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Title

Vegetarian diet and likelihood of becoming centenarians in Chinese adults aged 80 years or older: a nested case-control study

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Conflict of Interest Disclosures

All authors report no conflict of interest.

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Abstract

Background: Inverse associations of vegetarian diet with morbidity and mortality have been observed, however, the role of vegetarian diet on exceptional longevity remains unrevealed.

Objective: To examine the association between vegetarian diet and likelihood of becoming a centenarian in adults aged ≥ 80 years.

Methods: This prospective nested case-control study included 5,203 participants aged 80+ years from the Chinese Longitudinal Healthy Longevity Survey (CLHLS), a nationally representative cohort initiated in 1998. Participants were classified as omnivores and vegetarians, and further into vegetarian subgroups (pesco-vegetarians, ovo-lacto-vegetarians, and vegans) based on consumption of animal-derived foods. The primary outcome was living to 100 years old by the end of follow-up (2018). Multivariable unconditional logistic regression models were used to evaluate the association analysis.

Results: The study identified 1,459 centenarians and matched them with 3,744 non-centenarians (who deceased before reaching 100 years). Relative to omnivores, vegetarians had a lower likelihood of becoming centenarians [odds ratio (OR): 0.81, 95% confidence interval (CI): 0.69-0.96], and similar patterns were observed for vegans (OR: 0.71, 95%CI: 0.54-0.98), but not for pesco-vegetarians (OR: 0.84, 95%CI: 0.64-1.09) and ovo-lacto-vegetarians (OR: 0.86, 95%CI: 0.67-1.09). The significant association was seen in individuals with body mass index (BMI) < 18.5 kg/m² (OR: 0.72, 95%CI: 0.57-0.91), but not for those with BMI ≥ 18.5 kg/m² (OR: 0.92, 95%CI: 0.73-1.17) (P -interaction = 0.08).

Conclusions: Targeting individuals of advanced age (80+ years) in China, we found that individuals following vegetarian diet had lower likelihood of becoming centenarians relative to omnivores, underscoring the importance of a balanced high-quality diet with animal- and

54 plant-derived food composition for exceptional longevity, especially in the underweight
55 oldest-old.

56 **Keywords:** Oldest-old; Vegetarians; Exceptional longevity; Meat consumption; Underweight.

57 **Abbreviations:** BMI=body mass index; CLHLS=Chinese Longitudinal Healthy Longevity

58 Survey; CI=confidence interval; CVD=cardiovascular disease; HR=hazard ratio; OR=odds

59 ratio.

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61 **Introduction**

62 Achieving the global life expectancy appears not to be an insurmountable obstacle with
63 remarkable advances in social development and medical services. The global population aged
64 80 years or older is projected to triple between 2020 and 2050, reaching 426 million (1). In
65 this context, how to live a longer and healthier life beyond this milestone has become an
66 emerging challenge for the public health system. Centenarians, as an exceptionally long-lived
67 group among whom age-related diseases were either delayed or evaded, represent a unique
68 model for healthy aging (2, 3). Identifying factors (especially modifiable factors) related to
69 survivorship to 100 years in elders of advanced age (80+ years) could thus provide novel
70 insight into healthy longevity.

71 The vegetarian diet, a plant-based dietary pattern that restricts consumption of animal-
72 derived foods, has attracted growing attention for its environmental friendliness and
73 promising health benefits (4, 5). Existing population-based evidence regarding vegetarian diet
74 and health outcomes focused more on general adults (5-11). Although several studies reported
75 associations of vegetarian diet with lower risk cardiovascular disease (CVD) (6), diabetes (7),
76 and obesity (8); other studies linked vegetarian diet to a higher risk of fracture (9),
77 malnutrition (5), mental disorders (10), and gallstones (11). Of note, limited studies explored
78 to which extent vegetarian diet could be involved in exceptional longevity, particularly in
79 adults aged 80 years or above, a group susceptible to fractures and malnutrition (12-14).
80 Given the high prevalence of underweight individuals in the advanced age group (13), the role
81 of vegetarian diet on survivorship to 100 years in subgroups with different body mass index
82 (BMI) also warrants further exploration.

