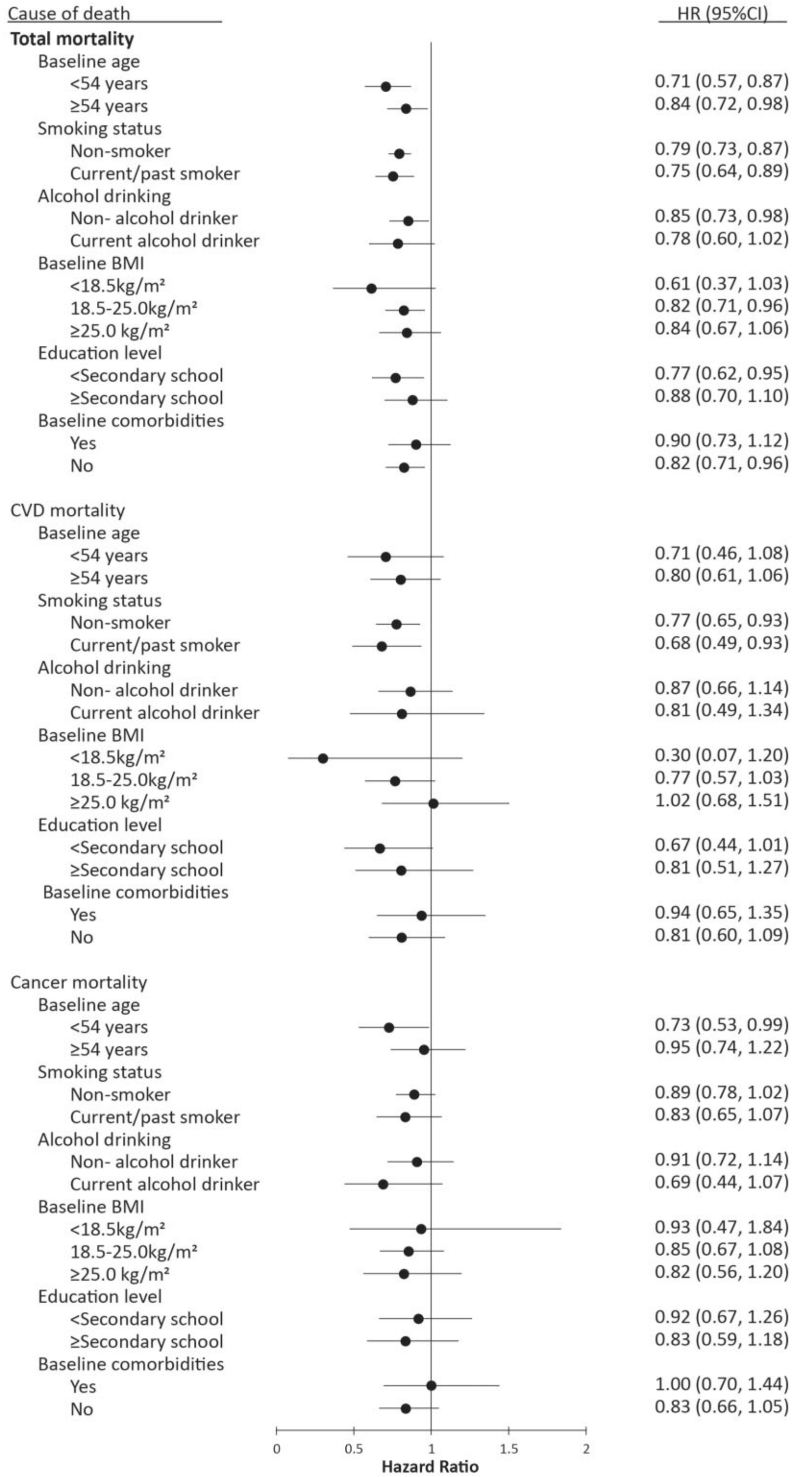

Figure 2 Hazard ratios (HRs) and 95% confidence intervals (CIs) for at least five cups per day of coffee consumption vs non-drinkers in relation to mortality by potential interaction factors among women. Aggregated HRs (95% CIs) were calculated using Cox proportional-hazards regression models. Study centre was adjusted as a stratifying variable. The associations between coffee consumption and mortality were analysed in subgroups of baseline age (<54 and ≥54 years; the median age of cohorts combined), baseline smoking status (never and ever for women), alcohol use (non-drinker and current drinker), body mass index (BMI) level (15–18.4, 18.5–24.9 and ≥25.0 kg/m^2), education level (lower than secondary and secondary education or higher) and baseline co-morbidities including diabetes, hypertension, cancer and coronary heart disease (yes and no). Models were adjusted for baseline age (years; continuous), BMI (kg/m^2; <18.5, 18.5–19.9, 20.0–24.9, 25.0–29.9 and ≥30.0) and smoking status (never smoked, former smoker, current with <20 pack-years of smoking and current with ≥20 pack-years of smoking), alcohol drinking (non-drinker and current drinker), educational level (less than secondary, secondary and more than secondary school graduate), energy intake (kcal/day; continuous) and green tea consumption (almost never, <1, 1 to <3, 3 to <5 and ≥5 cups/day).

