

This author's PDF version corresponds to the article as it appeared upon acceptance. Fully formatted PDF versions will be made available soon.

## **Association between dietary patterns and dyslipidemia in adults from the Henan rural cohort study**

doi: 10.6133/apjcn.202004/PP.0002

Published online: April 2020

**Running title:** Dietary patterns and dyslipidemia in adults

Chang Liu MPH<sup>1</sup>, Yuan Xue PhD<sup>1</sup>, Yan Wang PhD<sup>1</sup>, Yujing Zhang, MS<sup>1</sup>, Dou Qiao MPH<sup>2</sup>, Bingya Wang MS<sup>1</sup>, Zhenxing Mao PhD<sup>2</sup>, Songcheng Yu PhD<sup>1</sup>, Chongjian Wang PhD<sup>2</sup>, Wenjie Li PhD<sup>1</sup>, Xing Li PhD<sup>1</sup>

<sup>1</sup>Department of Nutrition and Food Hygiene, College of Public Health, Zhengzhou University, Henan, PR China

<sup>2</sup>Department of Epidemiology and Biostatistics, College of Public Health, Zhengzhou University, Henan, PR China

**Authors' email addresses and contributions:**

liuchang730aliu@163.com (C.L.); xueyuansnow@163.com (X.Y.); doctorwangxiaoy@163.com (Y.W.); 15093458874@163.com (Y.Z.); wangbingyaleehom@163.com (B.W.); scyu@zzu.edu.cn (S.Y.); lwj@zzu.edu.cn (W.L.); xiaoqiaozzu@126.com (D.Q.); zhenxingmao@hotmail.com (Z.M.); tjwcj2005@126.com (C.W.)..

W.-J. L. and C.-J. W., conceived and designed the study. B.-Y. W., Y. -W., Y. -J.Z., D.-Q., Z.-X. M, S.-C. Y., X.-L. performed the investigation. Y.-X., and C.-L. analyzed the data. C.- L. wrote the manuscript. All authors read and approved the final manuscript.

**Corresponding Author:** Dr Xing Li, Department of Nutrition and Food Hygiene, College of Public Health, Zhengzhou University, No.100 Science Road, Zhengzhou, 450001, Henan, China. Tel: +86 371 6773 9276. Fax: +64 3 470 9916. Email: lixing530@zzu.edu.cn

## ABSTRACT

**Background and Objectives:** The aim of the study was to explore the association between dietary patterns and lipid levels in Henan rural area. **Methods and Study Design:** Fasting blood samples, information on dietary intakes (with food frequency questionnaires) and other data were collected from the Henan Rural Cohort. Principal component analysis was used to identify the dietary patterns. Binary logistic regression and restricted cubic spline regression models were performed to obtain odds ratios (ORs) and 95% confidence intervals (95%CI). The study recruited 38,983 available participants aged from 18 to 79 from a rural area in Henan province. **Results:** The study showed that, three patterns were identified by higher factor loadings: namely the “meat” (high intakes of red meat, white meat and fish), “grain-egg-nut complex” (high intakes of nuts, milk, eggs, grains and beans), and “vegetable-staple food-fruits” pattern (high intakes of vegetables, staple food and fruits). “Grain-egg-nut complex” pattern was significantly positively related to the risk of dyslipidemia (OR: 1.10; 95% CI: 1.05–1.16,  $p < 0.05$ ). The multivariable-adjusted ORs across tertiles of each dietary pattern were significantly associated with each component of dyslipidemia indexes. **Conclusions:** Grain-egg-nut complex dietary pattern was positively associated with dyslipidemia. All three dietary patterns were associated with blood lipid profiles aberrations.

**Key Words:** dyslipidemia, dietary pattern, Henan rural area, lipid levels, adults

## INTRODUCTION

Dyslipidemia is a well-established risk factor for cardiovascular disease (CVD).<sup>1</sup> Despite the recent declining trend in developed areas, the social economic loss caused by CVD is still huge due to its increasing prevalence in the developing countries.<sup>2</sup> A recent study has shown the prevalence of dyslipidemia in China was 62.1% overall.<sup>3</sup> Besides of the high proportion of prevalence, the awareness, treatment and control rates of dyslipidemia were generally low (<54%, 36%, and 15%, respectively) in rural areas of China,<sup>4</sup> suggesting that dyslipidemia remained a serious threat to public health in the general population.

Fortunately, controlling of blood lipid level may effectively avoid the occurrence and the development of the CVD.<sup>5,6</sup> Several studies have proved that dyslipidemia can be treated with medical interventions and lifestyle changes, for instance, healthy diets, physical activities, drinking and smoking prohibitions.<sup>1,7-10</sup> Public health organization affirmed that dietary

improvement is one of the efficient approaches to prevent and control dyslipidemia and CVD.<sup>11</sup> Thus, dietary research is of great significance to the prevention of dyslipidemia.

Meanwhile, compared with single nutrient intake, general dietary pattern may create a comprehensive reflection on the food intake of the population, and provide more effective measures for the intervention of dyslipidemia.<sup>12</sup> Principal component analysis (PCA), one of the most commonly used statistical approaches in dietary pattern analysis, utilizes correlations of different foods according to the frequency and intake of each food group.<sup>13,14</sup> With the help of which, associations among dietary patterns, blood lipid levels and risk of multiple diseases have been established over a series of cohorts and cross-sectional studies across the world.<sup>15-20</sup> Notably, PCA can directly obtain the actual dietary patterns of a specific population and thus possess a high value to the public health researches of Henan rural area.

Therefore, the linkage between prevailing dietary patterns and lipid profiles in undeveloped areas is of great significance. And we try to establish a dose-response relationship between different dietary pattern factors and levels of blood lipids via a quantitative scoring system. The current study may provide us with the potential dietary trends that pose threats to lipid status in China rural areas.

## **MATERIALS AND METHODS**

### ***Study population***

Study population were recruited from the Henan Rural Cohort, which was launched in five rural areas on Henan province, China, from July 2015 to September 2017. Detailed study objectives and designs were described elsewhere.<sup>21</sup> In brief, 39,259 participants aged from 18-79 years were included in the baseline survey. Among the eligible subjects, participants with either incomplete information on dietary data (n=79), or missing information on blood lipid indices (n=196) were excluded. The final figure was fixed at 38,983 (15,334 males and 23,649 females). This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Committee of Zhengzhou University. Written informed consent was obtained from all subjects.

