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Adherence to dietary guidelines and mortality: a report from prospective cohort studies of 134,000 Chinese adults in urban Shanghai[1–4]

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Abstract

Background: A higher adherence to dietary recommendations, such as the Dietary Approaches to Stop Hypertension (DASH) and the Alternative Healthy Eating Index (AHEI), has been associated with lower morbidity and mortality from chronic diseases in Western populations. However, the health benefits of following the Dietary Guidelines for Chinese remain unknown.

Objective: We examined adherence to the Chinese Food Pagoda (CHFP) in association with total and cause-specific mortality and compared associations with those of the DASH and AHEI.

Design: Participants included 61,239 men and 73,216 women (aged 40–74 y) from 2 population-based prospective studies in Shanghai, China. Habitual dietary intakes were assessed at baseline in-person interviews by using validated food-frequency questionnaires. Deaths and underlying causes were identified through the Shanghai Vital Statistics Registry and follow-up home visits.

Results: We documented 2954 deaths in men and 4348 deaths in women during mean follow-ups of 6.5 and 12.0 y, respectively. A higher CHFP score was associated with lower total mortality with multivariable-adjusted HRs of 0.67 (95% CI: 0.60, 0.75) in men and 0.87 (95% CI: 0.80, 0.95) in women when extreme quartiles were compared (both P-trend < 0.005). Decreased risks associated with a higher CHFP score were observed for cardiovascular disease, cancer, and diabetes mortality, particularly in men. A significantly lower total mortality was shown for adherence to specific recommendations on vegetables, fruit, legumes, fish, and eggs but not grains, dairy, meat, fat, and salt. A higher DASH score and AHEI also predicted lower mortality from all causes, cardiovascular disease, and diabetes but not cancer.

Conclusions: A greater compliance with Chinese or US dietary guidelines is associated with lower total mortality in Chinese adults. Favorable associations are more evident in men than women and more consistent for cardiometabolic mortality than cancer mortality. *Am J Clin Nutr* 2014;100:693–700.

INTRODUCTION

Various dietary recommendations have been disseminated to help people eat healthier and live longer. A higher adherence to some recommendations has been associated with reduced morbidity and mortality from chronic diseases, mainly cardiovascular disease (CVD)[5] and cancer (1). For example, the Alternative Healthy Eating Index (AHEI) was developed on the basis of the Dietary Guidelines for Americans and modified by Harvard researchers to target foods and nutrients that had been reported to have health benefits (2, 3). A higher AHEI has been shown to predict 20–40% lower risks of developing CVD (2, 3), diabetes (4), heart failure (5), and colorectal and pancreatic cancers (6, 7) and 10–20% lower mortality (8) in US populations. Another healthy eating plan, the Dietary Approaches to Stop Hypertension (DASH), which has been promoted by the National Heart, Lung, and Blood Institute (9) as well as news media (10), has been associated with lower blood pressure (11) and decreased incidence of type 2 diabetes (12), CVD (13), and colorectal cancer (14). Both recommendations emphasize increasing consumptions of whole grains, vegetables, fruit, nuts, and legumes. However, the guidelines differ on recommendations on dairy products, meats, and sodium. For example, the DASH diet recommends >2 servings dairy products/d, whereas the AHEI does not contain a dairy component; and the DASH diet limits intakes of all meats, poultry, fish, and eggs (9), whereas the AHEI focuses on the ratio of white to red meat (2) and promotes fish consumption for a sufficient long-chain n−3 fat intake (3). Only a few studies have examined the capabilities of diet quality scores to predict total or cause-specific mortality (8, 15, 16).

The Dietary Guidelines for Chinese illustrated by a Food Pagoda were proclaimed by the Chinese Nutrition Society and Ministry of Health in 2007. The guidelines aim to help Chinese people keep a balanced diet during recent nutrition transitions from traditional diets to more-Westernized diets (17, 18). Similar to the DASH, Chinese dietary guidelines recommend

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[5] Abbreviations used: AHEI, Alternative Healthy Eating Index; CHFP, Chinese Food Pagoda; CVD, cardiovascular disease; DASH, Dietary Approaches to Stop Hypertension; FFQ, food-frequency questionnaire; SMHS, Shanghai Men's Health Study; SWHS, Shanghai Women's Health Study.

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the consumption of plenty of whole grains, vegetables, fruit, dairy products, and soy foods, appropriate amounts of fish, poultry, eggs, and lean meats, and limited amounts of fat and salt (18). Thus far, little is known about whether adherence to these national dietary guidelines could reduce the burden of chronic diseases. This possibility may be of particular importance in the fast developing and aging China, where CVD, cancer, diabetes, and other chronic diseases are now responsible for 80% of deaths (19, 20).