Table 3 Pooled hazard ratios (HRs)[a] and 95% confidence intervals (CIs) of all-cause and cause-specific mortality according to green tea consumption

	Green tea consumption						
	Almost never	Less than 1 cup/day	1 to <3 cups/day	3 to <5 cups/day	≥5 cups/day[b]	*P* for trend	*P* for heterogeneity[c]
Men							
No. of participants	56 867	41 265	55 887	36 399	35 204		
Total person-years	606 553	480 888	636 679	396 522	437 025		
All-cause-specific mortality (no. of cases)	8924	6649	9666	6952	9112		
HR (95% CI)	1.00 (Ref.)	0.91 (0.87–0.95)	0.91 (0.86–0.96)	0.91 (0.82–1.02)	0.91 (0.82–1.00)	0.011	<0.001
CVD-specific mortality (no. of cases)	2671	1980	2732	1799	2437		
HR (95% CI)	1.00 (Ref.)	0.90 (0.83–0.98)	0.85 (0.80–0.91)	0.83 (0.70–0.98)	0.79 (0.68–0.91)	<0.001	0.007
Cancer-specific mortality (no. of cases)	3276	2459	3679	2672	3630		
HR (95% CI)	1.00 (Ref.)	0.94 (0.87–1.02)	0.99 (0.90–1.08)	1.02 (0.91–1.16)	1.07 (0.92–1.25)	0.234	<0.001
Other cause-specific mortality (no. of cases)	2977	2210	3255	2481	3045		
HR (95% CI)	1.00 (Ref.)	0.88 (0.83–0.94)	0.89 (0.84–0.95)	0.91 (0.84–0.97)	0.83 (0.76–0.90)	<0.001	0.338
Women							
No. of participants	108 502	31 470	36 596	32 508	42 494		
Total person-years	1 425 367	391 362	549 387	393 930	563 773		
All-cause-specific mortality (no. of cases)	11 156	4112	6898	4344	7188		
HR (95% CI)	1.00 (Ref.)	0.94 (0.89–0.98)	0.91 (0.86–0.95)	0.87 (0.78–0.97)	0.86 (0.75–1.00)	0.032	<0.001
CVD-specific mortality (no. of cases)	3639	1350	2479	1326	2437		
HR (95% CI)	1.00 (Ref.)	0.88 (0.82–0.95)	0.88 (0.80–0.96)	0.80 (0.70–0.90)	0.78 (0.68–0.90)	0.014	0.061
Cancer-specific mortality (no. of cases)	4314	1381	1962	1482	2352		
HR (95% CI)	1.00 (Ref.)	1.01 (0.93–1.11)	0.99 (0.90–1.09)	1.08 (0.97–1.20)	1.12 (1.01–1.24)	0.426	0.625
Other cause-specific mortality (no. of cases)	3203	1381	2457	1536	2399		
HR (95% CI)	1.00 (Ref.)	0.92 (0.85–0.99)	0.87 (0.80–0.95)	0.80 (0.68–0.94)	0.76 (0.61–0.94)	0.001	<0.001

CVD, cardiovascular disease; BMI, body mass index.

[a]Pooled HRs (95% CIs) were calculated using a random-effects model after study-specific HRs (95% CIs) were obtained using Cox proportional-hazards regression models. Multivariate models were adjusted for baseline age (years; continuous), body mass index (BMI, kg/m^2; <18.5, 18.5–19.9, 20.0–24.9, 25.0–29.9 and ≥30.0) and smoking status (never-smoker, former smoker, current with <20 pack-years of smoking and current with ≥20 pack-years of smoking), alcohol intake (non-drinker, 1–155 and ≥156 g/week), educational level (less than secondary, secondary and more than secondary school graduate), energy intake (kcal/day; continuous) and coffee consumption (almost never, <1, 1 to <3, 3 to <5 and ≥5 cups/day).

