Dietary diversity and all-cause mortality among Chinese adults aged 65 or older: a community-based cohort study

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ABSTRACT

Background and Objectives: To evaluate the association between dietary diversity and all-cause mortality in older adults. **Methods and Study Design:** 17,949 community-based elderly participants aged ≥65 years in China were included in this cohort study. The baseline consumption frequencies of nine food groups (meat, vegetables, fish, eggs, fruits, legumes, milk, tea, and nuts) were recorded, and the dietary diversity score (0–9) was calculated. Survival status and death date were collected during follow-up. Cox proportional-hazards models were used to assess the association between dietary diversity and all-cause mortality. **Results:** We identified 8445 death events over 57,685 person-years of follow-up. Compared with participants in the lowest dietary diversity score group (score 0–1), higher dietary diversity scores were associated with lower mortality risk in univariate models. After adjusting for potential confounders, participants in the higher dietary diversity score group had a 9%–30% lower risk in all-cause mortality (p trend <0.001) compared with those in the lowest dietary diversity score group. The inverse relationship between dietary diversity score and all-cause mortality was also significant in four food groups (vegetables, fish, fruits, and nuts). Similar results were observed in sensitivity analyses. **Conclusions:** Our study showed that dietary diversity was inversely associated with all-cause mortality in the Chinese elderly, especially in the oldest old and men. Therefore, increasing dietary diversity may reduce mortality rates in the older population, and tailored interventions for improving dietary diversity are required to benefit health and survival in them.

Key Words: dietary diversity, mortality, elderly, oldest old, Cox proportion hazard model

INTRODUCTION

Given the aging of the global population, mortality in the older population is a growing public health concern. Diet is a well-established major modifiable risk factor for multiple chronic diseases and mortality and is particularly of consequence in older adults who are at a high risk of chronic disease and death.[1-3] Dietary diversity, defined as the number of different food groups consumed over a specified reference period, is recommended in the dietary guidelines of many countries.[4] The dietary diversity score (DDS) was first applied to the mortality data of a Greek elderly cohort, which was originally designed to identify a "Mediterranean diet pattern" and instead identified dietary diversity.[5] Compared with the dietary pattern, explicit recommendations of certain food groups are more easily understood by the public.

Many studies have assessed the association of certain food groups, nutrients, or dietary patterns with all-cause mortality rates.[1,6-10] Several studies have reported an inverse association between dietary diversity and health status (such as cognitive function and functional capacity) in the elderly population.[11-15] Otsuka et al. used cohort data from the National Longitudinal Study of Aging of 1317 participants aged 40–79 years at baseline and found that the daily intake of various food groups protected against a decline in the intellectual activity of middle-aged and elderly community dwellers in Japan.[13] A recent study including a prospective cohort of 23,238 participants in the United Kingdom demonstrated that a diet characterized by regular consumption of five food groups apparently contributed to a 30% decreased risk of diabetes.[15] Studies evaluating diet quality based on dietary recommendations have found higher diet quality to be associated with lower mortality.[16-18] In 1743 Taiwanese elderly people, Lee et al. found a reverse association between DDS and mortality, such that the multivariable hazard ratios were 0.50–0.74 in those whose DDS was 4-6 compared with those whose DDS was ≤3.[19] However, data on the relationship between dietary diversity and all-cause mortality in Chinese older adults are scant. China is one of the fastest aging countries in the world and has the largest aging population.[20]

Globally, reducing the risk of mortality in the elderly population is crucial. Assessment of dietary diversity in relation to the risk of mortality can help in determining the association, which a focus on a single food group would miss, and developing targeted interventions. Moreover, the DDS has been identified as a simple tool to predict disease risk. Given this background, we aimed to examine the prospective association between dietary diversity and all-cause mortality risk in a community-based cohort study of older Chinese adults, after adjusting for major known confounders.

MATERIALS AND METHODS

Study design and population

Data for this study were collected from the Chinese Longitudinal Healthy Longevity Study (CLHLS). The CLHLS is a national prospective cohort study of community-dwelling Chinese older people that was conducted in 22 of the 31 provinces of China. More details of the CLHLS have been described in a previous study.[21] In this study, we used data from the 2008, 2011, and 2014 waves of the CLHLS. In the 2008 cohort, 16,563 participants aged ≥65 years were investigated, and 1386 participants aged ≥65 years were newly added in the 2011 cohort. Finally, 17,949 participants were included in this study (Figure 1). At baseline, a structured questionnaire and physical examination were used to collect information regarding factors

such as sociodemographic characteristics, dietary behavior, lifestyle, and BMI. This study was approved by the Medical Ethics Committee of Peking University (number IRB00001052-13074), and all participants signed written informed consent to participate at the baseline and follow-up surveys.