Therefore, we designed a 10-component Chinese Food Pagoda (CHFP) score to measure the adherence to 2007 Chinese Dietary Guidelines. We also modified the original DASH score and AHEI-2010 according to dietary characteristics in Chinese populations. With the use of prospective data of 134,455 men and women from the Shanghai Men's Health Study (SMHS) and Shanghai Women's Health Study (SWHS), we examined associations of the CHFP score, modified DASH score, and modified AHEI-2010 with total and cause-specific mortality.

SUBJECTS AND METHODS

Study population

The SMHS and SWHS are both population-based, prospective cohort studies conducted in urban areas of Shanghai, China. Similar designs and methods were used in 2 studies and have been described previously (21, 22). Both studies were approved by the Institutional Review Boards of the Shanghai Cancer Institute and Vanderbilt University in accordance with the Helsinki Declaration of 1975 as revised in 1983. Written informed content was obtained from all participants. Through home visits, the SMHS enrolled 61,482 men (aged 40–74 y) from January 2002 to September 2006, and the SWHS enrolled 74,941 women (aged 40–70 y) from December 1996 to May 2000, with response rates of 74.1% and 92.7%, respectively. Baseline surveys were conducted by trained interviewers by using structured questionnaires to collect information on sociodemographics, diet and lifestyle habits, and medical histories. Weight, height, and circumferences of waist and hip were also measured at baseline.

Dietary assessment

Semiquantitative food-frequency questionnaires (FFQs) designed to capture commonly consumed foods in urban Shanghai were administered in face-to-face interviews to assess habitual dietary intakes over the preceding year. Similar FFQs were used in the SMHS and SWHS, which contained 81 and 77 food items, respectively. For each food item, participants were asked about the frequency (daily, weekly, monthly, yearly, or never) and quantity [liangs (50 g)] that they consumed each time. Energy and nutrients intake were calculated on the basis of the 2002 Chinese Food Composition Table (23). The FFQs have been validated against multiple 24-h dietary recalls separately for men (24) and women (25) and showed fairly high validity and reproducibility; correlation coefficients for major food groups and macronutrients were 0.41–0.72 in the SMHS and 0.41–0.66 in the SWHS.

Dietary recommendation adherence scores

Because recommendations were generally made according to energy requirements, dietary intakes were adjusted for total energy intake by using the density method and standardized to 2000 kcal/d (26). The CHFP score was created on the basis of the following 5 food groups (10 components) in the 2007 CHFP: *1*) grains; *2*) vegetables and fruit; *3*) dairy products and beans and bean products; *4*) meat and poultry, fish and shrimp, and eggs; and *5*) fats and oils and salt (*see* Supplemental Table 1 under "Supplemental data" in the online issue.) (17). We adopted scoring methods used in creating the US Healthy Eating Index 2005 (27). Standards for maximum points and 0 points were decided on the basis of recommended intakes in the Food Pagoda (18). Intermediate intakes between minimum and maximum amounts were scored proportionately. All component scores were summed to obtain a total CHFP score, which ranged from 0 (the lowest adherence) to 45 (the highest adherence).

The modified DASH score included the following 7 components listed in the DASH eating plan: vegetables; fruit; dairy; meat, poultry, fish, and eggs; nuts, seeds, and legumes; fats and oils; and sodium (*see* Supplemental Table 2 under "Supplemental data" in the online issue.) (9). Information on whole grains and sugar-sweetened beverages was not collected in the SMHS and SWHS because of very low consumptions in the study populations. Serving sizes for some components were estimated by converting the amount consumed in grams used in our FFQs to servings used in the DASH (g/serving for vegetables and fruit: 80; for dairy: 245; for meat, poultry, and fish: 28; for eggs: 50; for nuts: 43; for seeds: 28; for legumes: 113; and for fats and oils: 15).

The modified AHEI was calculated on the basis of 8 of 11 components contained in the AHEI-2010 as follows: vegetables, fruit, nuts and legumes, red and processed meat, long-chain (n−3) fats (EPA and DHA), PUFAs, sodium, and alcohol (*see* Supplemental Table 3 under "Supplemental data" in the online issue.) (3). Whole grains, sugar-sweetened beverages, and *trans* fats were not included because of very low consumptions and lack of data in the Chinese Food Composition Table.

Death ascertainment

Participants were followed by annual record linkage to the Shanghai Cancer Registry and the Shanghai Vital Statistics Registry as well as by home visits conducted every 2–3 y. Almost all participants (>99%) were successfully followed for their vital status from the baseline survey through 31 December 2010 in both cohorts. Underlying causes of death listed in the death certificates were coded according to the ninth revision of the *International Classification of Diseases*. Primary outcomes were all-cause mortality and mortality from CVD (codes 390–459), cancer (codes 140–208), or diabetes (code 250).