[b]The RERF (Radiation Effects Research Foundation Life Span Study) was excluded from 3 to <5 cups/day and KMCC (Korean Multi-center Cancer Cohort Study) and Seoul Male cohort were excluded from the 3 to <5 and ≥5 cups/day categories because there was no one in these categories due to the way that frequency of intake was assessed in these studies.

[c]*P* for heterogeneity for the highest category was calculated using the Q statistic.

Our study found inverse associations between coffee consumption and all-cause and CVD-specific mortality, which corresponded to the results of previous prospective studies. The National Institutes of Health–AARP Diet and Health Study found that coffee consumption was inversely associated with the risk of death from heart disease, respiratory disease, stroke, injuries and accidents, diabetes and infections.[13] A pooled analysis of three large US cohort studies found a lower risk of all-cause mortality among those who consumed one to five cups of coffee per day but not among those who consumed more than five cups per day unless the analysis was restricted to never-smokers.[12] This pooled analysis also found an inverse association with the CVD-specific mortality. The European Prospective Investigation into Cancer and Nutrition study,[16] Multiethnic Cohort study,[15] Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial cohort[41] and the UK Biobank study[42] observed that drinking coffee was associated with a lower all-cause mortality. An increased risk of mortality from ischaemic heart disease with increased coffee consumption was observed in men, whereas a decreased risk of mortality from ischaemic heart disease was observed in women in the Netherlands Cohort Study.[43] The JPHC study,[44] Japan Collaborative Cohort Study,[45] Miyagi Cohort Study[46] and SCHS[47] reported inverse associations for coffee consumption with all-cause and CVD mortality. The data from three of these cohorts were included in the current analysis.

We found that coffee consumption lowered the risk of cancer-specific mortality. Although several Western cohort studies have found no association[12,13,16,41] or a weak inverse association[15] for overall cancer death, stronger inverse associations have been reported for coffee consumption and deaths from colorectal cancer and liver cancer.[48] Our study warrants further investigation on whether coffee consumption is associated with the incidences of specific types of cancer in Asian populations.

Our study suggests that there is an inverse association between green tea consumption and the risk of death from all causes and CVD. The evidence for an association between green tea consumption and mortality is largely restricted to Japanese and Chinese studies. The Japan Collaborative Cohort Study for Evaluation of Cancer Risk (JACC Study) of 76 979 individuals aged 40–79 years found a 58% lower risk of mortality from coronary heart disease (95% CI 0.17–0.88) among women who drank six or more cups per day of green tea compared with those who did not drink green tea.[45] The Prospective Shizuoka Elderly Cohort of 12 251 elderly residents aged 65–84 years in Shizuoka, Japan, reported an inverse association for CVD mortality (HR, 0.24, 95% CI 0.14, 0.40 for those who consumed seven or more cups per day vs those consuming less than one cup per day) but no association for cancer mortality (HR, 0.82, 95% CI 0.45, 1.50 for those consuming seven or more cups per day vs those consuming less than one cup per day).[20] The JPHC study indicated that green tea consumption lowered the risk of stroke, as ascertained by computed tomography scanning and/or magnetic resonance imaging.[49] The SMHS and SWHS studies found that green tea consumption was inversely associated with the risk of all-cause and CVD-specific mortality.[23] A randomized double-blinded trial of 240 Chinese men and women aged ≥18 years demonstrated that a daily capsule of green tea extract (375 mg) decreased the circulating levels of total and low-density lipoprotein (LDL) cholesterol and increased the levels of high-density lipoprotein cholesterol.[50] Another Japanese double-blinded randomized trial of 240 men and women aged 25–55 years demonstrated that supplementation with green tea beverages containing 583 mg of catechins (intervention group) vs one containing only 96 mg of catechins (control group) led to greater reductions in body fat, systolic blood pressure and LDL cholesterol.[51]

In the present study, for green tea consumption, we observed no association among men and an increased risk of death from cancer among women. Most previous cohort studies found that green tea consumption was not associated with cancer-specific mortality.[20–22,47] Previous cohort studies did not report associations between green tea consumption and cancers of the stomach,[52] breast,[53] prostate[54] or colon.[55] Although the reason why we observed an increased risk at five or more cups per day of green tea is not clear, the potential mechanism may include the thermal injury to the mucosa and inflammation from drinking tea that has a high temperature.[56,57] For black tea consumption, a few cohort studies that assessed the association between the overall tea consumption and mortality in Western countries, where black tea is more common, showed an increased risk of total mortality[58] or showed no association,[59,60] whereas our study suggested a weak inverse, albeit inconsistent, association with mortality.