### ***Dietary assessment***

At the baseline survey, by following standard operating procedures, food frequency questionnaire (FFQ) which has been proved to be validated before<sup>22</sup> was conducted in face-to-

face investigations to assess the food intake of well-trained interviewers for the past 12 months. The questionnaire contains 13 food categories, including staple food which contained fine processed grain like polished rice, noodle, steamed twisted roll, steamed bread and other fine processed grains and cereals; red meat such as pork, lamb and beef; white meat such as chicken and duck; fish; eggs; milk and dairy products; fresh fruits; fresh vegetables; legumes and products; nuts and peanuts; pickles and salt vegetables; grains like sweet potato, maize, oats and sorghum; and animal oil like lard and tallow. The consumption of each food group per person per day was calculated in grams.

Subjects were questioned about every food product they had eaten. The amount of food per standard serving was clearly defined (also shown in a series of pictures), as “jin” (a jin is equal to 500 grams) and “liang” (a liang is equal to 50 grams) were used for weight measuring. Frequency of food consumption was categorized into five levels: never, daily, weekly, monthly, and yearly. The intakes of energy, carbohydrate, protein, fat, and micronutrients among the participants were analyzed based on the China Food Composition table.<sup>23</sup>

### ***Data collection***

Sociodemographic variables including age, gender, education, socioeconomic status, smoking status, drinking status, physical activity, family history of dyslipidemia was collected in the on-set baseline survey. Education attainment was categorized into primary school or below, junior high school, high school and above, respectively. Socioeconomic status was evaluated based on income per capita monthly (<500, 500~, and  $\geq 1000$  renminbi (RMB)). Current smokers were defined as smoking at least one cigarette per day in past 6 months, and current drinkers were defined as alcohol drinking (liqueur, beer, wine, and other alcohol beverages) at least 12 times per year. Physical activity was categorized into either low, mediate or high level according to the international physical activity questionnaire-short (IPAQ-short).<sup>24,25</sup> Family history of dyslipidemia was defined as having at least one grandparent, parent, or sibling with the disease.

Anthropometric measures were also assessed by trained research staffs. Each subject was measured twice in light indoor clothing without shoes according to standard protocols. The participants' data were obtained from the average of two measurements. Body mass index (BMI) was calculated as weight (kg) divided by square of height in meters (m<sup>2</sup>). Waist and hip circumferences were measured for three times using calibrated equipment.<sup>26</sup>

Serum samples were separated immediately from whole blood samples from participants after fasting for at least 8h, through centrifugation at for 10 min at 3000 rpm, 4°C. Subsequently, blood samples were used to measure total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C) in Roche Cobas C501 automatic biochemical analyzer.

### *Ascertainment of dyslipidemia*

On the one hand, the diagnostic index of this study was based on the standard of diagnosis and treatment of dyslipidemia in Chinese adult population, which was suitable for participants in this study. On the other hand, this diagnostic criteria for dyslipidemia with marginal elevation can be used to analyze the blood lipid levels and dietary intake of people with possible dyslipidemia.

Thus, dyslipidemia was identified according to the Guidelines on Prevention and Treatment of Dyslipidemia for Chinese Adults (2016). In present study, the definition of dyslipidemia was modified as exceeding at least one of marginal values: for TC  $\geq 5.2$  mmol/L, TG  $\geq 1.7$  mmol/L, HDL-C  $< 1.0$  mmol/L, and LDL-C  $\geq 3.4$  mmol/L. Meanwhile, the clinical diagnosis standard for abnormal lipid levels were as follows: TC  $\geq 6.2$  mmol/L, TG  $\geq 2.3$  mmol/L, LDL-C  $\geq 4.1$  mmol/L, HDL-C  $< 1$  mmol/L.<sup>27</sup>

### *Statistical analysis*

Data extraction and dimensionality reduction of diet intake information were conducted with principal component analysis from the 11 food groups which had mentioned above except for pickles and animal oil. We rotated the factors with varimax orthogonal transformation (factor analysis in SPSS) to identify the structures. The identified factors were retained by scree plot, evaluated eigenvalues ( $>1$ ) and interpretability. The sample adequacy was checked by the Kaiser-Mayer-Olkin (KMO) test.

Continuous variables presented as mean  $\pm$  standard deviation (SD) were compared using one-way ANOVA analysis, while categorical variables presented in numbers and proportions were compared using chi-square test. The associations between dietary patterns and dyslipidemia and single lipid level were performed by binary logistic regression models for the obtaining of odds ratios (ORs) and 95% confidence intervals (CIs). The trend tests were conducted using the median of each category as a continuous variable. Restricted cubic spline regression was used to depict the dose-response relationship between dietary factor scores at 3

nodes in the quartile (25th, 50th, 75th, respectively) and dyslipidemia, with the lowest dietary factor scores quartile as the reference.

All statistical analyses were produced using SPSS 25.0 software (IBM Corp., Armonk, NY, USA). R software (version 3.4.1) was used to shape the figures of restricted cubic spline. Statistical significance was set at a two-side,  $p < 0.05$ .

## RESULTS

### *Dietary patterns among participants*

The naming of these patterns was based on the higher food group factor loadings.<sup>28</sup> Three dietary patterns were obtained by the principal component analysis: the “Meat”, “Grain-egg-nut complex”, and “vegetable-staple food-fruits”. Table 1 showed the factor loadings of each pattern after orthogonal rotation. The scree plots were illustrated in Supplemental Figure 1, as all three factors explained 43.6% of the variance in total food intake. The meat pattern explained 17.64% of the variance due to the great contribution of white meat, fish and red meat. Grain-egg-nut complex pattern was characterized by high intake of grains (i.e., sweet potato/corn), eggs, nuts (i.e. peanut, melon seed), bean and milk, whereas vegetable-staple food-fruits pattern in this study is featured in main consumption of plant food like staple food, vegetables<sup>29</sup> and fruits. The latter two patterns accounted for 13.62% and 12.30% of the variation in food intakes, respectively.

### *Characteristics of study participants grouped by dietary patterns*

A total of 38,983 remaining participants (15,334 males and 23,649 females) were included in further analysis, among which 19,148 subjects (53.8% of total population) were with dyslipidemia. Related socio-demographic and health-related variables for subjects with different dietary patterns were described in Table 2. According to the classification of diet patterns, there were significant differences in the characteristics of the subjects ( $p < 0.001$ ). Subjects from meat pattern were likely to be younger, higher education level, more socialized, current smokers and drinkers, as well as inheritor of dyslipidemia than those of other two group. Additionally, the meat pattern group had higher TG levels but lower HDL-C levels when comparing with other dietary patterns. Meanwhile, the grain-egg-nut complex pattern group had more female, and fewer current smokers and drinkers than other pattern groups; participants who were subjected to the grain-egg-nut complex pattern had higher TC and LDL-C levels. Subjects from vegetable-staple food-fruits pattern were likely to be older, male,

poorly educated, shared a low monthly income, had higher level of physical activity and more energy intake, but lower BMI.