Dietary assessments

All participants were required to report their consumption frequencies of various food groups, including meat, vegetables, fish, eggs, fruits, legumes, milk, tea, and nuts. We constructed dietary diversity by using nine food groups, as reported in studies,[12,22] based on the principle that selection of food groups to assess the DDS can be driven by specific purposes.4 All participants were divided into five groups (0–1, 1–2, 2–3, 4–5, 6–7, and 8–9) according to their DDS.

Outcome

The primary outcome of this study was all-cause mortality. Participants' survival status and date of death were collected through interviews with close family members or the village doctor during the follow-up survey in 2011 and 2014. Survival time for participants was defined as the period from the date of the baseline survey to the date of death. Participants were censored on the date of death or at the end of the study period. Participants who were lost to follow-up in the first follow-up wave were censored at the midpoint of the follow-up (1.5 years); those who were lost to follow-up in the second follow-up wave were censored at midpoint of the follow-up (3.0 years).

Covariates

Measures of sociodemographic characteristics, lifestyle factors, and history of chronic disease were conducted at baseline by using the questionnaire. The sociodemographic characteristics were age at recruitment (continuous), education years (continuous), body mass index (BMI, continuous), sex (men or women), marriage status (unmarried, married, divorced, or widowed), and good family economic condition (yes or no). Lifestyle factors were smoking status (never, previous, or current), alcohol intake (never, previous, current), regular exercise (yes or no), residence (urban or rural), and living pattern (living with family members, at an institution, or alone). History of chronic disease included common chronic diseases in the elderly (hypertension, diabetes, cardiovascular disease, stroke and cerebrovascular disease, respiratory disease, and cancer).

Statistical analyses

The all-cause mortality rates among different DDS groups were compared using the log-rank test. Tests for risk-of-outcome trends were performed across the DDS groups. To examine the association between the DDS (continuous variable) and all-cause mortality, we performed a restricted cubic spline analysis, after adjusting for potential confounders. The associations of dietary diversity (categorical variable) with all-cause mortality were analyzed using univariate Cox proportional-hazard models (model 1) and multivariate models adjusted for age, education years, BMI, sex, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family-economic condition, and history of chronic disease. Cox regression models were tested for the proportion hazards assumption on the basis of Schoenfeld residuals, which was not found to be violated. Sensitivity analyses were performed by adjusting different confounders in the Cox proportional-hazard models. In model 2, we adjusted for age, education years, BMI, sex, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family-economic condition. In model 3 (the fully adjusted model), we then additionally adjusted the history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer. Moreover, we performed sensitivity analyses by excluding participants lost to follow-up to clarify its effect. In subgroup analyses, we used the fully adjusted model in the groups stratified according to sex (mem and women) and age group (the younger elderly and the oldest old). Analyses were performed using SPSS 23.0 (IBM SPSS Inc., Chicago, IL, USA), and SAS 9.4 (SAS Institute Inc.). Two-sided p values <0.05 were regarded as statistically significant.

RESULTS

Baseline characteristics of the study population

Of 17,949 participants, 57.73% (10362) were women and 37.86% (6795) were from urban areas. The mean (SD) baseline age and BMI were 87.39 (11.53) years and 20.34 (3.63) kg/m^2, respectively. All other baseline characteristics are listed in Table 1.

The mean DDS of study participants was 4.32 (2.00). Of all participants, 63.50% (11,399) had DDS of 4 or higher. Participants with higher DDS were younger, more educated, married, previous smokers or alcohol drinkers, regular exercisers, urban residents, and living with family members, as well as had higher BMI, poor family economic condition and a history of chronic diseases (Table 1).

Diet diversity and risk of all-cause mortality

The mean follow-up time to death or the end of the follow-up was 3.2 (±2.0) years. We identified 8445 deaths over 57,685 person-years of follow-up. The number (percentages) of death events was 691 (53.07%), 2634 (50.19%), 2978 (48.55%), 1841 (43.03%), and 301 (30.50%) in the five groups of the DDS, namely 0–1, 2–3, 4–5, 6–7, and 8–9, respectively.

Compared with participants in the lowest DDS group, higher DDSs were associated with lower mortality risk in univariate models (Figure 2). After adjusting for potential confounders, participants in the higher DDS group had a 9%–30% lower risk of all-cause mortality (p_{trend} <0.001) compared with participants in the lowest DDS group (Table 2). Additionally, participants in the highest DDS group had a 30% decreased risk of all-cause mortality (HR = 0.70, 95% CI: 0.60–0.80) compared with those in the lowest DDS group. The inverse relationship between DDS and all-cause mortality was also significant in four of the food groups (vegetables, fish, fruits, and nuts). Restricted cubic spline analysis also showed that the DDS was inversely associated with mortality. The lower the DDS, higher was the risk of death (p_{trend} <0.001, Figure 3).