83 Therefore, aiming participants aged 80+ years in the Chinese Longitudinal Healthy

84 Longevity Survey (CLHLS), we performed a nested case-control study to prospectively
85 investigate the association between vegetarian diet and the likelihood of becoming
86 centenarians. We further explored whether the studied association could be modified by BMI
87 and other relevant factors (e.g., smoking).

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88 **Methods**

89 **Study design and population**

90 This current study leveraged data from the CLHLS, a nationally representative cohort
91 investigating factors related to the health of older adults aged 65+ years in China (15-17). The
92 CLHLS was established in 1998, consisting of participants from 22 of the 31 provinces in
93 mainland China, with follow-up surveys and recruitment of new participants every 2-3 years
94 until 2018 (2000, 2002, 2005, 2008, 2011, 2014, and 2018). Noteworthy, the CLHLS had
95 one of the largest samples of adults aged 80+ years worldwide. Participants signed the
96 informed consent, underwent face-to-face interviewer-administered questionnaires, and
97 received physical examinations (18). Ethical approval was obtained from the Biomedical
98 Ethics Committee of Peking University (IRB0001052-13074).

99 Given our prospective nested case-control study design, first included were 18,129
100 centenarian candidates who entered the cohort between 1998 and 2014 and had the potential
101 to live to 100 years by 2018 (the end of follow-up). Briefly, participants enrolled in 1998
102 needed to be ≥ 80 years to allow us to confirm the survivorship to 100 years by 2018, and
103 participants enrolled in 2000 needed to be ≥ 82 years, likewise, participants entered in 2014
104 needed to be ≥ 96 years. Next, we excluded 4762 participants who lost to follow-up, 1527
105 participants had incomplete diet information, and 904 participants with CVD, cancer,
106 hypertension, or diabetes at baseline, leaving 10,936 participants as centenarian candidates
107 eligible for the next case and control identification process (**eFigure 1**).

108 Age of the CLHLS participants is computed by subtracting the date of birth from the date
109 of the survey, where date of birth was self-reported at interview and verified by ID card,
110 household registration booklet, and other reliable sources (19). The exact death date of the

111 decreased participants was collected and ascertained by their close family members,
112 village/community doctors, or local neighborhood committee (18, 20). By such means, we
113 identified centenarians as cases, and matched them with the deceased participants before
114 reaching 100 years of age (non-centenarians) as controls up to a 1:4 ratio by sex, years of
115 recruitment, and age (± 1 year). The matching procedure was performed using an algorithm
116 via a R package *ccoptimalmatch*, as described by Mamouris et. al (21), which prioritized the
117 closest available controls and maximized the number of cases included in the final analysis.
118 Finally, a total of 1459 centenarians and 3744 matched non-centenarians were included in the
119 present study (n=5,203).

120 **Assessment of diet**

121 Information on the dietary intake were collected using a food frequency questionnaire at
122 each round of survey (22, 23). For surveys before 2008, the food groups included fruits,
123 vegetables, fish, beans, tea, meat, egg, sugar, and garlic, and the responses were rarely or
124 never, occasionally (or except winter), and almost every day. For surveys from 2008, milk
125 consumption was additionally included, and the responses added another category as “1+
126 times/week” and “1+ times/month” that were classified as occasionally group. Based on their
127 dietary intake assessed at study entry, individuals who rarely or never consume meat were
128 considered as vegetarians, otherwise as omnivores. Among vegetarians, we further classified
129 them as pesco-vegetarians (eating fish regardless of egg/milk consumption), ovo-lacto-
130 vegetarians (eating egg/milk but no fish), and vegans (no fish and egg/milk) (24). Given the
131 unavailability of total energy intake data in the CLHLS, a predicted total energy expenditure
132 was estimated as a surrogate measure for total energy intake, and additionally controlled in
133 the full model. The predicted total energy expenditure was calculated based on a validated

134 predictive equation, with age, sex, ethnicity, body weight, height, and elevation as predictors
135 (25).