### ***Association between dietary patterns and lipid profile***

The relationship between each component of dyslipidemia across tertiles of different dietary patterns factor loading were shown in Table 3. After adjusting for gender, age, education, income, marital status, smoking, drinking, physical activity, BMI, family history of dyslipidemia and energy intake, the meat dietary pattern was not significantly correlated with neither high LDL-C level nor low HDL-C level, but connected strongly high TG level and high TC level. In a group of participants in the highest tertile of vegetable-staple food-fruits dietary pattern, the risks for high TG level was significantly higher than that in T1, while risks for high TC level and high LDL-C level decreased dramatically. However, low HDL-C levels were not significantly correlated with the vegetable-staple food-fruits pattern, regardless of the adjustment.

In model 2, individuals in the highest tertile of the grain-egg-nut complex dietary group shared significantly decreased risks of high TG level and low HDL-C level as compared with those in the lowest tertile. Meanwhile the very dietary pattern was significantly associated with increased risks of high TC level and High LDL-C level.

### ***Relationship between dietary patterns and dyslipidemia***

Supplemental Table 1 showed increasing intake of food groups compatible with tertile of factor scores under different dietary patterns. Adjusted OR and 95 % CIs for dyslipidemia in the tertiles of different dietary patterns were presented in Table4. After fully adjusted by covariates (model 3), the meat pattern and vegetable-staple food-fruits dietary pattern were not significantly associated with dyslipidemia. In contrast, grain-egg-nut complex pattern was strongly associated with dyslipidemia in model 3.

Furthermore, restricted cubic spline regressions were performed to shape the association between factor loadings of dietary patterns and dyslipidemia (Figure 1). U-shaped associations were found in the meat pattern ( $p$  for nonlinearity  $<0.05$ ) and in vegetable-staple food-fruits pattern groups ( $p$  for nonlinearity  $<0.001$ ) which indicated that balanced dietary intakes were essential to balance the individual lipid level. As for the Grain-egg-nut complex pattern, compared with the reference of the lower tertile, the risk of dyslipidemia increased gradually along with the continuously increasing of dietary factor loadings, suggesting that

significant linear dose-response relationships between factor loading and dyslipidemia might be existed ( $p$  overall significance  $<0.001$ ,  $p$  for nonlinearity  $>0.05$ ).

## DISCUSSION

The Henan Rural Cohort Study included 38,983 eligible participants aged from 18 years to 79 years, providing an ideal target for the relationship research among dietary patterns, dyslipidemia and lipid profiles. Three dietary patterns were derived by using PCA which were named as “Meat pattern”, “Grain-egg-nut complex pattern”, and “Vegetable-staple food-fruits pattern”, respectively. Taking the factor score of each dietary pattern in the lowest tertile as a reference, the grain-egg-nut complex pattern with high intakes of grains, bean, nuts, milk and eggs was positively associated with dyslipidemia. The meat pattern was in positive correlation with high TG level, but negatively correlated to high TC content. In addition, Grain-egg-nut complex pattern showed a positive relationship with high TC and LDL-C levels, while it was negatively related to high TG and low HDL-C levels. After adjustment for all covariates, vegetable-staple food-fruits pattern was significantly positively related to high TG content, and negatively correlated with high level of TC and LDL-C.

Our results showed a probably connection between grain-egg-nut complex pattern consuming (with high intake of grain, nuts, beans, milk and eggs) and dyslipidemia. The identified “grain-egg-nut complex pattern” is not common as an independent pattern in the previous studies.<sup>15,20,28,30</sup> Partially because of dietary composition and classification, for that grains in current study, included refined corns and sweet potatoes, which may indeed increase the risk of dyslipidemia or coronary heart disease (CHD).<sup>31</sup> Additionally, milk and dairy consumption<sup>32</sup> which was also a part of grain-egg-nut complex pattern, has been suggested to raise the mortality risk including CVD mortality.<sup>33</sup> Meanwhile, research has found that dietary cholesterol was related to serum cholesterol in Chinese urban adults, showing a higher risk of dyslipidemia at high levels of cholesterol intakes.<sup>34</sup> Taking egg for example, as the main source of dietary cholesterol intake, which was associated with increasing serum TC and LDL-C<sup>35</sup> and in consideration of high-oil content in the way they are cooked.<sup>36</sup> Furthermore, Maria L.F et al suggested that most foods that are rich in cholesterol are also high in saturated fatty acids and thus may increase the risk of CVD due to the saturated fatty acid content.<sup>37</sup>

The vegetable-staple food-fruits pattern include staple foods(e.g. wheat flour and rice), vegetables and fruits, which was in consistent with other several studies.<sup>30,38</sup> We found that vegetable-staple food-fruits pattern contains more recommended ingredients like vegetables



and fruits, which would in turn inhibit dyslipidemia within a proper range of factor scoring. Several studies suggested that diets rich in vegetables and fruits may resist non-communicable diseases, such as, metabolic syndrome, heart disease and cancer.<sup>3,39</sup> Consistent with previous studies, current results indicated that the high-carbohydrate diets like foods in vegetable-staple food-fruits pattern not only raised plasma TG<sup>40</sup> but also reduced the risk for high LDL-C.<sup>41</sup> Nevertheless, excessive intake of staple food such as refined grain<sup>42</sup> like rice and starchy food, as well as lack of vegetables and fruits<sup>43,44</sup> may increase the risk of abnormal lipids expressions. In accordance with previous studies,<sup>31</sup> the “vegetable-staple food-fruits” dietary pattern contained healthful plant food like vegetables and unhealthy food like starchy food which may contributed to the no relationship observed between dyslipidemia and this pattern in our study. More fundamentally, participants in this pattern may consume less cholesterol than other patterns, which well lead to serum TC concentration fluctuations.<sup>45</sup> Moreover, regular consumption of dietary fiber was also seen to aid the prevention of dyslipidemia,<sup>46</sup> and dietary fiber was highly contained in fruits and vegetables,<sup>4</sup> also suggesting that this dietary pattern might be beneficial to lipid metabolism.