Sensitivity analyses

Similar results were observed after including different confounders in model 2 and model 3 in sensitivity analyses. The findings were also robust after excluding the participants lost to the follow-up (Supplemental Table 1).

Subgroup analyses

In subgroup analyses, the inverse relationship between the DDS and all-cause mortality was observed in men (p_{trend} <0.001) but not in women (p_{trend} =0.052). After adjusting for potential confounders, men in the highest DDS group had a 40% decreased risk of all-cause mortality (HR=0.60, 95% CI: 0.48–0.74, p_{trend} <0.001) compared with men in the lowest DDS group (Table 3).

Additionally, the inverse relationship between the DDS and mortality was observed in the oldest old (p_{trend} <0.001) but not in the younger elderly (p_{trend} =0.084). After adjusting for potential confounders, the oldest old in the highest DDS group had a 28% decreased risk of all-cause mortality (HR=0.72, 95% CI: 062–0.84, p_{trend} <0.001) compared with those in the lowest DDS group (Table 4).

DISCUSSION

This prospective community-based cohort study examined the association between dietary diversity and all-cause mortality in 17,949 Chinese adults aged ≥65 years who had been followed up for a mean of over 4 years. Overall, we observed a 9%–30% lower risk of all-cause mortality in individuals with higher DDS.

A number of epidemiologic studies have reported that higher-quality dietary patterns to be related with 11%–26% lower risk of all-cause mortality.[17,23-26] However, these studies did not separately examine the role of dietary diversity in relation to mortality. Despite common advice to consume a varied diet,[27,28] studies investigating reason for the association of the number of different food groups included in a diet with the risk of mortality in the elderly populations are scant. Our findings suggested that individuals aged ≥65 years who consumed a healthy diet with more food items belonging to the nine food groups had a 30% decreased risk of mortality (HR=0.70, 95% CI: 0.60-0.80, p_{trend} <0.001). Kurotani et al reported that closer adherence to Japanese dietary guidelines was associated with a decreased risk of total mortality in Japanese adults.29 Russell et al. found a 21% decreased risk of all-cause mortality (HR=0.79, 95% CI 0.63–0.98, p_{trend} =0.04) in the older population who had greater compliance with published dietary guidelines.[30] Higher adherence to an empirically derived "Mediterranean-type" dietary pattern was also found to be associated with a decreased risk of mortality.[8] Compared with the assessment of the dietary pattern, calculation of the DDS is more applicable and easier for assessment and surveillance. Thus, the DDS can be used as a simple instrument to assess and predict the risk of mortality in the elderly population and also to guide targeted interventions.

Biological pathways linking the inverse associations of total diet diversity with the risk of mortality are still unclear. Several possible explanations can be considered for the association of DDS with mortality. One explanation is that low dietary diversity reflects poor nutrient intake and decreased microbiota diversity. Greater diversity of food groups consumed was found to be significantly positively associated with a more diverse intestinal microbiota in older adults, which suggested that dietary diversity influences microbiota compositon.[31] Dietary changes toward lower diversity resulted in loss in the range of intestinal microbiota, and decreased microbiota diversity was associated with poor health outcomes.[31] Another explanation is that low dietary diversity correlates with high levels of oxidative stress.[32] A recent study showed that oxidative stress was highly associated with epigenetic multiple sclerosis, and it had a higher predictive value for all-cause mortality in elderly people.[33]

Moreover, a greater DDS was found to be associated with greater plasma magnesium, which in turn was linked to lower mortality.[34]