Statistical analysis

For the current analysis, we excluded 243 men and 130 women who reported extreme energy intakes (>4200 or <800 kcal/d for men and >3500 or <500 kcal/d for women). We also excluded 1595 women with diagnosed cancer at baseline in the SWHS to be consistent with the SMHS in which a history of cancer was an exclusion criterion of enrollment.

Analyses were conducted separately for 61,239 men and 73,216 women in consideration of different time periods of 2 cohorts and possible sex-specific effects of dietary patterns on

mortality. Men and women were classified by quartile distributions of dietary recommendation adherence scores. Age-adjusted baseline characteristics were compared by using n ANOVA for continuous variables and chi-square tests for categorical variables. Associations between the adherence score and mortality were analyzed by using Cox proportional hazard regression with age as a time metric. HRs and 95% CIs were calculated and adjusted for educational attainment (4 levels); income (4 levels); cigarette smoking (for women, never or ever; for men, never, past, or currently 1–9, 10–19, or ≥20 cigarettes/d); alcohol consumption (for women, never or ever; for men, never, past, or currently <2 or ≥2 drinks/d); physical activity (metabolic equivalent task score per hours per week); use of multivitamin supplement; menopausal status and use of hormone therapy (for women only); BMI (in kg/m^2); waist-to-hip ratio; history of CVD, diabetes, or hypertension; and total energy intake. A linear trend was tested by treating the median value of each quartile as a continuous variable. The population-attributable risk percentage and 95% CI related to first to third quartiles of adherence score was calculated from multivariate models by using the fourth quartile as a referent (28). Stratified analyses were conducted by age, education, obesity, smoking, and history of chronic diseases. Sensitivity analyses were performed by omitting the first or the first 2 y follow-up. Analyses were also carried out to examine the association between each component score (standardized to a mean ± SD of 0 ± 1) and total mortality with additional adjustment for a modified total score that excluded the corresponding component. SAS software (version

TABLE 1
Age-standardized baseline characteristics according to quartiles of the CHFP score[1]

	Men (SMHS, n = 61,239)		Women (SWHS, n = 73,216)	
Characteristic	Lowest quartile	Highest quartile	Lowest quartile	Highest quartile
CHFP score[2]	27.8	38.5	28.4	38.0
No. of participants	15,458	15,213	18,494	18,133
Age (y)	54.8 ± 9.9[3]	55.9 ± 9.6	53.0 ± 9.5	52.2 ± 8.6
High education (%)[4]	14.8	32.3	9.7	17.7
High income (%)[5]	6.7	13.4	13.8	21.3
Smoking (%)				
Never	19.7	40.8	95.5	98.4
Past	9.5	11.8	4.5	1.6
Current	70.8	47.4		
Drinking alcohol (%)	44.7	27.0	3.2	1.8
Use of multivitamin (%)	4.8	10.6	5.0	9.5
Use of hormone therapy (%)	—	—	1.3	2.8
History of cardiovascular disease (%)	7.9	8.9	7.9	8.6
History of diabetes (%)	7.4	4.8	6.3	3.3
History of hypertension (%)	27.0	32.3	22.9	25.0
BMI (kg/m^2)	23.6 ± 3.2	23.9 ± 2.9	24.1 ± 3.5	23.9 ± 3.3
Waist-to-hip ratio	0.90 ± 0.06	0.90 ± 0.05	0.81 ± 0.05	0.81 ± 0.05
Physical activity (MET-h/wk)	58.5 ± 35.0	60.6 ± 33.7	105.1 ± 45.5	107.8 ± 45.1
Dietary intakes[6]				
Total energy (kcal/d)	1947 ± 552	1875 ± 413	1725 ± 455	1645 ± 343
Grains (g/d)	367 ± 84	367 ± 47	344 ± 92	347 ± 52
Vegetables (g/d)	312 ± 196	428 ± 166	302 ± 182	417 ± 169
Fruits (g/d)	92 ± 112	221 ± 121	257 ± 210	370 ± 191
Dairy products (g/d)	59 ± 99	161 ± 114	65 ± 110	140 ± 123
Beans and bean products (dry weight) (g/d)	21 ± 18	24 ± 12	20 ± 17	23 ± 12
Nuts (g/d)	3 ± 6	3 ± 4	2 ± 4	2 ± 3
Eggs (g/d)	33 ± 28	26 ± 16	38 ± 30	27 ± 17
Red meat (g/d)	91 ± 51	46 ± 21	83 ± 47	43 ± 21
Poultry (g/d)	22 ± 26	13 ± 16	24 ± 27	14 ± 12
Fish (g/d)	50 ± 52	60 ± 39	55 ± 54	65 ± 43
Total fats (g/d)	42 ± 16	33 ± 6	39 ± 14	32 ± 7
Total salt (g/d)	7 ± 2	6 ± 1	8 ± 3	6 ± 1