Meat pattern in the present study containing red meat like pork, lamb and beef, white meat like chicken and fish, which was not significantly associated with dyslipidemia. However, the result remains a debatable point. Sacks, F. M et al reported an adverse effect of beef consumption on plasma lipid.<sup>47</sup> And meat consumption was also cross-sectionally associated with high level of TG for the content of saturated fatty acid from red meat consumption.<sup>48</sup> While an open-labeled, randomized, cross-over study showed no correlation existed between lipid responses and lean red meat intake. A meta-analysis pointed out that consumption of red meat had no influence on either blood lipids, lipoproteins expressions or blood pressures.<sup>49</sup> After all, the no relationship between meat consumption and dyslipidemia in current results was in accordance with previous studies.<sup>50,51</sup>

Strengths of our study included large sample size and strict methods of outcome ascertainment. Selection of diagnostic criteria for dyslipidemia revealed the association of dietary intake in rural areas with the primitive warning on dyslipidemia. Besides, presented data represented dietary status in Henan rural areas, which may provide reference for improvements achieved in less resourced real-world practice. In this paper, there were also several study limitations. Firstly, we obtained dietary information via FFQ, there may have been recall bias in the reporting of food intake due to memory errors or between participant variability in the extent. Secondly, in consideration of the nature of the cross-sectional study,

causal relationship cannot be determined. Thirdly, residual confounding factors may affect the results, while study collected a wide range of data, which allowed to take potential factors into account. For instance, the relationship between dietary patterns and dyslipidemia remained stable, when excluded potential over- and under reporter of daily energy intake.<sup>52</sup> In addition, the current study did not collect data about cooking oil, thus we could not able to capture such source of variation and the possibility of other confounders from unmeasured intake of cooking oil cannot be completely ruled out. The intake of cooking oil would be taken into account in further research. Finally, our results may not be generalizable to the Chinese population as a whole given that the Henan Rural Cohort Study comprises rural adults in a specific region in central China.

In conclusions, three individual dietary patterns were identified from the Henan Rural Cohort Study: meat pattern, grain-egg-nut complex pattern and vegetable-staple food-fruits pattern. Our results indicated that grain-egg-nut complex pattern characterized by high intakes of nuts, grains, eggs, milk and bean was positively associated with dyslipidemia. Our findings may provide valuable data for developing dietary interventions and policies making to prevent dyslipidemia in Henan rural area and other undeveloped area. Further studies should be conducted to validate these findings and to explore other potential risk factors of dyslipidemia.

#### **ACKNOWLEDGEMENTS**

We are grateful to the villagers who took part in this study, the research team for their cooperation and assistance.

#### **CONFLICT OF INTEREST AND FUNDING DISCLOSURE**

No conflict of interest to declare. This work was supported by the National Key Research and Development Program Precision Medicine Initiative of China, grant number: 2016YFC0900803; National Natural Science Foundation of China, grant number: 81573151, 81872626; The Chinese Nutrition Society- Zhendong People's Physical and Health Research Fund, grant number: CNS-ZD2019066.

#### **REFERENCES**

1. Kopin L, Lowenstein C. Dyslipidemia. *Ann Intern Med.* 2017;167:ITC81-ITC96. doi: 10.7326/AITC201712050.

2. Farzadfar F, Finucane MM, Danaei G, Pelizzari PM, Cowan MJ, Paciorek CJ et al. National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3·0 million participants. *Lancet*. 2011;377:578-86. doi: 10.1016/s0140-6736(10)62038-7.
3. Zhang FL, Xing YQ, Wu YH, Liu HY, Luo Y, Sun MS, Guo ZN, Yang Y. The prevalence, awareness, treatment, and control of dyslipidemia in northeast China: a population-based cross-sectional survey. *Lipids Health Dis*. 2017;16:61. doi: 10.1186/s12944-017-0453-2.
4. Liu X, Yu S, Mao Z, Li Y, Zhang H, Yang K et al. Dyslipidemia prevalence, awareness, treatment, control, and risk factors in Chinese rural population: the Henan rural cohort study. *Sci Rep*. 2018;17:119. doi: 10.1038/s41598-018-31336-2 10.1186/s12944-018-0768-7.
5. Baigent C, Keech A, Kearney PM, Blackwell L, Buck G, Pollicino C et al. Efficacy and safety of cholesterol-lowering treatment: prospective meta-analysis of data from 90,056 participants in 14 randomised trials of statins. *Lancet*. 2005;366:1267-78. doi: 10.1016/s0140-6736(05)67394-1.
6. Pikula A, Beiser AS, Wang J, Himali JJ, Kelly-Hayes M, Kase CS, Yang Q, Seshadri S, Wolf PA. Lipid and lipoprotein measurements and the risk of ischemic vascular events: Framingham Study. *Neurology*. 2015;84:472-9. doi: 10.1212/wnl.0000000000001202.
7. Zachariah JP, Chan J, Mendelson MM, Regh T, Griggs S, Johnson PK et al. Adolescent Dyslipidemia and Standardized Lifestyle Modification: Benchmarking Real-World Practice. *J Am Coll Cardiol*. 2016;68:2122-3. doi: 10.1016/j.jacc.2016.08.041.
8. Yaghi S, Elkind MS. Lipids and Cerebrovascular Disease: Research and Practice. *Stroke*. 2015;46:3322-8. doi: 10.1161/STROKEAHA.115.011164.
9. Trautwein EA, Koppenol WP, de Jong A, Hiemstra H, Vermeer MA, Noakes M, Luscombe-Marsh ND. Plant sterols lower LDL-cholesterol and triglycerides in dyslipidemic individuals with or at risk of developing type 2 diabetes; a randomized, double-blind, placebo-controlled study. *Nutr Diabetes*. 2018;8:30. doi: 10.1038/s41387-018-0039-8.
10. Xu F, Wang Y, Ware RS, Tse LA, Dunstan DW, Liang Y, Wang Z, Hong X, Owen N. Physical activity, family history of diabetes and risk of developing hyperglycaemia and diabetes among adults in Mainland China. *Diabet Med*. 2012;29:593-9. doi: 10.1111/j.1464-5491.2011.03495.x.
11. Wang F, Zheng J, Yang B, Jiang J, Fu Y, Li D. Effects of Vegetarian Diets on Blood Lipids: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *J Am Heart Assoc*. 2015;4:e002408. doi: 10.1161/JAHA.115.002408.
12. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol*. 2002;13:3-9. doi: 10.1097/00041433-200202000-00002.
13. Melaku YA, Gill TK, Taylor AW, Adams R, Shi Z. A comparison of principal component analysis, partial least-squares and reduced-rank regressions in the identification of dietary patterns associated with bone mass in ageing Australians. *Eur J Nutr*. 2018;57:1969-83. doi: 10.1007/s00394-017-1478-z.
14. Htun NC, Suga H, Imai S, Shimizu W, Ishikawa-Takata K, Takimoto H. Dietary pattern and its association with blood pressure and blood lipid profiles among Japanese adults in the 2012 Japan