Our results further showed that individuals reporting regular consumption of vegetables, fish, fruits, and nuts also had a decreased risk of mortality, consistent with the findings of other studies.[6,25,35] Buil-Cosiales et al. reported that fiber (HR=0.63, 95% CI: 0.46–0.86) and fruit intake (HR=0.59, 95% CI: 0.42–0.82) were associated with a reduction in total mortality in the PREDIMED study.6 Another study using data from the China Health and Nutrition Survey reported fish consumption to be related to lower risk of all-cause mortality in Chinese adults.[36] Fish is an acknowledged healthy source of energy, high-quality proteins, vitamins, essential minerals, and lipids, such as marine omega-3 long-chain PUFA, vitamin D, selenium, iodine, taurine, and retinol.[37] Thus, fish can confer substantial health benefits and reduce the risk of mortality. Other than vegetables, fish, and fruits, nut consumption can also confer substantial health benefits. Luu et al identified an inverse association between nut intake and the risk of total mortality in all the three cohorts (all $p<0.001$ for trend) among US and Chinese adults.[35] Our findings indicated that elderly people should regularly consume vegetables, fish, fruits, and nuts. We did not observe a significant inverse association between legumes and mortality. However, Darmadi-BLackberry et al found that the legume food group showed 7%–8% reduction in the mortality hazard ratio in 785 participants aged 70 and over from Japan, Sweden, Greece, and Australia in the Food Habits in Later Life study, after adjusting for age at enrollment, sex, and smoking.[37] The discrepancy may be related to the difference in population characteristics, dietary habits, and adjusted confounders between the two studies.

Another noteworthy finding of our study is that decreased mortality was largely confined to the oldest old and men in subgroup analyses. Studies comparing the oldest old with the younger old in addition to comparison between men and women have been scant on the association between dietary quality and mortality. Kaluza et al assessed the relationship of mortality and diet quality in a population-based study of 40,837 men aged 45–79 years and found that both measures of diet quality and Recommended Food Score showed statistically significant inverse associations with all-cause mortality.[17] Our findings indicated that dietary diversity was crucial to the oldest old and in men for substantial health benefits.

To our knowledge, this is the first large-sample study focusing on the association of dietary diversity and total mortality among Chinese adults aged 65 or older in a prospective cohort study. The strengths of this study include a number of controlled covariates, large sample size, and long duration of follow-up among elderly people, especially for the oldest old. However,

this study has some limitations. First, information regarding cause of death was not collected because it is difficult to determine the cause of death in individuals who were likely to suffer from various chronic diseases. Nevertheless, we adjusted history of chronic disease in multivariate models. Second, DDSs were estimated only once for each participant at baseline; thus, no conclusions can be drawn regarding the effect of lifetime exposure. Third, data regarding consumption frequencies for cereals and oils were not collected in this study; thus, we could not include it in the DDS.

Conclusion

This large community-based prospective cohort study showed that dietary diversity is inversely associated with all-cause mortality among Chinese elderly people, especially in the oldest old and in men. Our findings suggest that increasing dietary diversity may lower mortality rates in the older population. Tailored interventions for improving dietary diversity are required to benefit health and survival in the older population.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare that they have no conflict of interests. This study was funded by the National Key R&D Program of China (2018YFC1704400).

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Table 1. Baseline characteristics and total diet diversity of participants (n=17949)

Characteristic	Total	Total diet diversity score					*p* value
		0-1	2-3	4-5	6-7	8-9	
N (%)	17949 (100)	1302 (7.25)	5248 (29.24)	6134 (34.17)	4278 (23.83)	987 (5.50)	
Age at recruitment, mean (SD), years	87.39 (11.53)	88.63 (10.88)	87.85 (11.07)	87.69 (11.61)	86.98 (11.82)	83.26 (11.99)	<0.001
Education years, mean (SD), years	1.97 (3.35)	0.96 (2.28)	1.29 (2.55)	1.89 (3.17)	2.68 (3.88)	4.36 (4.83)	<0.001
BMI, mean (SD), kg/m^2	20.34 (3.63)	19.50 (3.35)	19.93 (3.55)	20.28 (3.62)	20.85 (3.63)	21.83 (3.83)	<0.001
Sex, n (%)							<0.001
Men	7587 (42.27)	470 (36.10)	2027 (38.62)	2593 (42.27)	1968 (46.00)	529 (53.60)	
Women	10362 (57.73)	832 (63.90)	3221 (61.38)	3541 (57.73)	2310 (54.00)	458 (46.40)	
Marriage, n (%)							<0.001
Unmarried	168 (0.94)	29 (2.23)	58 (1.11)	44 (0.72)	33 (0.77)	4 (0.41)	
Married	5709 (31.82)	327 (25.12)	1464 (27.92)	1974 (32.19)	1461 (34.15)	483 (48.94)	
Divorced or widowed	12066 (67.25)	946 (72.66)	3722 (70.98)	4114 (67.09)	2784 (65.08)	500 (50.66)	
Smoking status, n (%)							<0.001
Never	12176 (67.90)	959 (73.71)	3685 (70.31)	4171 (68.03)	2763 (64.68)	598 (60.59)	
Previous	2705 (15.08)	173 (13.30)	713 (13.60)	881 (14.37)	739 (17.30)	199 (20.16)	
Current	3051 (17.01)	169 (12.99)	843 (16.08)	1079 (17.60)	770 (18.02)	190 (19.25)	
Alcohol intake, n (%)							<0.001
Never	12574 (70.13)	1015 (78.08)	3796 (72.42)	4277 (69.81)	2891 (67.66)	595 (60.28)	
Previous	2344 (13.07)	159 (12.23)	679 (12.95)	774 (12.63)	576 (13.48)	156 (15.81)	
Current	3011 (16.79)	126 (9.69)	767 (14.63)	1076 (17.56)	806 (18.86)	236 (23.91)	
Regular exercise, n (%)							<0.001
No	10923 (61.03)	965 (74.35)	3563 (68.01)	3794 (62.02)	2238 (52.55)	363 (36.85)	
Yes	6975 (38.97)	333 (25.65)	1676 (31.99)	2323 (37.98)	2021 (47.45)	622 (63.15)	
Residence, n (%)							<0.001
Urban	6795 (37.86)	265 (20.35)	1381 (26.31)	2393 (39.01)	2151 (50.28)	605 (61.30)	
Rural	11154 (62.14)	1037 (79.65)	3867 (73.69)	3741 (60.99)	2127 (49.72)	382 (38.70)	
Living Pattern, n (%)							<0.001
Living with family members	14787 (82.48)	961 (73.92)	4168 (79.48)	5089 (83.07)	3690 (86.32)	879 (89.33)	
Living in an institution	330 (1.84)	15 (1.15)	64 (1.22)	116 (1.89)	119 (2.78)	16 (1.63)	
Living alone	2812 (15.68)	324 (24.92)	1012 (19.30)	921 (15.03)	466 (10.90)	89 (9.04)	
Good family economic condition, n (%)							<0.001
Yes	15470 (86.54)	1235 (95.51)	4835 (92.45)	5305 (86.90)	3405 (79.87)	690 (69.98)	
No	2407 (13.46)	58 (4.49)	395 (7.55)	800 (13.10)	858 (20.13)	296 (30.02)	