136 **Measurement of covariates**

137 Sociodemographic factors, including sex (males, females), residence (urban dwellers,
138 rural dwellers), years of education (0, 1-9, > 9 years), and marital status (in marriage, not in
139 marriage); lifestyle factors, including smoking (never, former, current), drinking (never,
140 former, current), exercise (never, former, current); and chronic conditions, including
141 hypertension (yes, no), diabetes (yes, no), CVD (yes, no), and cancer (yes, no) were collected
142 via a validated questionnaire with the guidance of trained field workers (15, 16). Specifically,
143 the status of exercise (never: 2, former: 1, and current: 0) was determined using two yes-or-no
144 questions: "Do you exercise regularly (eg. Running, Qigong, etc.) at present?", and "Did you
145 exercise regularly (eg. Running, Qigong, etc.) in the past?" People who answered yes for the
146 first questions were defined as current exercisers regardless of the answer for the second
147 question; people who answered no for the first question but yes for the second question were
148 categorized as former exercisers, otherwise as never exercisers." The BMI was calculated as
149 weight (kg) / height squared (m^2) measured from physical examination, and underweight was
150 defined as having a BMI of $<18.5 \text{ kg}/m^2$ (26). Given that height measurements were
151 unavailable in the first four waves of surveys, individual height was estimated using knee
152 height measurement (males: $\text{height}=67.78+2.01 \times \text{knee height}$; females: $\text{height}=74.08+1.81 \times$
153 knee height), which has been validated in older Chinese (27). For missing data, continuous
154 variables were imputed with the median value; categorical variables were classified as a
155 separate group.

156 **Statistical analysis**

157 Multivariable unconditional logistic regression models were adopted to evaluate the
158 association between the vegetarian diet and the likelihood of becoming centenarians,
159 adjusting for matching factors (age, sex, and years of recruitment (28)), sociodemographic
160 factors, lifestyles, predicted total energy expenditure, and chronic conditions. The odds ratios
161 (ORs) and 95% confidence intervals (CIs) were estimated. The associations between
162 individual food groups and odds of becoming centenarians were also investigated using the
163 aforementioned models. We further tested the dose-response relationship by treating the
164 frequency of consumption as a continuous variable, where a per-unit increment represented
165 the consumption frequency increased from a less frequent category to the next category, for
166 example, from “rarely or never” to “occasionally”, or from “occasionally” to “almost every
167 day”.

168 To explore whether the association between vegetarian diet and becoming centenarians
169 could be modified by BMI, we performed a stratified analysis, treating BMI as a binary
170 variable ($<18.5 \text{ kg/m}^2$ or $\geq 18.5 \text{ kg/m}^2$). Other potential effect modifiers were also examined,
171 including age, sex, residence, years of education, marital status, chronic conditions, smoking,
172 drinking, and exercise. Likelihood ratio test was adopted to examine the potential interaction
173 between vegetarian diet and these variables.

174 We carried out several sensitivity analyses to test the robustness of observed results. First,
175 to minimize the potential reverse causation, a 2-y lag analysis and a 5-y lag analysis were
176 performed by excluding centenarians who lived to 100 years within two years and five years
177 of follow-up, and their matched non-centenarians, respectively. Second, to further explore the
178 association between vegetarian diet and healthy longevity, we identified “becoming relatively
179 healthy centenarians” as an outcome. The centenarians who met 3 out of 4 following healthy

180 aging indicators were considered “healthy centenarians”(22, 29, 30), including (1) no self-
181 reported chronic conditions: no hypertension, diabetes, CVD, and cancer; (2) normal physical
182 function: having a full score of the Activities of Daily Living index, namely not requiring any
183 form of assistance in performing daily tasks such as bathing, dressing, toileting, getting out of
184 bed, and feeding; (3) normal cognitive performance: having a score of 18 or higher of a
185 validated Chinese version of the Mini-Mental State Exam; and (4) mental wellness: no feeling
186 of loneliness and anxiety, as detailed previously (22). Third, to control the potential impact of
187 missing covariates, we repeated the analysis after excluding individuals with missing
188 covariates at baseline. Fourth, to account for potential change in dietary preference, we
189 evaluated the updated dietary pattern based on the last measurement of diet, and examined its
190 association with living to be centenarians. Fifth, we excluded participants from the first four
191 waves of the survey, given that no direct height measurements were available. Sixth, because
192 we excluded individuals with self-reported cancer, CVD, and diabetes at baseline in primary
193 analysis, we re-included these participants in our analytical sample and controlled for these
194 chronic conditions. Seventh, we re-conducted the analyses using a conditional logistic
195 regression model. Lastly, to confirm the results we observed in the nested case-control study
196 design and account for the competing risk of death given the very old age of the study sample,
197 Fine and Gray competing risk model was performed on an eligible cohort population, where
198 the hazard ratio (HR) and 95%CI was computed.