- National Health and Nutrition Survey. *Asia Pac J Clin Nutr.* 2018;27:1048-61. doi: 10.6133/apjcn.072018.04.
15. Zhang J, Wang Z, Wang H, Du W, Su C, Zhang J et al. Association between dietary patterns and blood lipid profiles among Chinese women. *Public Health Nutr.* 2016;19:3361-8. doi: 10.1017/s136898001600197x.
  16. Lee J, Kim J. Association between Dietary Pattern and Incidence of Cholesterolemia in Korean Adults: The Korean Genome and Epidemiology Study. *Nutrients.* 2018;10. doi: 10.3390/nu10010053.
  17. Hamer M, Mishra GD. Dietary patterns and cardiovascular risk markers in the UK Low Income Diet and Nutrition Survey. *Nutr Metab Cardiovasc Dis.* 2010;20:491-7. doi: 10.1016/j.numecd.2009.05.002.
  18. Masana MF, Tyrovolas S, Kolia N, Chrysohoou C, Skoumas J, Haro JM et al. Dietary Patterns and Their Association with Anxiety Symptoms among Older Adults: The ATTICA Study. *Nutrients.* 2019;11. doi: 10.3390/nu11061250.
  19. Ilesanmi-Oyelere BL, Brough L, Coad J, Roy N, Kruger MC. The Relationship between Nutrient Patterns and Bone Mineral Density in Postmenopausal Women. *Nutrients.* 2019;11. doi: 10.3390/nu11061262.
  20. Lin LY, Hsu CY, Lee HA, Wang WH, Kurniawan AL, Chao JC. Dietary Patterns in Relation to Components of Dyslipidemia and Fasting Plasma Glucose in Adults with Dyslipidemia and Elevated Fasting Plasma Glucose in Taiwan. *Nutrients.* 2019;11. doi: 10.3390/nu11040845.
  21. Liu X, Mao Z, Li Y, Wu W, Zhang X, Huo W et al. The Henan Rural Cohort: a prospective study of chronic non-communicable diseases. *Int J Epidemiol.* 2019. doi: 10.1093/ije/dyz039.
  22. Xue Y, Yang K, Wang B, Liu C, Mao Z, Yu S et al. Reproducibility and validity of an FFQ in the Henan Rural Cohort Study. *Public Health Nutr.* 2019;1-7. doi: 10.1017/s1368980019002416.
  23. Yuexin Y GW, Xingchang P. *China Food Composition Table.* China Institute of Nutrition and Food Safety, China CDC, Peking. Peking: Beijing medical university press; 2002.
  24. Liu L, Liu Y, Sun X, Yin Z, Li H, Deng K et al. Identification of an obesity index for predicting metabolic syndrome by gender: the rural Chinese cohort study. *BMC Endocr Disord.* 2018;18:54. doi: 10.1186/s12902-018-0281-z.
  25. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35:1381-95. doi: 10.1249/01.mss.0000078924.61453.fb.
  26. Zhou J, Ren Y, Wang C, Li L, Zhang L, Wang B et al. Association of change in waist circumference and dyslipidaemia risk: The rural Chinese cohort study. *Diabetes Metab Res Rev.* 2018;34. doi: 10.1016/j.jash.2018.10.005 10.1002/dmrr.2949.
  27. adults JcdfCgopatodi. Chinese guidelines on prevention and treatment of dyslipidemia in adults (2016) . *Chinese Circulation Journal.* 2016;31:937-50. doi: 10.3969/j.issn.1000-3614.2016.10.001.

28. Liu D, Zhao LY, Yu DM, Ju LH, Zhang J, Wang JZ, Zhao WH. Dietary Patterns and Association with Obesity of Children Aged 6(-)17 Years in Medium and Small Cities in China: Findings from the CNHS 2010(-)2012. *Nutrients*. 2018;11. doi: 10.3390/nu11010003.
29. Xu SH, Qiao N, Huang JJ, Sun CM, Cui Y, Tian SS et al. Gender Differences in Dietary Patterns and Their Association with the Prevalence of Metabolic Syndrome among Chinese: A Cross-Sectional Study. *Nutrients*. 2016;8:180. doi: 10.3390/nu8040180.
30. Li M, Shi Z. Dietary Pattern during 1991-2011 and Its Association with Cardio Metabolic Risks in Chinese Adults: The China Health and Nutrition Survey. *Nutrients*. 2017;9. doi: 10.3390/nu9111218.
31. Satija A, Bhupathiraju SN, Spiegelman D, Chiuve SE, Manson JE, Willett W, Rexrode KM, Rimm EB, Hu FB. Healthful and Unhealthful Plant-Based Diets and the Risk of Coronary Heart Disease in U.S. Adults. *J Am Coll Cardiol*. 2017;70:411-22. doi: 10.1016/j.jacc.2017.05.047.
32. Guo J, Astrup A, Lovegrove JA, Gijbbers L, Givens DI, Soedamah-Muthu SS. Milk and dairy consumption and risk of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies. *Eur J Epidemiol*. 2017;32:269-87. doi: 10.1007/s10654-017-0243-1.
33. Michaelsson K, Wolk A, Langenskiold S, Basu S, Warensjo Lemming E, Melhus H, Byberg L. Milk intake and risk of mortality and fractures in women and men: cohort studies. *Bmj*. 2014;349:g6015. doi: 10.1136/bmj.g6015.
34. Zhu Z, Wu F, Lu Y, Wang Z, Zang J, Yu H et al. The association of dietary cholesterol and fatty acids with dyslipidemia in Chinese metropolitan men and women. *Nutrients*. 2018;10. doi: 10.3390/nu10080961.
35. Pang SJ, Jia SS, Man QQ, Song S, Li YQ, Song PK, Zhao WH, Zhang J. Dietary cholesterol in the elderly Chinese population: An analysis of CNHS 2010-2012. *Nutrients*. 2017;9. doi: 10.3390/nu9090934.
36. Cahill LE, Pan A, Chiuve SE, Sun Q, Willett WC, Hu FB, Rimm EB. Fried-food consumption and risk of type 2 diabetes and coronary artery disease: a prospective study in 2 cohorts of US women and men. *Am J Clin Nutr*. 2014;100:667-75. doi: 10.3945/ajcn.114.084129.
37. Blesso CN, Fernandez ML. Dietary cholesterol, serum Lipids, and heart disease: Are eggs working for or against you? 2018;10. doi: 10.3390/nu10040426.
38. Batis C, Sotres-Alvarez D, Gordon-Larsen P, Mendez MA, Adair L, Popkin B. Longitudinal analysis of dietary patterns in Chinese adults from 1991 to 2009. *Br J Nutr*. 2014;111:1441-51. doi: 10.1017/S0007114513003917.
39. Bradbury KE, Appleby PN, Key TJ. Fruit, vegetable, and fiber intake in relation to cancer risk: findings from the European Prospective Investigation into Cancer and Nutrition (EPIC). *Am J Clin Nutr*. 2014;100 Suppl 1:394s-8s. doi: 10.3945/ajcn.113.071357.
40. Garg A, Grundy SM, Koffler M. Effect of high carbohydrate intake on hyperglycemia, islet function, and plasma lipoproteins in NIDDM. *Diabetes Care*. 1992;15:1572-80. doi: 10.2337/diacare.15.11.1572.