BMI (calculated as weight in kilograms divided by height in meters squared). *p* values are from the test for trend for continuous variables and the $\chi 2$ test for categorical variables.
[†]Missing data, education years 73 (0.41%), BMI 528 (2.94%), marriage 6 (0.03%), smoking 17 (0.09%), alcohol intake 20 (0.11%), regular exercise 51 (0.28%), residence 20 (0.11%), good family economic condition 72 (0.40%).

Table 1. Baseline characteristics and total diet diversity of participants (n=17949) (cont.)

Characteristic	Total	Total diet diversity score					*p* value
		0-1	2-3	4-5	6-7	8-9	
History of chronic diseases, n (%)							
Hypertension	3543 (19.74)	222 (17.05)	967 (18.43)	1206 (19.66)	907 (21.20)	241 (24.42)	<0.001
Diabetes	451 (2.51)	18 (1.38)	89 (1.70)	136 (2.22)	158 (3.69)	50 (5.07)	<0.001
Cardiovascular disease	1571 (8.75)	84 (6.45)	371 (7.07)	516 (8.41)	451 (10.54)	149 (15.10)	<0.001
Stroke or cerebrovascular disease	1106 (6.16)	77 (5.91)	309 (5.89)	347 (5.66)	302 (7.06)	71 (7.19)	0.023
Respiratory disease	1857 (10.35)	129 (9.91)	558 (10.63)	635 (10.35)	433 (10.12)	102 (10.33)	0.915
Cancer		5 (0.38)	19 (0.36)	21 (0.34)	27 (0.63)	12 (1.22)	0.001

BMI (calculated as weight in kilograms divided by height in meters squared). *p* values are from the test for trend for continuous variables and the $\chi 2$ test for categorical variables.
[†]Missing data, education years 73 (0.41%), BMI 528 (2.94%), marriage 6 (0.03%), smoking 17 (0.09%), alcohol intake 20 (0.11%), regular exercise 51 (0.28%), residence 20 (0.11%), good family economic condition 72 (0.40%).

