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Tea Consumption and Mortality Among Oldest-Old Chinese

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Abstract

Objectives—To investigate the association between tea consumption and mortality among oldest-old Chinese.

Design—Population-based longitudinal data from The Chinese Longitudinal Healthy Longevity Survey (CLHLS) was analyzed using Cox semi-parametric proportional hazard model.

Setting—631 randomly selected counties and cities of China's 22 provinces.

Participants—9,093 old adults aged 80 and above who provided complete data at baseline survey (year 1998).

Measurements—Self-reported current frequency of tea drinking and past frequency around age 60 were ascertained at baseline survey, and follow-up survey was conducted respectively in years 2000, 2002 and 2005.

Results—Among oldest-old Chinese, tea consumption was associated with reduced risk of mortality after adjusting for demographic characteristics, socioeconomic status, health practices, and health status. Compared with non-tea drinkers, the adjusted hazard ratio (HR) was 0.90 (95% CI 0.84–0.96) for daily tea drinkers (at the baseline survey, 1998) and 1.00 (95% CI 1.01–1.07) for occasional tea drinkers respectively (P for linear trend=0.003). Similar results were found when tea drinking status around age 60 was used in analysis. Further analysis showed that compared to consistently infrequent tea drinkers, subjects who reported frequent tea drinking at both age 60 and at baseline survey had a 10% reduction in mortality (HR=0.90, 95%CI 0.84–0.97).

Conclusion—Tea consumption is associated reduced risk of mortality among oldest-old Chinese.

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Keywords

Tea; Oldest-old Chinese; mortality; longitudinal study

INTRODUCTION

Tea is frequently consumed by people in almost all countries and is the most common beverage after water.¹ In China, tea (pronounced as “Cha” in Chinese) refers to all types of tea that are made from the leaves of the plant *Camellia sinensis*. As China is a huge country that spans across regions with distinct climate, culture and traditions, the predominant type of tea in different regions varies. For example, in Zhejiang Hangzhou, people mostly drink the green tea “West Lake Dragon Well”; in Yunnan, the black tea ‘Pu Er’ is the dominant type. Because of the high rates of tea consumption in the world, even small effects in humans could have large implications for public health.¹ There has therefore been growing research interests on various health benefits of tea consumption in the past decades. Tea contains various bioactive components, of which the most widely studied compounds are tea catechins such as the *Epigallocatechin-3-Gallate* (EGCG). Most of the health benefits of tea drinking have been attributed to tea catechins but other components in tea such as theaflavins, thearubigins, L-theanine and caffeine also could play important roles. Accumulating data indicate that tea drinking reduces the risk of stroke,² dementia,^{3–6} depression,^{7–9} cardiovascular diseases,¹⁰ cancers.¹⁰

Since chronic diseases in late life are associated with premature death, it is plausible to speculate that tea drinking should be related to longevity, given its protective effects on various chronic medical conditions. Evidence from basic research on insects and animals also indicated that compounds in tea can increase lifespan.^{11–13} Recently, longitudinal cohort studies from Japan reported that tea consumption was associated with reduced risk of mortality, death from cardiovascular diseases,^{1, 14} and death caused by cancer.¹⁵ However, those encouraging findings have not been replicated in large sample studies from other populations, and especially have not been replicated in large oldest-old samples. A recent work by Qiu et al.²¹ based on four waves (1998, 2000, 2002 and 2005) of recruitment of The Chinese Longitudinal Healthy Longevity Survey (CLHLS) failed to show a reduced mortality risk associated with tea drinking in the whole sample of men and women combined. Only in men who drank tea almost every day was there a 10–20% lower risk of death compared to their counterparts. That study only analysed the mortality effects of tea consumption reported at baseline survey of subjects aged 80+ recruited in the earlier surveys and subsequent new younger subjects aged 65–79 recruited at later surveys. Changes in consumption habits are common during late life, and the influence of possible changes in the frequency of tea drinking on effect estimates is not known. In the present study, in contrast, we analyzed available data from CLHLS subjects recruited at the baseline survey; we used data on the frequency of tea drinking reported not only at the baseline survey, but also previously at around age 60 years old and took into account changes in tea drinking habits during the interval to derive stable measures of tea drinking frequency. We hypothesized a reduction in mortality risk associated with the level of tea drinking (non-drinker, occasional drinker, daily drinker) assessed at baseline and around age 60 and from both surveys.