41. Ma Y, Su C, Wang H, Wang Z, Liang H, Zhang B. Relationship between carbohydrate intake and risk factors for cardiovascular disease in Chinese adults: data from the China Health and Nutrition Survey (CHNS). *Asia Pac J Clin Nutr.* 2019;28:520-32. doi: 10.6133/apjcn.201909\_28(3).0011.
42. Aune D, Norat T, Romundstad P, Vatten LJ. Whole grain and refined grain consumption and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies. *Eur J Epidemiol.* 2013;28:845-58. doi: 10.1007/s10654-013-9852-5.
43. Yuan C, Lee HJ, Shin HJ, Stampfer MJ, Cho E. Fruit and vegetable consumption and hypertriglyceridemia: Korean National Health and Nutrition Examination Surveys (KNHANES) 2007-2009. *Eur J Clin Nutr.* 2015;69:1193-9. doi: 10.1038/ejcn.2015.77.
44. Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T et al. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. *Int J Epidemiol.* 2017;46:1029-56. doi: 10.1093/ije/dyw319.
45. Berger S, Raman G. Dietary cholesterol and cardiovascular disease: a systematic review and meta-analysis. *Am J Clin Nutr.* 2015;102:276-94. doi: 10.3945/ajcn.114.100305.
46. Moreno Franco B, Leon Latre M, Andres Esteban EM, Ordozas JM, Casasnovas JA, Penalvo JL. Soluble and insoluble dietary fibre intake and risk factors for metabolic syndrome and cardiovascular disease in middle-aged adults: the AWHs cohort. *Nutr Hosp.* 2014;30:1279-88. doi: 10.3305/nh.2014.30.6.7778.
47. Sacks FM, Donner A, Castelli WP, Gronemeyer J, Pletka P, Margolius HS, Landsberg L, Kass EH. Effect of ingestion of meat on plasma cholesterol of vegetarians. *JAMA.* 1981;246:640-4. doi:
48. Cocate PG, Natali AJ, de Oliveira A, Alfenas Rde C, Peluzio Mdo C, Longo GZ et al. Red but not white meat consumption is associated with metabolic syndrome, insulin resistance and lipid peroxidation in Brazilian middle-aged men. *Eur J Prev Cardiol.* 2015;22:223-30. doi: 10.1177/2047487313507684.
49. O'Connor LE, Kim JE, Campbell WW. Total red meat intake of  $\geq 0.5$  servings/d does not negatively influence cardiovascular disease risk factors: a systemically searched meta-analysis of randomized controlled trials. *Am J Clin Nutr.* 2017;105:57-69. doi: 10.3945/ajcn.116.142521.
50. Nam GE, Cho KH, Park YG, Han KD, Choi YS, Kim SM et al. Socioeconomic status and dyslipidemia in Korean adults: the 2008-2010 Korea National Health and Nutrition Examination Survey. *Prev Med.* 2013;57:304-9. doi: 10.1016/j.ypmed.2013.06.008.
51. Perini W, Agyemang C, Snijder MB, Peters RJG, Kunst AE. Ethnic disparities in educational and occupational gradients of estimated cardiovascular disease risk: The Healthy Life in an Urban Setting study. *Scand J Public Health.* 2018;46:204-13. doi: 10.1177/1403494817718906.
52. Htun NC, Suga H, Imai S, Shimizu W, Takimoto H. Food intake patterns and cardiovascular risk factors in Japanese adults: analyses from the 2012 National Health and nutrition survey, Japan. *Nutr J.* 2017;16:61. doi: 10.1186/s12937-017-0284-z.

**Table 1.** Factor-loading matrix for dietary patterns identified by principal component analysis

Food Group	Meat pattern <sup>†</sup>	Grain-egg-nut complex pattern <sup>‡</sup>	Vegetable-staple food-fruits pattern <sup>‡</sup>
White meat	0.783		
Fish	0.733		
Red meat	0.725		
Grains		0.614	
Eggs		0.525	
Nuts		0.524	
Bean		0.510	
Milk		0.431	
Vegetable			0.749
Staple food			0.709
Fruits			0.403

<sup>†</sup>The patterns were interpreted and named according to high factor loadings >0.3.

**Table 2.** Characteristics of study participants in different dietary patterns

Variables	Meat pattern (n=12145)	Grain-egg-nut complex pattern (n=12899)	Vegetable-staple food- fruits pattern (n=13939)	<i>p</i> <sup>‡</sup>
Age, years	52.84 (12.70)	56.62 (12.83)	57.10 (10.61)	<0.001
Male	4978 (41.0)	4443 (34.4)	5913 (42.4)	<0.001
Education				<0.001
Elementary school or below	4666 (38.4)	5692 (44.1)	7119 (51.1)	
Junior high school	5200 (42.8)	4882 (37.8)	5444 (39.1)	
High school or above	2279 (18.8)	2325 (18.0)	1376 (9.9)	
Married/cohabitation	11027 (90.8)	11490 (89.1)	12478 (89.5)	<0.001
Per capita monthly income				<0.001
<500 RMB	3568 (29.4)	4749 (36.8)	5605 (40.2)	
500~RMB	4011 (33.0)	4347 (33.7)	4461 (32.0)	
1000~RMB	4566 (37.6)	3803 (29.5)	3873 (27.8)	
Current smoker	2827 (21.8)	2046 (15.9)	2710 (19.4)	<0.001
Current drinker	2827 (23.3)	1935 (15.0)	2228 (16.0)	<0.001
Physical activity				<0.001
Low	4070 (33.5)	4873 (37.8)	3656 (26.2)	
Moderate	4747 (39.1)	4154 (32.2)	5823 (41.8)	
High	3328 (27.4)	3872 (30.0)	4460 (32.0)	
Family history of dyslipidemia	494 (4.1)	393 (3.0)	490 (3.5)	<0.001
Energy intake(kcal/d)	1923.86 (636.48)	1848.5 (551.68)	2213.25 (646.44)	<0.001
BMI (kg/m <sup>2</sup> )	24.94 (3.58)	24.90 (3.63)	24.65 (3.48)	<0.001
TC (mmol/L)	4.68 (0.94)	4.94 (1.04)	4.65 (0.92)	<0.001
TG (mmol/L)	1.71 (1.19)	1.60 (1.05)	1.71 (1.12)	<0.001
HDLC (mmol/L)	1.32 (0.33)	1.33 (0.33)	1.33 (0.33)	<0.05
LDLC (mmol/L)	2.86 (0.81)	2.94 (0.84)	2.87 (0.82)	<0.001
Dyslipidemia	6695 (55.1)	7600 (58.9)	7688 (55.2)	<0.001

SD: standard deviation; BMI: body mass index; TC: total cholesterol; TG: triglycerides; HDL-C: high density lipoprotein cholesterol; LDL-C: low density lipoprotein cholesterol.