Table 2. Adjusted hazard ratios of all-cause mortality for diet diversity and food groups

	Score	n of events (%)	n of person years	HR (95% CI) for all-cause mortality		
				Model 1	Model 2	Model 3
Total DDS						
	0-1	691 (53.07)	3927.8	1 (reference)	1 (reference)	1 (reference)
	2-3	2634 (50.19)	17118.1	0.87 (0.80, 0.95)*	0.90 (0.82, 0.98)*	0.89 (0.82, 0.97)*
	4-5	2978 (48.55)	19485.6	0.87 (0.80, 0.94)*	0.90 (0.83, 0.98)*	0.91 (0.83, 0.99)*
	6-7	1841 (43.03)	13692.4	0.76 (0.70, 0.83)*	0.84 (0.77, 0.92)*	0.84 (0.77, 0.92)*
	8-9	301 (30.50)	3461.3	0.49 (0.43, 0.56)*	0.70 (0.61, 0.81)*	0.70 (0.60, 0.80)*
	p for trend			<0.001*	<0.001*	<0.001*
Food group						
Meat						
	0	2798 (47.77)	18986.7	1 (reference)	1 (reference)	1 (reference)
	1	5647 (46.70)	38698.5	0.99 (0.95, 1.04)	0.97 (0.93, 1.02)	0.97 (0.93, 1.02)
Vegetables						
	0	1262 (55.42)	6315.7	1 (reference)	1 (reference)	1 (reference)
	1	7183 (45.83)	51369.5	0.69 (0.65, 0.73)*	0.86 (0.80, 0.91)*	0.86 (0.81, 0.91)*
Fish						
	0	5415 (50.51)	34821.1	1 (reference)	1 (reference)	1 (reference)
	1	3030 (41.92)	22864.1	0.85 (0.82, 0.89)*	0.93 (0.88, 0.97)*	0.92 (0.88, 0.97)*
Eggs						
	0	2543 (46.90)	17770.1	1 (reference)	1 (reference)	1 (reference)
	1	5902 (47.11)	39915.1	1.03 (0.99, 1.08)	0.99 (0.94, 1.04)	0.98 (0.94, 1.03)
Fruits						
	0	5562 (50.36)	35243.1	1 (reference)	1 (reference)	1 (reference)
	1	2883 (41.75)	22442.1	0.81 (0.78, 0.85)*	0.92 (0.88, 0.96)*	0.92 (0.87, 0.96)*
Legumes						
	0	3888 (47.79)	26114.8	1 (reference)	1 (reference)	1 (reference)
	1	4557 (46.44)	31570.5	0.97 (0.93, 1.01)	0.99 (0.94, 1.03)	0.99 (0.94, 1.03)
Milk						
	0	6016 (47.52)	41563.7	1 (reference)	1 (reference)	1 (reference)
	1	2429 (45.93)	16121.5	1.05 (1.00, 1.10)	0.96 (0.92, 1.01)	0.95 (0.90, 1.00)
Tea						
	0	5836 (49.83)	36282.4	1 (reference)	1 (reference)	1 (reference)
	1	2609 (41.82)	21402.8	0.75 (0.72, 0.79)*	0.96 (0.92, 1.01)	0.97 (0.92, 1.02)
Nuts						
	0	7839 (48.54)	51087.3	1 (reference)	1 (reference)	1 (reference)
	1	606 (33.65)	6597.9	0.59 (0.55, 0.65)*	0.83 (0.76, 0.91)*	0.83 (0.76, 0.91)*

DDS: dietary diversity score; HR: Hazard ratio; CI: confidence interval. * $p<0.05$.
Model 1 was unadjusted. Model 2 was adjusted for age, education years, BMI, sex, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family economic condition.
Model 3 as model 2 plus: history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer.

Table 3. Adjusted hazard ratios of all-cause mortality for total diet diversity in men and women

Total DDS	n of events	n of person years	HR (95% CI) for all-cause mortality		
			Model 1	Model 2	Model 3
Men					
0-1	246 (52.34)	1395.52	1 (reference)	1 (reference)	1 (reference)
2-3	1000 (49.33)	6807.30	0.83 (0.72, 0.95)*	0.83 (0.72, 0.95)*	0.82 (0.71, 0.95)*
4-5	1167 (45.01)	8593.70	0.76 (0.67, 0.88)*	0.81 (0.70, 0.93)*	0.81 (0.70, 0.93)*
6-7	791 (40.19)	6641.68	0.67 (0.58, 0.77)*	0.74 (0.64, 0.86)*	0.74 (0.64, 0.86)*
8-9	157 (29.68)	1908.44	0.46 (0.38, 0.56)*	0.61 (0.49, 0.76)*	0.60 (0.48, 0.74)*
p for trend			<0.001*	<0.001*	<0.001*
Women					
0-1	445 (53.49)	2532.24	1 (reference)	1 (reference)	1 (reference)
2-3	1634 (50.73)	10310.84	0.90 (0.81, 1.00)	0.93 (0.83, 1.03)	0.93 (0.83, 1.03)
4-5	1811 (51.14)	10891.91	0.94 (0.85, 1.05)	0.95 (0.85, 1.06)	0.96 (0.86, 1.06)
6-7	1050 (45.45)	7050.68	0.85 (0.76, 0.95)*	0.90 (0.80, 1.01)	0.90 (0.80, 1.01)
8-9	144 (31.44)	1552.88	0.52 (0.43, 0.63)*	0.79 (0.64, 0.96)*	0.78 (0.64, 0.95)*
p for trend			<0.001*	0.054	0.052