Several potential biologically active compounds found in coffee, including chlorogenic acid, caffeine, diterpenes, trigonelline, melanoidins, potassium and magnesium, may explain the potential health benefits of coffee.[4] These compounds have been shown to have antioxidant, anti-inflammatory and antidiabetic activities in experimental and clinical trials. Coffee polyphenols have been shown to scavenge free radicals[61,62] and modulate the postprandial glycaemic response in mouse models[63] and in humans.[64] Antioxidants in green tea may similarly be responsible for the potential health benefits related to green tea consumption. Green tea is rich in catechins, the major form of which is epigallocatechin-3-gallate, which increases the resistance to oxidative damage. Green tea catechins have been shown to reduce LDL oxidation[65] and adipose insulin resistance.[66]

Our study has several limitations. First, because decaffeinated coffee was not commonly consumed in Asia at the time at which these cohorts were initiated, the caffeine type was generally not assessed. Thus, we were unable to distinguish decaffeinated coffee from total coffee consumption. Nevertheless, cohorts that have evaluated the associations of decaffeinated and caffeinated coffee with mortality have consistently observed similar results for both types of coffee,[13,15,41] suggesting that compounds other than caffeine are important. Second, coffee consumption was only assessed at baseline; therefore, changes in consumption habits over time were not considered. Third, we cannot rule out the possibility that residual confounding factors, including smoking and alcohol consumption, may be present. A positive association for green tea consumption among women could be partly explained by residual confounding factors. In our study, coffee drinkers were more likely to smoke and green tea drinkers were more likely to drink alcohol. Thus, it is possible that there is a residual confounding effect by these risk factors, or other unmeasured or poorly measured risk factors may have affected the HR estimates. Additionally, the possibility of reverse causation could be another limiting factor. However, the exclusion of participants who died during the first 3 years of the follow-up period did not change the results. Additionally, we found similar associations with the presence or absence of the baseline co-morbidities. Additionally, we did not have detailed information on additives (e.g. sugar or cream) or brewing methods for either coffee or tea and therefore we were not able to examine the effects of additives or types of brewing on mortality. For the black tea analysis, we were not able to include all of the studies or able to examine the association above two cups per day because of only a few cases in that category. The strengths of this study include its use of multiple large Asian cohorts to evaluate the associations of coffee and tea consumption with mortality. Additionally, the adjustment for potential confounding factors and robust associations in subgroup and sensitivity analyses suggests that our findings may not be fully explained by confounding factors or reverse causation. The contribution of our study to current knowledge lies primarily in the convincing finding that coffee and green tea consumption are associated with a lower risk of mortality across a diverse sample of Asian populations. Although a few Asian studies have published analyses of coffee or green tea, other Asian studies have not analysed or published their results, owing, in part, to a limited statistical power. Our pooled analysis of 10 or more studies across diverse populations in four countries enabled us to examine a wide range of tea and coffee intake, and to explore the potential effect modifications by age, smoking and other important risk factors for mortality.

In conclusion, drinking as little as one cup of coffee per day was associated with a lower risk of death during the follow-up period among Asian populations. Green tea consumption was associated with a lower risk of CVD death, but the association between black tea consumption and mortality was unclear. These findings warrant further observational and intervention studies in Asian populations to explore the effects of the specific types of coffee and tea.

Supplementary data

Supplementary data are available at *IJE* online.

Ethics approval

The present study was reviewed and approved by the Institutional Review Boards of their corresponding institutions.

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Data availability

Investigators are granted access to the Asia Cohort Consortium data upon reasonable request and with the approval of ACC members and the Institutional Review Board. We cannot publicly provide individual data due to participant privacy based on the ethical guidelines in Japan. Additionally, the informed consent that the participating studies obtained did not include a provision for publicly sharing data.

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Author contributions

J.E.L. and R.S. had the idea for the study and designed the study. S.S., J.E.L., E.L. and R.S. wrote the first draft. X.-O.S., S.T., N.S., I.T., S.K., Y.S., Y.T., A.S., K.O., I.O., H.I., M-H.S., Y.-O.A., S.K.P., A.S., Y.-B.X., H.C., W.-P.K., J.-M.Y., K.-Y.Y., K.S.C., H.A., W.Z., M.I., D.K. and K.M. collected the data. S.K.A., M.S.R., E.S., M.R.I. and M.I. coordinated the ACC data collection and analysis. S.S. analysed the data. All authors contributed to data interpretation and approved the final manuscript.

Conflict of interest

None declared.

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