<sup>†</sup>Data are presented as the mean (SD) for continuous variables and n (%) for categorical variables.

<sup>‡</sup>The *p*-values were derived from one-way ANOVA analysis for continuous variables and from  $\chi^2$  test for categorical variables

**Table 3.** Odds ratios (95% confidence intervals) for abnormal lipid levels in the tertiles of different dietary patterns

Variable	Tertile	Meat Pattern		Grain-egg-nut complex Pattern		Vegetable-staple food-fruits pattern	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
High TG	T1 <sup>†</sup>	1	1	1	1	1	1
	T2 <sup>†</sup>	1.127 (1.056,1.202)**	1.103 (1.031,1.180)*	0.906 (0.851,0.964)*	0.887 (0.831,0.946)**	1.012 (0.948,1.080)	1.076 (1.002,1.156)*
	T3 <sup>†</sup>	1.261 (1.183,1.344)**	1.209 (1.126,1.298)**	0.797 (0.748,0.850)**	0.766 (0.716,0.819)**	1.268 (1.190,1.350)*	1.480 (1.362,1.607)**
	<i>p</i> -trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
High TC	T1 <sup>†</sup>	1	1	1	1	1	1
	T2 <sup>†</sup>	0.774 (0.710,0.844)**	0.844 (0.772,0.922)**	1.590 (1.441,1.754)**	1.680 (1.520,1.857)**	0.638 (0.585,0.696)**	0.707 (0.644,0.778)**
	T3 <sup>†</sup>	0.617 (0.563,0.677)**	0.846 (0.765,0.935)*	1.958 (1.780,2.153)**	2.286 (2.070,2.524)**	0.505 (0.461,0.554)**	0.654 (0.581,0.736)**
	<i>p</i> -trend	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
High LDL-C	T1 <sup>†</sup>	1	1	1	1	1	1
	T2 <sup>†</sup>	0.857 (0.781,0.940)*	0.935 (0.850,1.028)	1.205 (1.093,1.327)**	1.244 (1.127,1.372)**	0.815 (0.744,0.893)**	0.879 (0.796,0.971)*
	T3 <sup>†</sup>	0.791 (0.720,0.870)**	1.046 (0.943,1.160)	1.267 (1.151,1.395)**	1.392 (1.260,1.538)**	0.665 (0.604,0.733)**	0.808 (0.714,0.915)*
	<i>p</i> -trend	<0.001	>0.05	<0.001	<0.001	<0.001	<0.001
Low HDL-C	T1 <sup>†</sup>	1	1	1	1	1	1
	T2 <sup>†</sup>	1.070 (1.000,1.145)	1.019 (0.948,1.094)	0.966 (0.904,1.033)	0.954 (0.890,1.023)	1.045 (0.976,1.118)	1.063 (0.986,1.146)
	T3 <sup>†</sup>	1.118 (1.058,1.211)*	0.956 (0.886,1.032)	0.922 (0.861,0.986)*	0.910 (0.847,0.977)*	1.088 (1.017,1.164)*	1.066 (0.974,1.166)*
	<i>p</i> -trend	<0.001	>0.05	<0.05	0.001	<0.05	>0.05

Model 1 was Unadjusted; Model 2 was adjusted for the baseline values of age, gender, education, monthly income, marital status, smoking, alcohol consumption, exercise, BMI, family history of dyslipidemia, and energy intake.

<sup>†</sup>T1-T3, the tertile for the factor loadings. Factor loadings of “meat” pattern were categorized as: T1: <-0.602, T2: -0.602-0.175, and T3: ≥0.175; factor loadings of “grain-egg-nut complex” pattern were categorized as: T1: <-0.550, T2: -0.550-0.320, and T3: ≥0.320; factor loadings of “vegetable-staple food-fruits” pattern were as T1: <-0.483, T2: -0.483-0.332, and T3 ≥0.332.

\**p*-value<0.05, \*\**p*-value <0.001.



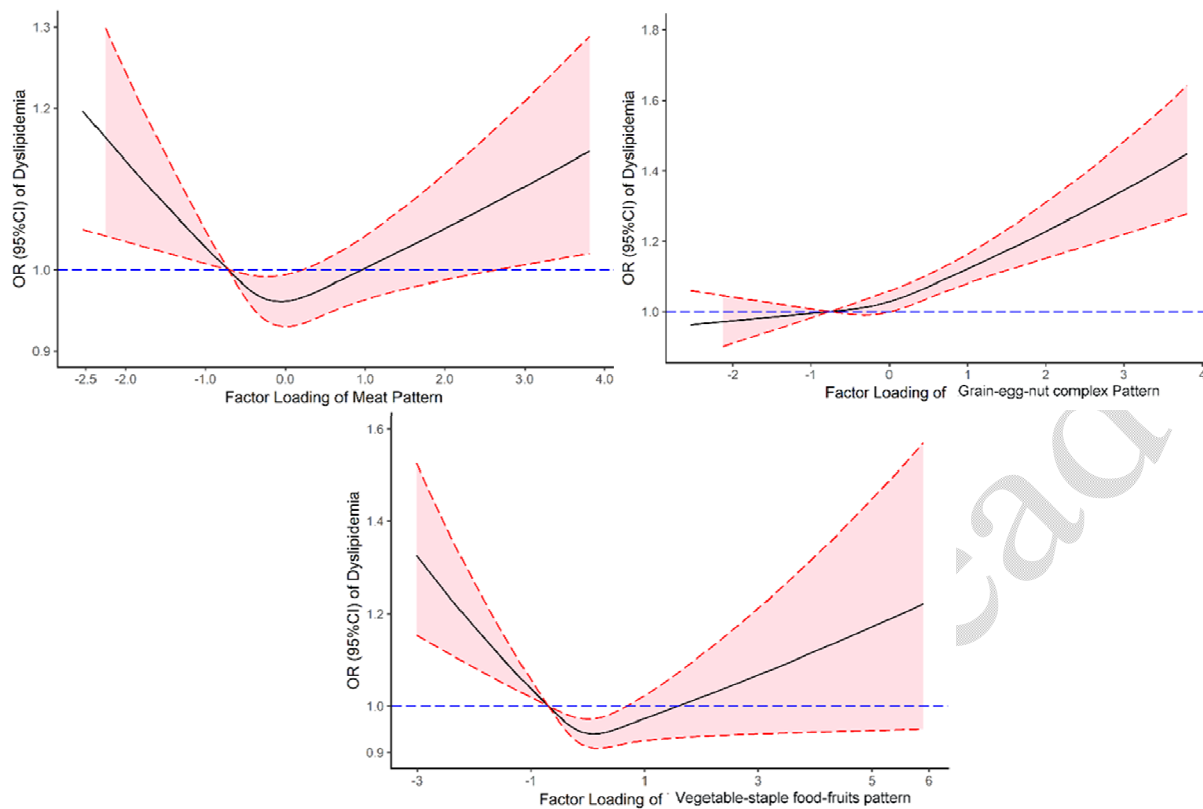
**Table 4.** Odds ratios (95% confidence intervals) for dyslipidemia in the tertiles of different dietary patterns