[1] Continuous and categorical variables were compared by using ANOVA and chi-square tests, respectively. All P values <0.05 are for comparison between quartiles, with the exception for grain intake (P = 0.96) and nut intake (P = 0.17) in men and history of cardiovascular disease (P = 0.05) and nut intake (P = 0.23) in women. CHFP, Chinese Food Pagoda; MET-h, metabolic equivalent task-hours; SMHS, Shanghai Men's Health Study; SWHS, Shanghai Women's Health Study.

[2] All values are medians.

[3] Mean ± SD (all such values).

[4] Defined as having a professional or college education or more.

[5] Defined as an annual personal income >24,000 yuan in the SMHS and an annual family income >30,000 yuan in the SWHS.

[6] Dietary intakes were adjusted for total energy intake (density method) and standardized to 2000 kcal.

9.3; SAS Institute) was used for analyses, and a 2-sided $P < 0.05$ was considered statistically significant.

RESULTS

Mean (±SD) CHFP scores were 33.4 ± 4.7 (range: 9.0–44.6) in men and 33.4 ± 4.2 (range: 11.4–44.9) in women. More than 50% of participants met CHFP recommendations (scored with maximum points) regarding consumptions of grains (>300 g/d), fruit (>100 g/d), meat and poultry (<100 g/d), and eggs (<50 g/d). In contrast, <10% of participants met the recommendation on dairy products (>300 g/d). For salt, 46% men and 30% women consumed <6 g/d as recommended in the CHFP, whereas only 8% men and 4% women met the stricter standard of the DASH diet (<1500 mg sodium/d, equal to <3.8 g salt/d). Spearman's correlation coefficient was 0.68 between the CHFP and DASH, 0.57 between the CHFP and AHEI, and 0.49 between the DASH and AHEI (all $P < 0.05$).

Participants with a higher adherence to Chinese dietary recommendations were older men and younger women (**Table 1**). These groups had higher education, income, and physical activity. Also, they were more likely to use multivitamin supplements and hormone therapy in women and less likely to smoke cigarettes or drink alcohol. Participants with a higher CHFP score had a lower prevalence of diabetes but higher prevalence of CVD or hypertension.

During average follow-ups of 6.5 and 12.0 y, we documented 2954 and 4348 deaths in men and women, respectively. Inverse associations were shown for all 3 scores in both sexes (**Table 2**). After adjustment for potential confounders, higher CHFP and DASH scores and AHEI all predicted lower total mortality, with HRs that ranged from 0.67 to 0.76 in men and 0.80 to 0.87 in women for comparison of the highest with lowest quartiles (all P-trend < 0.005). The per SD increase in adherence score was associated with a 11–15% decrease in total mortality in men and a 4–8% decrease in women (*see* Supplemental Table 1–3 under "Supplemental data" in the online issue). Of individual dietary components, adherence to recommendations on vegetables, fruit, nuts and legumes, fish (EPA plus DHA), and eggs showed significant inverse associations with total mortality in both men and women. *See* Supplemental Table 4 under "Supplemental data" in the online issue for correlations of components in the CHFP.

For cause-specific mortality, in men, there were 964 CVD deaths, 1290 cancer deaths, 105 diabetes deaths, and 595 deaths were attributable to other causes. The CHFP was associated with reduced mortality from these chronic diseases (**Table 3**). HRs (95% CIs) for comparison of extreme quartiles were 0.54 (0.45, 0.66), 0.83 (0.70, 0.97), and 0.58 (0.31, 1.10) for CVD, cancer, and diabetes mortality, respectively (all P-trend < 0.02). The modified DASH score and AHEI also predicted a 40–44% reduction in CVD mortality in the highest compared with lowest

TABLE 2
HRs (95% CIs) for total mortality by quartiles of dietary recommendation adherence scores[1]