METHODS

Study Population

The data used in this study are from the 1998–2005 longitudinal dataset which is derived from the first four waves (1998, 2000, 2002, and 2005) of the CLHLS and presents both static and seven-year interval dynamic information for the respondents who were first

interviewed in 1998. The CLHLS randomly selected half of the counties and cities of 22 provinces in China, and attempted interviews on all centenarians who voluntarily agreed to participate in the study. For each centenarian, one neighborhood octogenarian and one neighborhood nonagenarian of pre-designated age and sex was interviewed. “Neighborhood” was loosely defined – it could be in the same village or street if available, or in the same town or in the same sampled county or city. The predefined age and sex, used to identify approximately equal numbers of male and female nonagenarians and octogenarians, were randomly determined, based on the code numbers of the centenarians.¹⁶

Gu provided a comprehensive review of data quality of CLHLS in terms of proxy use, non-response rate, sample attrition, and reliability and validity of major health measures. His results showed that the data quality of CLHLS is generally good. For example, compared with data attrition in surveys conducted in Western countries, the CLHLS has a similar proportion of data attrition. And the unit non-response rate among the Chinese oldest-old was very low.¹⁷ Goodkind wrote in his review on CLHLS: “The story emerging from these chapters is that the quality of reporting, despite a few flaws endemic to this kind of survey, was fairly good.”¹⁸

The CLHLS baseline survey included 9,093 respondents. Of these, 3,368 persons died between the first and second waves, 1,604 persons died between the second and third waves, and 1,308 persons died between the third and fourth waves. There were 894 respondents lost to follow-up in the 2000 survey, 584 lost in the 2002 survey, and 284 lost in the 2005 survey. The average attrition per wave is 4.85% (see figure 1). In this study, we use cross-sectional data collected in 1998 from 9,093 participants and their follow-up data between 1998 and 2005. As was previously reported by Zeng et al.¹⁶ and Qiu et al.²¹, those who were invalid or incomplete cases were excluded in this research.

Tea Consumption

The key independent variables are frequency of tea consumption at the baseline survey and around age 60. Respondents were asked two questions, (1) “Do you drink tea regularly at present?”, and (2) “Did you drink tea regularly around 60 years old?” Response categories were “almost everyday”; “occasionally”; “rarely or never”.^a In addition, based on the above two questions, we construct a new variable to reflect consistent frequency of tea consumption across different stages of late life cycle. The responses were first categorized into two groups, that is, frequently (“almost everyday”) and infrequently (“occasionally or rarely or never”). Then the respondents were categorized into three groups based on frequency of tea consumption around age 60 and at the baseline survey, (1) “consistently infrequent drinker”: drank tea infrequently both around age 60 and at the baseline survey; (2) “inconsistently frequent drinker”: drank tea frequently/infrequently around age 60, but infrequently/frequently at the baseline survey; (3) “consistently frequent drinker”: drank tea frequently both around age 60 and at the baseline survey.

Covariates

The frequency distributions of the covariates across different tea drinking frequency categories included in our statistical models are listed in Table 1. We choose these variables as relevant covariates based on reviews of previous studies in this field^{1, 11–15} and our understanding of the Chinese social context.

^aThe definition of the three categories in CLHLS is that “daily or almost daily” means drink tea five times or more per week, “occasionally” means drink tea two to four times per week, and “seldom or never” means drink tea once a week or less.

The covariates chosen in our regressions were: (1) demographic variables, including gender, age, and marital status (currently married and living with spouse vs. lone, including separated, divorced, widowed and never married); (2) socioeconomic status (SES), that is, education (illiterate vs. literate) and residence (rural area vs. urban area); (3) health practices, including smoking, drinking alcohol; (4) health status (self reported health and total number of medical conditions^b reported by the respondent).

Statistical analysis

The association between tea consumption and mortality among the Chinese oldest-old was examined using Cox semi-parametric proportional hazard model. Statistical test showed that the required proportionality assumption is met with our dataset. The basic model (1) in this paper is,

$$h(t)=h_0(t)exp(\beta_1 tea) \quad (1)$$

In model (1), “tea” refers to tea consumption, which is measured by three variables, frequency of tea drinking at the baseline survey, frequency of tea drinking around age 60, and changes of frequency of tea drinking from age 60 to the baseline survey, and the three-dimensional vector coefficient β_1 refers to effect of tea consumption on mortality hazard.

As model (1) may produce a biased estimation of β_1 due to confounding, we control for confounding by variables which are known to be correlated with mortality hazard as well as with tea consumption. These include demographic variables, as in model (2).

$$h(t)=h_0(t)exp(\beta_1 tea+\beta_2 X_0) \quad (2)$$

where X_0 refers to the demographic variables and SES.