Variable	Tertile	Crude	Model 1	Model 2	Model 3
Meat Pattern	T1 <sup>†</sup>	1	1	1	1
	T2 <sup>†</sup>	0.93 (0.89,0.98)*	0.98 (0.93,1.03)	0.96 (0.91,1.01)	0.961 (0.914,1.011)
	T3 <sup>†</sup>	0.88 (0.84,0.93)**	0.99 (0.94,1.05)	0.954 (0.906,1.005)	0.978 (0.927,1.031)
	<i>p</i> -trend	<0.001	>0.05	>0.05	>0.05
Grain-egg-nut complex pattern	T1 <sup>†</sup>	1	1	1	1
	T2 <sup>†</sup>	1.012 (0.964,1.063)	1.025 (0.976,1.077)	1.013 (0.964,1.065)	1.019 (0.969,1.070)
	T3 <sup>†</sup>	1.069 (1.018,1.123)*	1.090 (1.038,1.145)*	1.079 (1.026,1.134)*	1.104 (1.049,1.161)**
	<i>p</i> -trend	<0.05	<0.05	<0.05	<0.001
Vegetable-staple food-fruits pattern	T1 <sup>†</sup>	1	1	1	1
	T2 <sup>†</sup>	0.884 (0.841,0.928)**	0.880 (0.838,0.924)**	0.903 (0.859,0.949)**	0.935 (0.887,0.985)*
	T3 <sup>†</sup>	0.902 (0.858,0.947)**	0.908 (0.864,0.954)**	0.949 (0.902,0.998)*	1.025 (0.963,1.092)
	<i>p</i> -trend	<0.001	<0.001	<0.05	>0.05

Crude was unadjusted; Model1 was adjusted for age, gender; Model2 was adjusted for the baseline values of age, gender, education, marital status, income, smoking, alcohol consumption, exercise, family history of dyslipidemia; model3 was additionally adjusted for energy intake.

<sup>†</sup>T1-T3, the tertile for the factor loadings. Factor loadings of “meat” pattern were categorized as: T1: <-0.602, T2: -0.602-0.175, and T3: ≥0.175; factor loadings of “grain-egg-nut complex” pattern were categorized as: T1: <-0.550, T2: -0.550-0.320, and T3: ≥0.320; factor loadings of “vegetable-staple food-fruits” pattern were as T1: <-0.483, T2: -0.483-0.332, and T3 ≥0.332.

\**p*-value<0.05, \*\**p*-value <0.001.



**Figure 1.** Dose-reponse relationships between continuous factor scores from different dietary patterns and dyslipidemia. All models were adjusted for age, gender, education level, per capita monthly income, marital status, smoking, alcohol drinking, physical activity, family history of dyslipidemia, and intake of energy

**Supplemental table and Figure**

**Supplemental figure 1.** The scree plot of the component number. Result of Principle Components Analysis The Kaiser–Meyer–Olkin index=0.739>0.7; Bartlett’s test  $\chi^2=36841.740$ ,  $p=0.000$ . Three factors explained 43.56% of the variance.

**Supplemental table 1.** Mean intakes of food groups and nutrients according to tertiles of three dietary patterns

Food group and nutrients intake	Meat pattern			Grain-egg-nut complex pattern			Vegetable-staple food-fruits pattern		
	T1 <sup>†</sup>	T2 <sup>†</sup>	T3 <sup>†</sup>	T1 <sup>†</sup>	T2 <sup>†</sup>	T3 <sup>†</sup>	T1 <sup>†</sup>	T2 <sup>†</sup>	T3 <sup>†</sup>
Food groups (g/d)									
Staple food <sup>‡</sup>	285.05	332.53	416.21	280.45	328.51	368.80	363.44	435.82	557.75
Red meat	4.24	21.34	66.90	4.46	12.80	25.51	4.46	12.37	24.20
White meat	1.03	7.42	29.11	0.91	3.92	9.63	1.49	4.55	11.75
Fish	0.26	1.84	9.14	0.28	1.13	2.70	0.29	0.99	2.83
Egg	15.69	27.54	47.17	31.65	54.70	82.31	27.57	36.69	59.86
Milk <sup>§</sup>	1.05	6.51	15.36	1.49	12.26	23.48	0.77	2.65	5.36
Fruit	27.11	71.29	163.32	34.89	81.04	156.35	37.77	89.97	187.15
Vegetable	154.31	187.20	299.99	157.73	207.27	293.15	204.30	277.45	484.46
Bean	6.98	18.30	40.00	9.84	23.75	51.56	7.41	14.98	23.38
Nut	2.02	5.75	17.60	3.60	10.13	27.51	2.59	6.22	14.70
Grain	19.56	24.94	44.68	51.71	60.46	116.34	22.31	29.68	43.30
Nutrients									
Carbohydrate (g/d)	230.51	276.74	366.59	238.66	288.96	357.24	293.22	359.06	474.14
Protein (g/d)	37.84	52.04	83.16	40.95	56.07	78.31	48.67	62.87	88.19
Fat (g/d)	8.16	17.24	39.95	10.24	18.40	32.11	10.61	16.56	27.28
Insoluble fiber (mg/d)	47.32	121.09	353.10	78.18	206.04	543.82	60.45	133.03	301.40
Cholesterol (mg/d)	85.62	169.12	334.61	167.78	298.34	458.98	147.17	204.45	341.48
Total energy intake (kcal/d)	1130.43	1448.76	2125.25	1192.57	1521.32	1994.59	1442.31	1809.53	2454.84

<sup>†</sup>T1-T3, the tertile for the factor scores.

<sup>‡</sup>Staple food which contains fine processed grain like polished rice, noodle, steamed twisted roll, steamed bread and other fine processed grains and cereals.

<sup>§</sup>The unit is ml/day.