	Quartile of dietary recommendation adherence scores				
	1	2	3	4	*P*-trend
Shanghai Men's Health Study (n = 61,239)					
CHFP score					
No. of deaths	1003	720	685	546	—
Age- and energy-adjusted HR	1.00	0.70 (0.64, 0.77)	0.64 (0.58, 0.70)	0.51 (0.46, 0.56)	<0.0001
Multivariable HR[2]	1.00	0.78 (0.71, 0.86)	0.77 (0.69, 0.85)	0.67 (0.60, 0.75)	<0.0001
Modified DASH score					
No. of deaths	834	771	706	643	—
Age- and energy-adjusted HR	1.00	0.80 (0.73, 0.88)	0.69 (0.63, 0.77)	0.58 (0.52, 0.64)	<0.0001
Multivariable HR[2]	1.00	0.86 (0.78, 0.95)	0.82 (0.74, 0.91)	0.76 (0.69, 0.85)	<0.0001
Modified AHEI-2010					
No. of deaths	1020	750	671	513	—
Age- and energy-adjusted HR	1.00	0.75 (0.68, 0.83)	0.65 (0.59, 0.71)	0.53 (0.48, 0.59)	<0.0001
Multivariable HR[2]	1.00	0.83 (0.76, 0.92)	0.77 (0.70, 0.85)	0.68 (0.61, 0.76)	<0.0001
Shanghai Women's Health Study (n = 73,216)					
CHFP score					
No. of deaths	1353	1166	989	840	—
Age- and energy-adjusted HR	1.00	0.91 (0.84, 0.98)	0.83 (0.77, 0.90)	0.73 (0.67, 0.80)	<0.0001
Multivariable HR[2]	1.00	0.99 (0.92, 1.07)	0.95 (0.88, 1.04)	0.87 (0.80, 0.95)	0.004
Modified DASH score					
No. of deaths	1379	1138	1005	826	—
Age- and energy-adjusted HR	1.00	0.85 (0.78, 0.91)	0.77 (0.71, 0.83)	0.67 (0.61, 0.73)	<0.0001
Multivariable HR[2]	1.00	0.92 (0.85, 0.99)	0.88 (0.81, 0.96)	0.84 (0.76, 0.91)	<0.0001
Modified AHEI-2010					
No. of deaths	1542	1161	952	693	—
Age- and energy-adjusted HR	1.00	0.88 (0.81, 0.95)	0.83 (0.77, 0.91)	0.67 (0.61, 0.74)	<0.0001
Multivariable HR[2]	1.00	0.93 (0.86, 1.00)	0.93 (0.86, 1.01)	0.80 (0.73, 0.87)	<0.0001

[1] AHEI, Alternative Healthy Eating Index; CHFP, Chinese Food Pagoda; DASH, Dietary Approaches to Stop Hypertension.

[2] Cox proportional hazards model was adjusted for age; education; income; smoking; alcohol consumption (for CHFP and DASH scores only); multivitamin use; menopausal status and hormone therapy (for women only); physical activity; BMI; waist-to-hip ratio; history of cardiovascular disease, diabetes, or hypertension; and total energy intake.

TABLE 3
HRs (95% CIs) for cause-specific mortality by quartiles of dietary recommendation adherence scores[1]