199 Statistical analyses were performed using SAS version 9.4 and R version 4.2 from August
200 2023 to February 2025. A two-sided $P < 0.05$ was considered statistically significant.

201 **Results**

202 In this prospective nested case-control study, during a median follow-up of 4 (IQR: 2-7)
203 years, we identified 1459 centenarians (cases) and matched them with 3744 non-centenarians
204 (controls), the mean age was 93.9 ± 3.3 years and 61.5% were females. Compared to
205 omnivores, vegetarians were more likely to be females, never smokers, never drinkers, non-
206 current exercisers, and received less education (**Table 1**).

207 In the fully adjusted model, vegetarian diet was inversely associated with the likelihood
208 of becoming centenarians (OR 0.81, 95%CI: 0.69-0.96; **Table 2**). Individuals adhering to a
209 vegan diet (OR 0.71, 95%CI: 0.52-0.97) also showed lower likelihood of living to 100 years,
210 relative to omnivores. The observed association between vegetarian diet and becoming
211 centenarians persisted in the underweight participants (OR 0.72, 95%CI: 0.57-0.91; *P* for
212 interaction =0.08), but no significant association was observed among the participants with
213 normal weight or overweight (OR 0.92, 95%CI: 0.73-1.17; **Table 2**).

214 Among individual food groups, daily consumption of vegetables was significantly
215 associated with a higher likelihood of becoming centenarians (OR 1.84, 95%CI: 1.31-2.58),
216 and this pattern persisted across BMI subgroups (**Figure 1**). Similar association was observed
217 between daily consumption of meat and becoming centenarians (OR 1.30, 95%CI: 1.08-1.57),
218 with a significant association (OR 1.44, 95%CI: 1.08-1.92) existing in the underweight
219 individuals but not detected in the normal weight or overweight group (OR 1.09, 95%CI:
220 0.82-1.46) (**Figure 1**).

221 According to the results of subgroup analysis, a significant interaction between
222 vegetarian diet and sex was detected (*P* for interaction = 0.03; **eTable 1**), where we observed
223 a sex difference in the association between vegetarian diet and becoming centenarians, and

224 the OR(95%CI) was 0.71 (0.58,0.87) for females and 1.06 (0.80, 1.40) for males. No
225 interactions between vegetarian diet and age, residence, years of education, marital status,
226 chronic conditions, smoking, drinking, and exercise were found (P for interaction > 0.05 for
227 all).

228 The observed association between vegetarian diet and the likelihood of becoming
229 centenarians was supported by several sensitivity analyses, with the magnitude of association
230 slightly varying in different situations (**Table 3**). After excluding centenarians with follow-up
231 time of less than two or five years and their corresponding controls, the association became
232 more pronounced, with adjusted ORs of 0.71 (95%CI: 0.59-0.86) for two-year lag analysis
233 and 0.70 (95%CI 0.54-0.91) for five-year lag analysis. Similar patterns were observed in other
234 sensitivity analyses, but when restricting becoming centenarians with a relatively healthy
235 status as the outcome, or excluding participants from the first four survey waves, the
236 associations were non-significant.

237 **Discussion**

238 In this prospective nested case-control study of Chinese adults over 80 years, we
239 observed that adherence to vegetarian diet, including its subdivisions of vegan diet, was
240 associated with a lower likelihood of becoming centenarians. Specifically, this inverse
241 association was observed in the underweight participants, but not in the normal weight or
242 overweight group.