Other putative confounders include health practices and health status, were further added into model (2), as in the following model (3).

$$h(t)=h_0(t)exp(\beta_1 tea+\beta_2 X_0+\beta_3 X_1) \quad (3)$$

where X_1 refer to health practices and health status.

All analyses were performed using STATA version 10.0 (StataCorp 2007).

RESULTS

As Table 1 shows, frequent tea drinkers were significantly more likely to be men, younger, urban-living, literate, and living with a spouse. At the same time, they were more likely to smoke and drink alcohol. They were more likely to report being healthy, but with more reported medical conditions.

We first analyzed the relationship between tea consumption at baseline survey and mortality hazard. The results are summarized in panel A of table 2. ^c In all the models, there was a

^bThey are defined in CLHLS as hypertension, diabetes, heart disease, stroke, cerebrovascular disease, bronchitis, pulmonary emphysema, asthma, pneumonia, pulmonary tuberculosis, cataract, glaucoma, cancer, prostate tumor, gastric or duodenal ulcer, Parkinson’s disease, bedsores and others specified by responders.

^cTo save space, we did not report the estimated effects of covariates on mortality hazard in table 2–4. However, they are available on request.

significant linear trend of effects of tea drinking frequency on mortality hazard ($p=0.001-0.015$). With adjustment for confounders, the mortality hazard of daily drinkers compared to non-drinkers was reduced by 10%.

Secondly, we estimated the relationship between tea consumption around age 60 and the subsequent mortality risk. The results are summarized in panel B of table 2. Model 1 which included tea drinking only shows that tea consumption was associated a reduction in mortality risk among occasional drinkers (by 1%) and daily drinkers (by 4%), but the lower 95% confidence intervals included 1, and the p value for linear trend was 0.272. The final model including demographic variables, SES, health activities and health status gave 95% confidence intervals of the estimated relative mortality hazard of daily drinker below 1, and the p value for linear trend was 0.036.

Next, we estimated the mortality hazard associated with consistently and inconsistently frequent tea drinking between age 60 and baseline survey using the same procedures, compared with subjects who consistently drank tea infrequently. The results are summarized in Table 3. After adjusting for confounding variables (model 3), the mortality hazard of subjects who were inconsistently frequently tea drinkers was reduced by 3%, and the mortality hazard of subjects who were consistently frequent tea drinkers was reduced by 10%; the p value for the linear trend was 0.042.

DISCUSSION

Based on longitudinal data from a large sample of oldest-old Chinese, we found that higher tea consumption frequency was associated with reduced risk of mortality across a 7-year follow-up period. The results were statistically significant after controlling for potential confounding variables and remained essentially the same regardless of whether tea consumption habit around age 60, tea consumption habit at baseline survey, or frequent tea drinking consistently reported for each of the two time points were used in the analysis. The oldest-old is a unique group which is relatively understudied, and the CLHLS cohort is the largest study sample of the oldest-old in the world.¹⁹ This is the first time that a study has shown a relationship between frequent tea consumption and reduced mortality among oldest-old Chinese, supporting the beneficial effects of tea in extreme late life on survival and longevity. Our findings confirm reports from a handful of previous longitudinal studies that were conducted among middle-aged and young-old Japanese and Chinese.^{1, 14, 15, 21} At the population level, a 10% mortality risk reduction associated with consistent frequent tea drinking represents a considerable health impact.

Arguably, tea consumption may measure some other unobserved characteristics which may be related to both tea consumption and mortality. As shown in Table 1, tea consumption was associated with higher education, urban-living and living with a spouse, which are well-established positive social determinants of longer survivorship.^{22,23} They could represent an healthy group of old individuals with longer survival likelihood. Indeed they were more likely to report being healthy. Although they reported more medical conditions than non-drinkers, they may possibly be more aware of the number of medical problems they had while the latter may possibly be under-reporting. The overall number of medical conditions reported was remarkably low in both groups, likely due to general under-reporting of medical conditions, but also may be partly related to their longer survivor status. Although they were more likely to smoke and drink alcohol, the mortality hazard due to negative lifestyle, behavioral and biomedical risk factors is known to be lessened in the very old; indeed for obesity and high cholesterol, they have also been found to be reversed.²⁴ The study does not exclude the possibility that other unknown personal, psychosocial and behavioral characteristics associated with tea drinking may favor better survival and

longevity among tea drinkers. However, there are biologically plausible links that support the likelihood of a beneficial effect of tea drinking on mortality risks.