DDS: diet diversity score; HR: Hazard ratio; CI: confidence interval.
Model 1 was unadjusted.
Model 2 was adjusted for age, education years, BMI, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family economic condition.
Model 3 as model 2 plus: history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer.
* $p<0.05$

Table 4. Adjusted hazard ratios of all-cause mortality for total diet diversity among the younger elderly and the oldest old

Total DDS	n of events	n of person years	HR (95% CI) for all-cause mortality		
			Model 1	Model 2	Model 3
Younger elderly					
0-1	63 (22.50)	1215.20	1 (reference)	1 (reference)	1 (reference)
2-3	221 (18.07)	5511.29	0.77 (0.58, 1.02)	0.79 (0.59, 1.04)	0.80 (0.60, 1.07)
4-5	261 (16.48)	6824.82	0.74 (0.56, 0.98)*	0.80 (0.60, 1.06)	0.81 (0.61, 1.08)
6-7	176 (14.18)	5230.74	0.66 (0.49, 0.87)*	0.73 (0.54, 0.98)*	0.76 (0.56, 1.02)
8-9	50 (12.14)	1733.26	0.56 (0.39, 0.82)*	0.68 (0.46, 0.99)*	0.66 (0.45, 0.98)*
p for trend			0.001*	0.090	0.084
Oldest old					
0-1	628 (61.45)	2712.56	1 (reference)	1 (reference)	1 (reference)
2-3	2413 (59.95)	11606.85	0.89 (0.81, 0.97)*	0.90 (0.82, 0.98)*	0.89 (0.82, 0.98)*
4-5	2717 (59.71)	12660.79	0.92 (0.84, 1.00)	0.93 (0.86, 0.99)*	0.90 (0.82, 0.99)*
6-7	1665 (54.82)	8461.62	0.85 (0.77, 0.93)*	0.90 (0.82, 0.99)*	0.90 (0.82, 0.99)*
8-9	251 (43.65)	1728.06	0.62 (0.53, 0.71)*	0.73 (0.62, 0.85)*	0.72 (0.62, 0.84)*
p for trend			<0.001*	<0.001*	<0.001*

DDS: diet diversity score; HR: Hazard ratio; CI: confidence interval.
Model 1 was unadjusted.
Model 2 was adjusted for age, education years, BMI, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family economic condition.
Model 3 as model 2 plus: history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer.

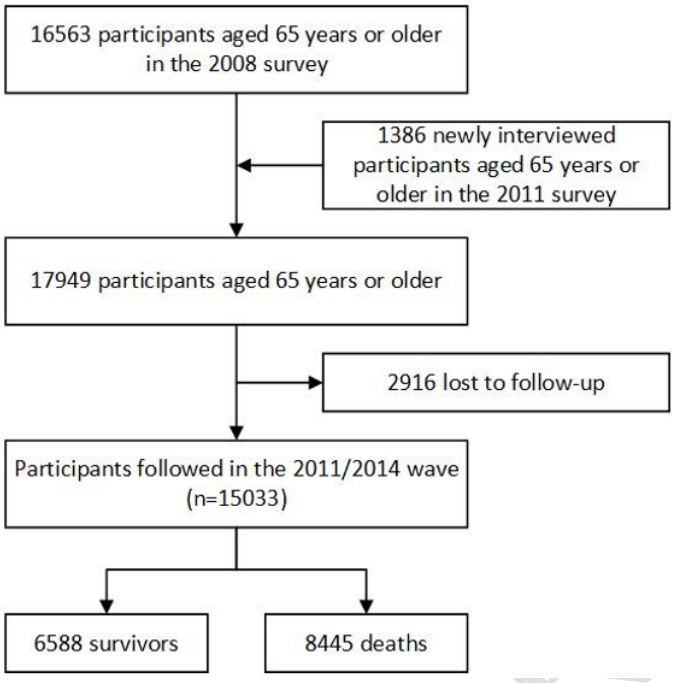

Figure 1. Flow chart of the study population.