	Quartile of dietary recommendation adherence scores				
	1	2	3	4	*P*-trend
Shanghai Men's Health Study (n = 61,239)					
CHFP score					
Cardiovascular disease mortality					
No. of deaths	345	245	214	160	—
Multivariable HR[2]	1.00	0.73 (0.62, 0.87)	0.68 (0.57, 0.81)	0.54 (0.45, 0.66)	<0.0001
Cancer mortality					
No. of deaths	409	302	312	267	—
Multivariable HR[2]	1.00	0.82 (0.71, 0.96)	0.88 (0.75, 1.02)	0.83 (0.70, 0.97)	0.02
Diabetes mortality					
No. of deaths	46	30	16	13	—
Multivariable HR[2]	1.00	0.83 (0.52, 1.32)	0.53 (0.30, 0.96)	0.58 (0.31, 1.10)	0.02
Modified DASH score					
Cardiovascular disease mortality					
No. of deaths	293	257	222	192	—
Multivariable HR[2]	1.00	0.77 (0.65, 0.92)	0.70 (0.58, 0.83)	0.60 (0.49, 0.73)	<0.0001
Cancer mortality					
No. of deaths	350	335	311	294	—
Multivariable HR[2]	1.00	0.93 (0.80, 1.08)	0.90 (0.77, 1.05)	0.88 (0.75, 1.04)	0.11
Diabetes mortality					
No. of deaths	29	34	27	15	—
Multivariable HR[2]	1.00	1.16 (0.70, 1.92)	0.99 (0.58, 1.70)	0.68 (0.36, 1.31)	0.29
Modified AHEI-2010					
Cardiovascular disease mortality					
No. of deaths	380	242	193	149	—
Multivariable HR[2]	1.00	0.74 (0.63, 0.87)	0.61 (0.51, 0.73)	0.56 (0.46, 0.68)	<0.0001
Cancer mortality					
No. of deaths	385	324	321	260	—
Multivariable HR[2]	1.00	0.94 (0.81, 1.09)	0.97 (0.83, 1.12)	0.87 (0.74, 1.02)	0.13
Diabetes mortality					
No. of deaths	46	20	27	12	—
Multivariable HR[2]	1.00	0.49 (0.29, 0.84)	0.83 (0.50, 1.36)	0.48 (0.25, 0.91)	0.04
Shanghai Women's Health Study (n = 73,216)					
CHFP score					
Cardiovascular disease mortality					
No. of deaths	443	358	285	258	—
Multivariable HR[2]	1.00	0.94 (0.82, 1.08)	0.88 (0.76, 1.03)	0.88 (0.75, 1.03)	0.06
Cancer mortality					
No. of deaths	524	492	441	379	—
Multivariable HR[2]	1.00	1.02 (0.90, 1.15)	0.99 (0.87, 1.12)	0.89 (0.77, 1.02)	0.11
Diabetes mortality					
No. of deaths	132	79	56	40	—
Multivariable HR[2]	1.00	0.91 (0.68, 1.20)	0.90 (0.65, 1.23)	0.73 (0.51, 1.05)	0.11
Modified DASH score					
Cardiovascular disease mortality					
No. of deaths	459	341	310	234	—
Multivariable HR[2]	1.00	0.84 (0.73, 0.97)	0.85 (0.73, 0.98)	0.79 (0.67, 0.92)	0.003
Cancer mortality					
No. of deaths	503	499	451	383	—
Multivariable HR[2]	1.00	1.04 (0.92, 1.17)	0.97 (0.86, 1.11)	0.90 (0.78, 1.03)	0.12
Diabetes mortality					
No. of deaths	133	92	51	31	—
Multivariable HR[2]	1.00	0.99 (0.76, 1.30)	0.75 (0.54, 1.04)	0.65 (0.44, 0.97)	0.02
Modified AHEI-2010					
Cardiovascular disease mortality					
No. of deaths	525	337	294	188	—
Multivariable HR[2]	1.00	0.83 (0.73, 0.96)	0.92 (0.80, 1.07)	0.73 (0.62, 0.87)	0.001
Cancer mortality					
No. of deaths	559	501	426	350	—
Multivariable HR[2]	1.00	1.03 (0.92, 1.17)	1.01 (0.89, 1.15)	0.92 (0.80, 1.06)	0.30

(Continued)

TABLE 3 (*Continued*)

	Quartile of dietary recommendation adherence scores				
	1	2	3	4	*P*-trend
Diabetes mortality					
No. of deaths	150	85	47	25	—
Multivariable HR[2]	1.00	0.76 (0.58, 0.99)	0.61 (0.44, 0.86)	0.50 (0.32, 0.77)	<0.0001

[1] AHEI, Alternative Healthy Eating Index; CHFP, Chinese Food Pagoda; DASH, Dietary Approaches to Stop Hypertension.
[2] Cox proportional hazards model was adjusted for age; education; income; smoking; alcohol consumption (for CHFP and DASH scores only); multivitamin use; menopausal status and hormone therapy (for women only); physical activity; BMI; waist-to-hip ratio; history of cardiovascular disease, diabetes, or hypertension; and total energy intake.

quartiles (both *P*-trend < 0.0001), but their associations with all-cancer mortality were not significant. In additional analyses of specific cancer, CHFP and DASH scores were associated with 50–60% lower risk of colorectal cancer across extreme quartiles, and no associations were shown for other major cancers in men (lung, stomach, and liver cancer) (*see* Supplemental Table 5 under "Supplemental data" in the online issue).

In women, there were 1344 CVD deaths, 1836 cancer deaths, 307 diabetes deaths, and 861 deaths that were attributable to other causes (Table 3). The CHFP score tended to be associated with 12%, 11%, and 27% lower risks of CVD, cancer, and diabetes mortality across extreme quartiles, but associations were not statistically significant (*P*-trend = 0.06, 0.11, and 0.11, respectively). The modified DASH score and AHEI were significantly associated with 21–27% and 35–50% reductions in CVD and diabetes mortality, respectively, across extreme quartiles (all *P*-trend < 0.02) but not with all-cancer mortality. We observed a significant inverse association between the AHEI and female-specific cancer, including breast, uterus, cervix, placenta, and ovary cancers (*see* Supplemental Table 5 under "Supplemental data" in the online issue) but no associations for other major cancers in women (lung, stomach, and colorectal cancer).

With the use of participants in the highest quartile as the referent, a lower adherence to Chinese dietary guidelines was significantly associated with population attributable risks (95% CIs) of 18% (11%, 26%) for all-cause mortality and 27% (15%, 40%) for CVD mortality in men and 10% (3%, 17%) for all-cause mortality in women.