243 Vegetarian diet is characterized by a low intake of saturated fat and a high intake of
244 dietary fiber (31), which may present potential benefits in preventing major chronic
245 conditions such as CVD (6) and cancer (32). However, dietary diversity and dietary protein,
246 as the key contributors to healthy aging among the older population (22, 33), may be limited
247 in vegetarian diet, potentially compromising the health of vegetarians with advanced age. For
248 example, fracture incidence substantially increased at age 80 years and older and posed a
249 threat of mortality (14). Findings from a cohort of the EPIC-Oxford study showed that the
250 vegetarian diet was associated with a higher risk of fracture, and this association was more
251 pronounced among the older adults, compared the relatively younger group (34), suggesting
252 that adhering to vegetarian diet needed deliberateness, particularly in older adults. Vegetarian
253 diet was also found to be associated with higher likelihood of total stroke (35), symptomatic
254 gallstone disease (11), and depression (36), all could pose health concerns in older adults of
255 advanced age. Although no direct comparison could be made given our unique study outcome
256 as becoming centenarians, these population-based studies in general supported our results,
257 implying the importance of animal-derived food consumption for a better health outcome in
258 older adults over 80 years.

259 Although vegetarian diet has been associated with improved cardiometabolic health in

260 people who were overweight/obese or with overweight/obese-related diseases (8, 37, 38),
261 considering the high prevalence of underweight in the oldest old population (39-41), along
262 with the potential detrimental impact of low BMI, such as higher risk of disability and
263 mortality, observed in individuals of advanced age (17, 18), the role of BMI played in the
264 relationship between vegetarian diet and healthy longevity is worth exploring (31).
265 Interestingly, our study observed that the association between vegetarian diet and longevity
266 varied across different BMI groups, where a significantly inverse association between
267 vegetarian diet and becoming centenarians was seen in the underweight individuals (BMI
268 $<18.5 \text{ kg/m}^2$), but no significant association detected in the normal weight or overweight
269 group (BMI $\geq 18.5 \text{ kg/m}^2$). Consistently, daily consumption of meat was associated with a
270 44% higher likelihood of reaching 100 years old in the underweight group, whereas this
271 association did not present in the normal weight or overweight group. These findings further
272 emphasized that a nutrition-balanced omnivorous diet, incorporating animal- and plant-based
273 foods, may better support longevity in the underweight oldest-old.

274 To the best of our knowledge, the current study was the first prospective study
275 investigating the association between vegetarian diet and becoming centenarians. However,
276 several limitations should be acknowledged. First, the observational study design precluded
277 causal inference, despite the lag analyses remained robust. Second, reliance on self-reported
278 dietary information was subjected to misclassification. However, the food frequency
279 questionnaire employed in the CLHLS was a widely acceptable tool in previous population-
280 based studies, allowing for the capture of habitual dietary intake over extended periods (23,
281 42, 43). Besides, the frequency of consumption provided in the questionnaire combined rarely
282 or never as a single option, which could potentially misclassify those with relatively low

283 consumption of meat as the vegetarian group. Nevertheless, given the observed inverse
284 association between vegetarian diet and the likelihood of becoming centenarians, this type of
285 misclassification would dilute the observed association, and the robustness of our findings
286 was further supported by sensitivity analyses. Third, we determined participants' dietary
287 preferences according to their baseline survey, while their dietary habits could change over
288 time. To address this concern, we conducted a sensitivity analysis using an updated method
289 where the vegetarian dietary pattern was determined based on the most recent dietary
290 assessment, and results were generally consistent with our main analyses. Fourth, chronic
291 condition status was also collected via a questionnaire, potentially leading to the
292 underestimation of chronic condition prevalence and residual confounding from unreported
293 diseases. Last, we cannot adjust for energy intake in our analyses due to the lack of
294 quantitative dietary intake data in the CLHLS. Nonetheless, we computed a predicted total
295 energy expenditure through a validated equation and additionally controlled it in the full
296 model.

297 To summarize, the present study observed a significant association between adherence to
298 vegetarian diet and lower likelihood of becoming centenarians among older individuals over
299 80 years in China, especially in those who were underweight. Our findings emphasized the
300 importance of a balanced diet from both animal- and plant-derived food for healthy longevity,
301 and future studies focusing on older adults of advanced age are needed for the formulation of
302 dietary guidance for this expanding oldest-old population in the aging society.

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306 Author Contributions

307 YQL, KYW, XG, XMS designed the study. YQL and KYW performed the statistical analysis and
308 wrote the first draft. YBL, GJ, YLH, XHS, XMS, and XG provided critical revised comments for
309 this manuscript. XG and XMS accessed and verified the data. All authors had full access to all the
310 data in the study and had final responsibility for the decision to submit for publication.