Most lifestyle-related diseases show chronic progression with multiple processes,¹ hence the delay of progression will help to increase lifespan. From this perspective, the observed protective effect of tea on survival at follow-up could be partially explained by the protective effects of tea on the pathogenesis and progression of multiple chronic medical conditions that are common in late life. However, since we did not collect detailed information on the incidence of chronic diseases and the exact cause of death at follow-up, the relative contribution from each medical condition and the association between tea consumption and disease specific mortality remained unknown. On the other hand, it is possible that compounds in tea could promote longevity independently of its effects in preventing disease and delaying progression for various chronic medical conditions. However, we are limited in further investigating this hypothesis as we did not measure biomarkers that could be related to longevity pathways.

A limitation in this study is that we did not collect more detailed information on the types and quantity of tea consumed in estimating the effects of tea consumption on mortality. Different types of tea vary in their bioactive constituents, and may therefore have diverse effects on mortality. The main type of tea consumed by Chinese is green tea, about 58% of total tea consumption,²⁰ so the results may mainly reflect the effects of green tea consumption on mortality. Also we did not have data on blood concentrations of tea compounds such as epigallocatechin gallate (EGCG) or L-theanine, which could be useful in validating the reported frequency measurement of tea consumption.

A potential bias to the results may arise from loss to follow-up. We analyzed the characteristics of those lost to follow up, and found that they were more likely to be male, younger, literate, urban-living, report being healthy, and drink tea frequently. Most of those characteristics are positively correlated with lower mortality hazard. As a result, the estimated effects of tea drinking on mortality may be prone to bias downward as a result of the attrition problem, hence unlikely to weaken the strength of association.

Another possible limitation is that we only adjusted for the number of co-morbid medical conditions, which was generally low, but not specific conditions in our model. However, Kuhn et al. have pointed out that objective health measures are not necessarily better predictors of mortality, and individuals can effectively assess their own health status even in settings of poor education and low levels of interaction with modern health systems. On the other hand, self-reported health status has been shown in many studies to be a robust predictor of all-cause mortality, and was included in our adjustment models. Hence, having adjusting for self-reported health status and the number of medical conditions, it is unlikely that adjustment for specific medical co-morbidities will substantially alter our estimates of the association between tea consumption and mortality.

CONCLUSION

We found that tea consumption was associated with reduced risk of mortality among oldest-old Chinese. The life span extending effects of tea and the underlying mechanisms should be further investigated.

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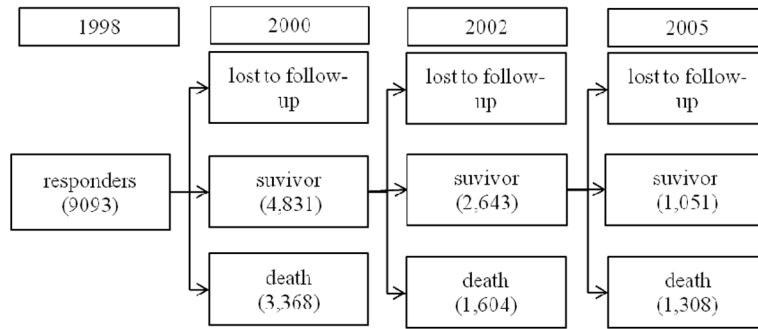


Figure 1. Survivors, deaths and loss to follow-up in the sample

Table 1

Distribution of Potential Confounders across Different Drinking Frequency Categories