We did not find significant effect modifications on the CHFP-total mortality association in analyses stratified by age, education, obesity, smoking, and history of chronic diseases (**Table 4**). Inverse associations of the modified DASH score and AHEI with total mortality were also independent of these known risk factors (data not shown). After the exclusion of the first year of follow-up

TABLE 4
HRs (95% CIs) for total mortality by quartiles of Chinese Food Pagoda score in stratified analyses[1]

Subgroup	No. of deaths/subjects	Quartile of Chinese Food Pagoda score				*P*-trend
		1	2	3	4	
Shanghai Men's Health Study						
Age <55 y	595/34,354	1.00	0.65 (0.52, 0.82)	0.73 (0.58, 0.91)	0.82 (0.65, 1.03)	0.02
Age ≥55 y	2359/26,885	1.00	0.82 (0.74, 0.91)	0.79 (0.70, 0.88)	0.65 (0.57, 0.73)	<0.0001
Low education	1623/24,286	1.00	0.79 (0.70, 0.90)	0.73 (0.64, 0.84)	0.66 (0.57, 0.77)	<0.0001
High education	1331/36,953	1.00	0.75 (0.64, 0.88)	0.79 (0.68, 0.92)	0.66 (0.56, 0.78)	<0.0001
BMI <25 kg/m^2	1956/40,960	1.00	0.77 (0.69, 0.87)	0.76 (0.67, 0.86)	0.64 (0.56, 0.74)	<0.0001
BMI ≥25 kg/m^2	998/20,279	1.00	0.78 (0.66, 0.92)	0.78 (0.65, 0.92)	0.71 (0.59, 0.85)	0.0001
Nonsmokers	878/18,631	1.00	0.78 (0.65, 0.95)	0.77 (0.63, 0.93)	0.60 (0.49, 0.73)	<0.0001
Smokers	2076/42,608	1.00	0.77 (0.69, 0.86)	0.76 (0.68, 0.86)	0.71 (0.62, 0.81)	<0.0001
Without chronic diseases	1216/39,975	1.00	0.77 (0.66, 0.89)	0.72 (0.61, 0.84)	0.73 (0.61, 0.86)	<0.0001
With any chronic disease	1738/21,264	1.00	0.78 (0.68, 0.88)	0.77 (0.68, 0.88)	0.61 (0.53, 0.71)	<0.0001
Shanghai Women's Health Study						
Age <55 y	942/46,210	1.00	1.11 (0.93, 1.32)	0.97 (0.80, 1.16)	0.91 (0.76, 1.10)	0.23
Age ≥55 y	3406/27,006	1.00	0.97 (0.88, 1.05)	0.96 (0.87, 1.05)	0.89 (0.79, 0.96)	0.01
Low education	3371/42,877	1.00	1.00 (0.92, 1.09)	0.97 (0.89, 1.07)	0.84 (0.76, 0.93)	0.005
High education	997/30,339	1.00	0.93 (0.77, 1.13)	0.85 (0.70, 1.02)	0.87 (0.73, 1.04)	0.08
BMI <25 kg/m^2	2339/47,376	1.00	0.96 (0.86, 1.07)	0.95 (0.84, 1.06)	0.92 (0.81, 1.03)	0.14
BMI ≥25 kg/m^2	2009/25,840	1.00	1.03 (0.92, 1.16)	0.96 (0.85, 1.09)	0.83 (0.72, 0.95)	0.01
Nonsmokers	4028/71,184	1.00	0.99 (0.91, 1.07)	0.96 (0.88, 1.05)	0.89 (0.81, 0.97)	0.02
Smokers	320/2032	1.00	1.09 (0.84, 1.43)	0.88 (0.64, 1.20)	0.66 (0.45, 0.98)	0.07
Without chronic diseases	2048/52,526	1.00	1.03 (0.92, 1.16)	0.97 (0.86, 1.10)	0.92 (0.81, 1.05)	0.19
With any chronic disease	2300/20,690	1.00	0.92 (0.83, 1.03)	0.88 (0.79, 0.99)	0.79 (0.70, 0.89)	0.0001

[1] Cox proportional hazards model was adjusted for all variables listed in footnote 2 of Table 2 except for one used for stratification. Chronic diseases included cardiovascular disease, diabetes, and hypertension at baseline. All *P*-interaction values were >0.05.

in the SMHS and the first 2 y in the SWHS, associations between dietary adherence scores and total mortality were essentially unchanged (data not shown).

DISCUSSION

Results from these 2 large population-based prospective cohort studies suggest that a higher adherence to dietary guidelines, which indicates an overall healthier diet, is associated with lower mortality in Chinese men and women. Magnitudes of reduction in total mortality were comparable across dietary guidelines (ie, the CHFP, DASH, and AHEI-2010) with 24–33% lower risks in men and 13–20% lower risks in women. Favorable associations seemed to be more consistent for CVD and diabetes mortality than cancer mortality.