311 Ethics Approval

312 Ethical approval was obtained from the Biomedical Ethics Committee of Peking University
313 (IRB0001052-13074), and all the participants or their proxy respondents signed the informed
314 consent.

315 Data Sharing

316 All data requests should be submitted to the corresponding author for consideration. Access to
317 anonymized data may be granted upon reasonable request.

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Tables and Figure

494 **Table 1.** Baseline characteristics of participants according to dietary patterns.

495 **Table 2.** Association between vegetarian diet and becoming centenarians and subgroup
496 analysis stratified by body mass index.

497 **Figure 1.** Association between individual food groups and becoming centenarians and
498 subgroup analysis stratified by body mass index.

499 **Table 3.** Sensitivity analyses for the association between vegetarian diet and becoming
500 centenarians.

501 **Table 1. Baseline characteristics of participants according to dietary patterns.**

	Omnivores (n=4203)	Vegetarians (n=1000)
Age, years	93.9 ± 3.3	93.7 ± 3.6
Sex, females	2519 (59.9)	679 (67.9)
Residence, urban dwellers	1610 (38.3)	351 (35.1)
Years of education		
0	3044 (72.4)	781 (78.1)
1-9	1036 (24.7)	192 (19.2)
>9	111 (2.6)	25 (2.5)
Missing	12 (0.3)	2 (0.2)
Marital status, in marriage	470 (11.2)	122 (12.2)
Never smoking	2975 (70.8)	752 (75.2)
Never drinking	2911 (69.3)	737 (73.7)
Current exercisers	1010 (24.0)	198 (19.8)
Underweight (body mass index <18.5 kg/m²)	2429 (57.8)	603 (60.3)
Predicted total energy expenditure, kcal/d	1364 ± 223	1346 ± 211

502 Data are mean ± SD or n (%).

503 ^a Characteristics across the dietary patterns were compared using Wilcoxon rank sum test for continuous variables
504 and chi-square test for categorical variables.

505 **Table 2. Odds ratios (95% confidence intervals) for the association between vegetarian diet and becoming centenarians and subgroup analysis**
 506 **stratified by body mass index.**

		Omnivore	Vegetarian	Vegetarian		
				Pesco-vegetarian	Ovo-lacto-vegetarian	Vegan
Total (n=5203)	Centenarians / Total (%)	1209 / 4203 (28.8)	250 / 1000 (25.0)	86 / 335 (25.7)	105 / 401 (26.2)	59 / 264 (22.4)
	Model 1	Reference	0.83 (0.70, 0.97)	0.89 (0.68, 1.15)	0.86 (0.68, 1.10)	0.70 (0.51, 0.95)
	Model 2	Reference	0.81 (0.69, 0.96)	0.84 (0.64, 1.09)	0.86 (0.67, 1.09)	0.71 (0.52, 0.97)
Stratified by BMI						
Underweight (n=2619)	Centenarians / Total (%)	626 / 2116 (29.6)	122 / 503 (24.3)	39 / 169 (23.1)	51 / 194 (26.3)	32 / 140 (22.9)
	Model 2	Reference	0.72 (0.57, 0.91)	0.73 (0.49, 1.08)	0.75 (0.53, 1.06)	0.66 (0.43, 1.01)
Normal weight or overweight (n=2584)	Centenarians / Total (%)	583 / 2087 (27.9)	128 / 497 (25.8)	47 / 166 (28.3)	54 / 207 (26.1)	27 / 124 (21.8)
	Model 2	Reference	0.92 (0.73, 1.17)	1.03 (0.71, 1.50)	0.94 (0.67, 1.33)	0.75 (0.47, 1.18)
Interaction item	Model 2	Reference	0.93 (0.85, 1.01)	/		
P for interaction	/	/	0.08	/		

507 Model 1: Adjusted for age (years, continuous), sex (males and females), and years of recruitment (1998, 2000, 2002, 2005, 2008, 2011, and 2014).

508 Model 2: Additionally adjusted for residence (urban dwellers, rural dwellers, and missing), years of education (0, 1-9, >9 years, and missing), marital status (in marriage, not
 509 in marriage, and missing), smoking (never, former, current, and missing), drinking (never, former, current, and missing), exercise (never, former, current, and missing), BMI
 510 (kg/m², continuous), and predicted total energy expenditure (kcal/d, continuous). When conducting subgroup analysis stratified by BMI, BMI was not controlled in the
 511 models.