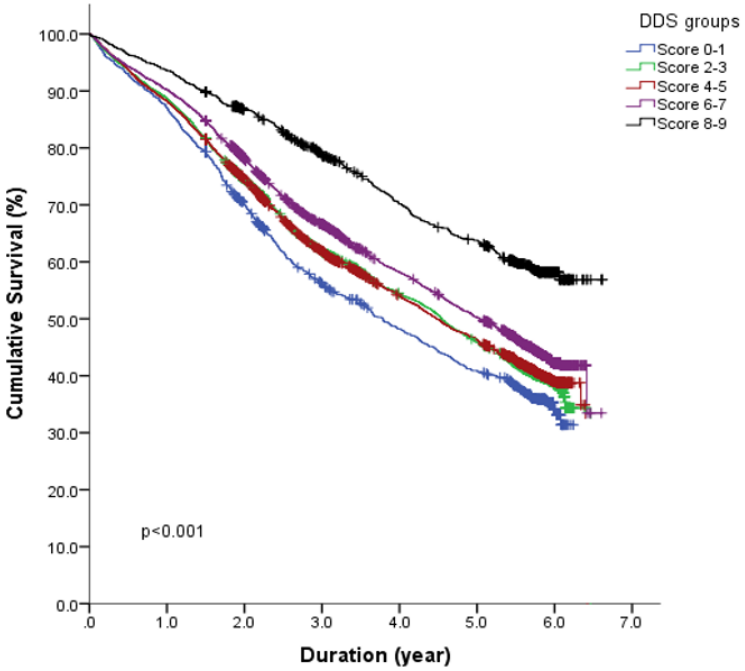

Figure 2. Cumulative Kaplan-Meier curves for total mortality during follow-up.

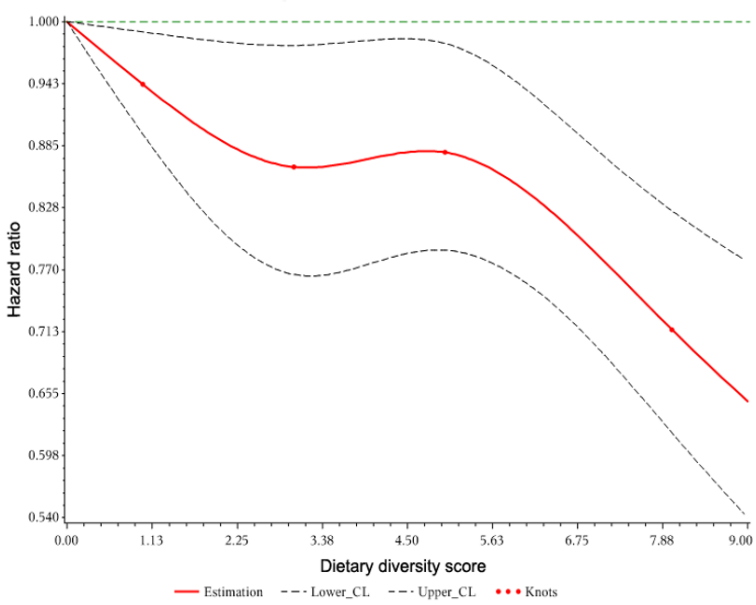

Figure 3. Association between mortality and dietary diversity score using restricted cubic spline analysis with 4 knots. (Hazard ratios are indicated by solid lines and 95% confidence intervals by dotted lines, reference point is the lowest value of dietary diversity score (DDS=0), after adjusting for age, education years, sex, BMI, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family economic condition, and history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer)

Supplementary table 1. Adjusted hazard ratios (95% CI) of all-cause mortality for total diet diversity in sensitivity analyses

Score	HR (95% CI) for all-cause mortality		
	Model 1	Model 2	Model 3
Total DDS			
0-1	1 (reference)	1 (reference)	1 (reference)
2-3	0.86 (0.79, 0.94)*	0.90 (0.82, 0.98)*	0.90 (0.82, 0.98)*
4-5	0.87 (0.80, 0.94)*	0.91 (0.83, 0.99)*	0.91 (0.84, 0.99)*
6-7	0.78 (0.71, 0.85)*	0.86 (0.78, 0.94)*	0.86 (0.78, 0.94)*
8-9	0.50 (0.44, 0.58)*	0.74 (0.64, 0.86)*	0.73 (0.63, 0.84)*
p for trend	<0.001*	<0.001*	<0.001*

DDS: diet diversity score; HR: Hazard ratio; CI: confidence interval.
Model 1 was unadjusted.
Model 2 was adjusted for age, education years, BMI, marriage, smoking status, alcohol intake, regular exercise, residence, living pattern, good family economic condition.
Model 3 as model 2 plus: history of hypertension, cardiovascular disease, stroke, cerebrovascular disease, respiratory disease, and cancer.
* $p<0.05$