Few studies have examined total and cause-specific mortality in relation to national dietary guidelines. To our knowledge, our study is the first study to assess mortality risk associated with adherence to 2007 Chinese Dietary Guidelines and compare it with 2 well-known US dietary guidelines. Our findings are in agreement with results from other studies that healthy diets assessed by diet-quality scores were associated with reduced morbidity or mortality from major chronic diseases, with more-pronounced associations for CVD than cancers (1). In the Health Professionals Follow-Up Study and Nurses' Health Study, the highest quintile of the AHEI-2010 was associated with 17% lower risk in men and 21% lower risk in women for chronic diseases (CVD, cancer, and nontraumatic death combined). Associations in both sexes were mainly driven by a reduced CVD incidence (3). A higher AHEI has lately been shown to be also associated with decreased mortality in myocardial infarction survivors in these 2 studies (16). In the Iowa Women's Health Study, Mursu et al (8) reported that the highest quartile of AHEI predicted 12–24% lower risks of total, CVD, cancer, or inflammatory-related mortality in postmenopausal women. And in the Whitehall II cohort, British men and women in the third compared with first tertiles of the AHEI showed 25% and 42% lower risk of total and CVD mortality, respectively (15).

Several diet-quality indexes have been developed on the basis of prevailing dietary guidelines, traditional regional diets, or data-driven pattern analyses (29). Besides the DASH and AHEI, the Mediterranean diet score has been consistently associated with 15–40% lower mortality in several US and European populations (30–32). In our study, magnitudes of reduction in total mortality were similar across 3 dietary scores when we compared the highest with lowest quartiles. These scores were correlated with each other and may have comparable capabilities to separate participants with overall healthy diets from those with less-healthy diets. Some common components in these recommendations, such as vegetables, fruit, legumes, and fish, showed significant benefits in the current study. However, other components showed null or even adverse associations with mortality. For example, grain intake >300 g/d that is recommended in the CHFP showed a trend of positive associations with total mortality in both men and women. One reason for this result may have been that the majority of grains consumed in our study populations were white rice and refined wheat products that may increase risks of diabetes and CVD (33–35). Another recommendation of >300 g dairy/d was practically difficult to achieve in our study populations because <10% of participants consumed the recommended quantity. For meat intake, the DASH combines red meat, poultry, fish, and eggs in one component, and this component score was positively associated with total mortality in our female cohort. Because fish intake may decrease, whereas red meat intake may increase, risk of mortality, it would be difficult to predict the overall effect when they are lumped together (36, 37). Nevertheless, our results support the health benefits of adherence to either Chinese or US dietary guidelines to achieve a balanced diet with adequate and diverse nutrients and food intakes, although some recommendations on individual food or food groups could be improved.

Our study had several limitations. First, dietary measurement errors are inevitable although FFQs used in both cohorts had been validated against multiple 24-h dietary recalls and were administered during face-to-face interviews by trained interviewers who were recently retired medical professionals. We did not assess the performance of the FFQ in capturing sodium intake. As with many other epidemiologic studies, the measurement of dietary sodium intake by using an FFQ is crude and likely to underestimate the intake. But because of the prospective design, dietary measurement errors were nondifferential and likely attenuated associations. Second, some components originally proposed in the DASH and AHEI were not included because of the low consumption in our study populations. Thus, the predictive value of these 2 modified scores might have been underestimated in our study. Third, our participants were recruited from urban communities in Shanghai, which is one of the most-developed regions in Southern China. Therefore, findings of this study may not necessarily be generalizable to other populations.

In conclusion, in 134,455 Chinese men and women, we showed that higher adherence to both Chinese and US dietary recommendations predicted lower total mortality, especially lower mortality from CVD and diabetes. These associations were independent of sociodemographics, lifestyles, and chronic disease status at baseline. Our results support the benefits of adopting healthy diets with an emphasis on consuming vegetables, fruit, nuts, legumes, and fish. However, we showed no clear evidence for reduced mortality by following recommendations on grains, dairy, meat, fat, and salt in the 2007 Dietary Guidelines for Chinese, which warrants further research.

The authors' responsibilities were as follows—XZ, Y-BX, GY, Y-TG, WZ, and X-OS: designed and conducted the study; XZ, Y-BX, GY, HL, Y-TG, WZ, and X-OS: collected and managed data; DY: analyzed data and drafted the manuscript; X-OS: had primary responsibility for the final content of the manuscript; and all authors: contributed to the preparation and revision of the manuscript and approved the manuscript submission. None of the authors had a conflict of interest.

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