512 Multivariable unconditional logistic regression models were used to assess the association between the vegetarian diet and the likelihood of becoming centenarians.

513 Underweight participants were defined as having a BMI of <18.5 kg/m², and the rest (BMI ≥ 18.5 kg/m²) were classified as normal weight or overweight.

514 Abbreviations: BMI, body mass index.

515 **Figure 1. Association between individual food groups and becoming centenarians and**
516 **subgroup analysis stratified by body mass index.**

517 Multivariable unconditional logistic regression models were used to assess the association between the
518 individual food groups and the likelihood of becoming centenarians, adjusting for age (years, continuous),
519 sex (males and females), years of recruitment (1998, 2000, 2002, 2005, 2008, 2011, and 2014), residence
520 (urban dwellers, rural dwellers, and missing), years of education (0, 1-9, >9 years, and missing), marital
521 status (in marriage, not in marriage, and missing), smoking (never, former, current, and missing), drinking
522 (never, former, current, and missing), exercise (never, former, current, and missing), BMI (kg/m^2 ,
523 continuous), and predicted total energy expenditure (kcal/d , continuous). When conducting subgroup
524 analysis stratified by BMI, BMI was not controlled in the models. Underweight participants were defined as
525 having a BMI of $<18.5 \text{ kg}/\text{m}^2$, and the rest ($\text{BMI} \geq 18.5 \text{ kg}/\text{m}^2$) were classified as normal weight or
526 overweight. *P* for interaction: the interactions between per unit increment of each food group and
527 underweight were non-significant. Per-unit increment represented the consumption frequency increased
528 from a less frequent category to the next category, for example, from “rarely or never” to “occasionally”, or
529 from “occasionally” to “almost every day”.
530 Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index.

531 **Table 3. Sensitivity analyses for the association between vegetarian diet and becoming centenarians.**

		Omnivore	Vegetarian	Vegetarian		
				Pesco-vegetarian	Ovo-lacto-vegetarian	Vegan
Two-year lag analysis^a	Centenarians / Total (%)	921 / 3612 (25.5)	167 / 848 (19.7)	54 / 280 (19.3)	69 / 340 (20.3)	44 / 228 (19.3)
	OR (95% CI) ^f	Reference	0.71 (0.59, 0.86)	0.70 (0.51, 0.96)	0.73 (0.55, 0.97)	0.69 (0.49, 0.97)
Five-year lag analysis^b	Centenarians / Total (%)	433 / 2052 (21.1)	87 / 537 (16.2)	33 / 195 (16.9)	41 / 204 (20.1)	13 / 138 (9.4)
	OR (95% CI) ^f	Reference	0.70 (0.54, 0.91)	0.75 (0.50, 1.11)	0.91 (0.63, 1.31)	0.36 (0.20, 0.66)
Becoming relatively healthy centenarians as an outcome^c	Centenarians / Total (%)	106 / 424 (25.0)	20 / 97 (20.6)	5 / 31 (16.1)	10 / 41 (24.4)	5 / 25 (20.0)
	OR (95% CI) ^f	Reference	0.89 (0.50, 1.58)	0.78 (0.28, 2.20)	1.11 (0.50, 2.47)	0.69 (0.24, 1.98)
Excluding participants with missing covariates	Centenarians / Total (%)	1032 / 3114 (33.1)	209 / 723 (28.9)	76 / 251 (30.3)	88 / 291 (30.2)	45 / 181 (24.9)
	OR (95% CI) ^f	Reference	0.78 (0.65, 0.94)	0.86 (0.63, 1.16)	0.85 (0.65, 1.12)	0.59 (0.41, 0.85)
Using updated dietary patterns as exposure^d	Centenarians / Total (%)	908 / 1836 (49.5)	151 / 401 (37.7)	44 / 123 (35.8)	76 / 185 (41.1)	31 / 93 (33.3)
	OR (95% CI) ^f	Reference	0.68 (0.53, 0.87)	0.62 (0.41, 0.93)	0.80 (0.57, 1.11)	0.56 (0.35, 0.90)
Excluding the first four waves without direct BMI measurement	Centenarians / Total (%)	299 / 1015 (29.5)	39 / 152 (25.7)	12 / 54 (22.2)	23 / 73 (31.5)	4 / 25 (16.0)
	OR (95% CI) ^f	Reference	0.80 (0.53, 1.21)	0.69 (0.35, 1.39)	1.05 (0.60, 1.81)	0.43 (0.14, 1.33)
Including the participants with chronic conditions at baseline	Centenarians / Total (%)	1427 / 5004 (28.5)	294 / 1177 (25.0)	99 / 402 (24.6)	126 / 472 (26.7)	69 / 303 (22.8)
	OR (95% CI) ^f	Reference	0.82 (0.71, 0.96)	0.80 (0.63, 1.03)	0.90 (0.72, 1.13)	0.73 (0.55, 0.97)
Using conditional logistic models to assess the associations	Centenarians / Total (%)	1209 / 4203 (28.8)	250 / 1000 (25.0)	86 / 335 (25.7)	105 / 401 (26.2)	59 / 264 (22.4)
	OR (95% CI) ^f	Reference	0.82 (0.69, 0.97)	0.83 (0.63, 1.08)	0.89 (0.69, 1.14)	0.72 (0.52, 0.98)
Cohort analysis^e	Centenarians / Total (%)	1740 / 9046 (19.2)	327 / 1915 (17.1)	109 / 605 (18.0)	140 / 770 (18.2)	78 / 540 (14.4)
	HR (95% CI) ^f	Reference	0.87 (0.77, 0.99)	0.90 (0.74, 1.10)	0.94 (0.80, 1.12)	0.73 (0.58, 0.94)