	Panel A Tea consumption at 1998 wave survey time			Panel B Tea consumption around 60 years old		
	No drinker n= 4930	Occasional drinker n=1507	Daily drinker n=2264	No drinker n= 4960	Occasional drinker n=1712	Daily drinker n=1993
Gender						
Female	66.7	56.7	46.6	66.5	56.5	45.7
Male	33.3	43.3	53.4	33.5	43.5	54.3
Mean age	93.42	92.61	91.26	93.36	92.55	91.22
		Pearson chi2(2) = 267.46 P = 0.00	F=60.81 P=0.00		Pearson chi2(2) = 264.39 P = 0.00	F =54.44 P=0.00
Residence						
Rural	65.3	64.9	53.8	66.4	61.5	52.4
Urban	34.7	35.1	46.2	33.6	38.5	47.6
		Pearson chi2(2) = 93.00 P = 0.00			Pearson chi2(2) = 118.64 P = 0.00	
Education						
Illiterate	74	65.7	51.6	74	64.5	49.9
Literate	26	34.3	48.4	26	35.5	50.1
		Pearson chi2(2) = 348.42 P = 0.00			Pearson chi2(2) = 375.59 P = 0.00	
Marital/live-in status						
Live alone	86.4	82.7	77.1	86.4	82.1	76.3
Married and living with spouse	13.6	17.3	22.9	13.6	17.9	23.7
		Pearson chi2(2) = 95.90 P = 0.00			Pearson chi2(2) = 106.72 P = 0.00	
Smoking						
No	86.6	81.9	75.4	85.9	82.2	75.6
Yes	13.4	18.1	24.6	14.1	17.8	24.4
		Pearson chi2(2) = 136.70 P = 0.00			Pearson chi2(2) = 106.94 P = 0.00	
Drinking Alcohol						
No	90.5	87.6	83.7	90.2	87.8	83.5
Yes	9.5	12.4	16.3	9.8	12.2	16.5
		Pearson chi2(2) = 68.12 P = 0.00			Pearson chi2(2) = 60.88 P = 0.00	
Self-Reported Health						
Not healthy	45.3	42.5	37	44.3	42.9	38.4

	Panel A Tea consumption at 1998 wave survey time			Panel B Tea consumption around 60 years old		
	No drinker n= 4930	Occasional drinker n=1507	Daily drinker n=2264	No drinker n= 4960	Occasional drinker n=1712	Daily drinker n=1993
<i>Healthy</i>	54.7	57.5	63	55.7	57.1	61.6
		Pearson chi2(2) = 41.09 P= 0.00			Pearson chi2(2) = 18.83 P= 0.00	
Number of Medical Conditions	0.75	0.77	0.87	0.74	0.79	0.91
		F=10.60 P =0.00			F= 20.71 P =0.00	

Table 2

Relative Hazards Ratio (HR) of Tea Consumption on 7-Year Mortality, CLHLS, 1998–2005

Panel A tea consumption at 1998 survey wave				
Model	Non drinker [n= 4930]	Occasional drinker [n=1507]	Daily drinker [n=2264]	P for linear trend
Model 1	1	0.98 (0.92 to 1.05)	0.92 (0.87 to 0.98)	0.015
Model 2	1	0.97 (0.90 to 1.04)	0.90 (0.84 to 0.96)	0.001
Model 3	1	1.00(0.93 to 1.07)	0.90(0.84 to 0.96)	0.003

Panel B tea consumption around 60 years old				
Model	Non drinker [n= 4960]	Occasional drinker [n=1712]	Daily drinker [n=1993]	P for linear trend
Model 1	1	0.99 (0.93 to 1.06)	0.96 (0.90 to 1.03)	0.272
Model 2	1	0.98 (0.91 to 1.04)	0.94 (0.88 to 1.01)	0.073
Model 3	1	0.98 (0.91 to 1.05)	0.93 (0.86 to 0.99)	0.036

Note: Values in the cell are hazards ratio (HR) estimated based on Cox semi-parametric proportional hazard model, and values in the bracket are 95% confidence interval (CI) of the HR. Panel A reports the estimation to effects of tea consumption at 1998 wave survey time on 7-year mortality, CLHLS, 1998–2005, while panel B reports the estimation to effects of tea consumption around 60 years old

Variables in model 1: only tea consumption status

Variables in model 2: + demographic variables and socioeconomic status (SES).

Variables in model 3: +health activities and health status.

Table 3

Relative Hazards Ratio (HR) of Consistent Tea Drinking Habit between 60 Years Old and the 1998 Wave Survey Time On 7-Year Mortality, CLHLS, 1998–2005

Model	Infrequently drinking consistently [n=6,143]	Drinking inconsistently [n=740]	Frequently drinking consistently [n=1,748]	P for linear trend
Model 1	1	1.00 (0.91 to 1.01)	0.93(0.87 to1.00)	0.053
Model 2	1	0.99 (0.90 to 1.09)	0.91 (0.85 to 0.96)	0.010
Model 3	1	0.97(0.88 to 1.07)	0.90 (0.84 to 0.97)	0.042

Note: Values in the cell are hazards ratio (HR) estimated based on Cox semi-parametric proportional hazard model, and values in the bracket are 95% confidence interval (CI) of the HR.

Variables in model 1: only tea consumption status

Variables in model 2: + demographic variables and socioeconomic status (SES).

Variables in model 3: +health activities and health status