532 ^a The two-year lag analysis was conducted (n=4460), after excluding cases who lived to be centenarians within 2 years of follow-up and their matched controls.533 ^b The five-year lag analysis was conducted (n=2589), after excluding cases who lived to be centenarians within 5 years of follow-up and their matched controls.

534 ^c Healthy centenarians were the centenarians with 3+ out of 4 healthy aging items, including no self-reported chronic conditions, normal physical function, normal cognitive
535 function, and mental wellness. No self-reported chronic conditions: none of the four chronic conditions, including hypertension, diabetes, cardiovascular disease, and cancer.
536 Normal physical function: physical function was assessed using the Activities of Daily Living (ADL) index, with physical function impairment defined as requiring any
537 form of assistance (ranging from partial to complete help) in performing daily tasks such as bathing, dressing, toileting, getting out of bed, and feeding. Normal cognitive
538 function: a validated Chinese version of the Mini-Mental State Exam (MMSE) was used to test the cognitive function, with a score of 18 or higher indicating the absence of
539 cognitive impairment. Mental wellness: having no feeling of loneliness or anxiety. Additionally, before analyzing the outcome of becoming relatively healthy centenarians,
540 those unhealthy centenarians and their matched non-centenarian controls were excluded.

541 ^d The updated dietary patterns were calculated from the last measurement of diet status.

542 ^e With an eligible cohort study design (n=10,961), the HRs and 95% CIs were calculated using Fine and Gray competing risk models.

543 ^f Except for the cohort analysis, other sensitivity analysis results (i.e. ORs and 95% CIs) were computed using multivariable unconditional logistic regression models. All
544 models were adjusted for age (years, continuous), sex (males and females), years of recruitment (1998, 2000, 2002, 2005, 2008, 2011, and 2014), residence (urban dwellers,
545 rural dwellers, and missing), years of education (0, 1-9, >9 years, and missing), marital status (in marriage, not in marriage, and missing), smoking (never, former, current,
546 and missing), drinking (never, former, current, and missing), exercise (never, former, current, and missing), BMI (kg/m², continuous), and predicted total energy expenditure
547 (kcal/d, continuous). In the analysis that re-included the participants with chronic conditions at baseline, the unconditional model was also additionally adjusted for
548 hypertension (yes, no, and missing), diabetes (yes, no, and missing), cardiovascular disease (yes, no, and missing), and cancer (yes, no, and missing).

549 Abbreviations: OR, odds ratio; CI, confidence interval; HR, hazard ratio; BMI, body mass index.

