

RESEARCH ARTICLE

Social capital and dietary patterns in three ethnic minority groups native to Yunnan Province, Southwest China

Qiang Zhang¹*, Zhitao Liu¹*, Wenmin Hu¹, Xinguang Chen², Juanjuan Li¹, Qingqing Wan¹, Jiang Zhao¹, Yuan Ruan¹, Baoqing Dao³, Yunfei Li⁴, Xiangdong Min¹*

1 Department of Nutrition and Food Hygiene, Yunnan Center for Disease Control and Prevention, Kunming, China, **2** Department of Epidemiology, University of Florida, Gainesville, Florida, United States of America, **3** Department of Public Health, Dehong Center for Disease Control and Prevention, Mangshi, China, **4** Department of Health Education, Lanping Center for Disease Control and Prevention, Lanping, China

* These authors contributed equally to this work.

* counterstriker_zq@163.com



OPEN ACCESS

Citation: Zhang Q, Liu Z, Hu W, Chen X, Li J, Wan Q, et al. (2021) Social capital and dietary patterns in three ethnic minority groups native to Yunnan Province, Southwest China. PLoS ONE 16(8): e0256078. <https://doi.org/10.1371/journal.pone.0256078>

Editor: Srinivas Goli, University of Western Australia, AUSTRALIA

Received: October 27, 2020

Accepted: August 2, 2021

Published: August 12, 2021

Copyright: © 2021 Zhang et al. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability Statement: All relevant data are within the paper and its [Supporting Information](#) files.

Funding: This study was funded by the High-level Health Talents Project of Yunnan Province (H-2018046 to Q.Z.) and the Health Commission of Yunnan Province (2018NS-0230 to Z.L.). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Abstract

Background

Few studies have focused on the influencing factors of dietary practices among ethnic minority groups in China, particularly from a social capital perspective.

Methods

Between May and September 2019, we conducted a cross-sectional survey among adults ($n = 1,813$) from three ethnic minority communities (A Chang, De Ang and Jing Po) in Yunnan Province, Southwest China. Dietary intakes during the past 12 months were measured with a 100-item Food Frequency Questionnaire (FFQ), and two forms of social capital (bonding and bridging) were measured using the validated Personal Social Capital Scale 16 (PSCS-16). Principal component factor analysis was used to derive dietary patterns from 20 food groups. Multivariate linear regressions were used to examine the associations between social capital and dietary patterns.

Results

Two distinct dietary patterns were identified: the traditional and the modern. The traditional pattern was characterized by high consumptions of tubers, poultry, rice, fruits, vegetables and low consumptions of oil and salt, whereas the modern pattern was highly correlated with egg, nut, beverage, snack and oil consumptions. After adjusted for potential confounders, the modern pattern was positively associated with bonding capital ($\beta = 0.066$; 95%CI: 0.058, 0.075) and negatively associated with bridging capital ($\beta = -0.017$; 95%CI: -0.024, -0.010).

Conclusion

In conclusion, an unhealthy dietary pattern was identified among the ethnic minority groups in Southwest China. The influences of people's social connections on dietary behaviors

Competing interests: The authors have declared that no competing interests exist.

should be considered in designing and implementing nutrition intervention programs for the population.

Introduction

Good nutrition is vital for both physical and mental health [1]. However, it is estimated that 22% of global deaths among adults in 2017 were attributable to dietary risk factors [2]. During the past decades, China has also experienced a rapid nutrition transition characterized by unhealthy changes in eating behaviors and a surge in non-communicable diseases, even in less developed areas [3–5]. Given the challenges above, more in-depth researches on factors that affect diet are urgently needed.

Apart from factors such as age, sex, education and income, the influence of social capital on dietary behaviors have received increasing attention in recent years. Social capital can be conceptualized at both the collective and individual levels, e.g., either as the features of social organization, or as the personal resource emerges from social network [6, 7]. Social capital has been recognized as a health determinant, while health-related behavior is proposed to be a mechanism [8, 9]. Studies from China and abroad showed that people having high individual social capital are more likely to adhere to a healthy diet [10, 11]. In this sense, social capital intervention might be a promising approach to promote healthy eating. However, individual social capital is also a multifaceted concept [12]. According to social networks and the interactions within, social capital can be divided into bonding, bridging and linking capital. Bonding capital refers to “inward” connections between homogeneous individuals, bridging capital refers to “outward” connections between heterogeneous individuals, and linking capital characterizes connections between individuals across authority gradients [13, 14]. Because of this, different types of social capital may have different effects on individual dietary practices. A study from Spain indicated that family and peers are the most influential sources of social capital in relation to adolescent dietary behaviors, including both protective and damaging effects [15]. Moreover, a recent study on older adults in China showed that people with higher bonding and bridging social capital are less likely to skip breakfast [16]. Thus, studies that assess the effects of types of social capital on overall diet quality are needed.

Dietary pattern analysis is a holistic and data-driven approach to evaluate dietary behaviors [17]. By assessing dietary intakes of individuals as a whole, dietary patterns can reflect the combined effects of multiple foods and nutrients on health outcomes [18, 19]. Moreover, dietary patterns are also strongly correlated with socioeconomic characteristics, which is helpful to determine dietary preference across subgroups [19]. To date, two main dietary patterns (the traditional and the modern) have been identified in Chinese adult population [20, 21]. The traditional pattern is characterized by high intakes of rice, wheat and vegetables, which represents a typical traditional diet in China. The modern pattern is characterized by high intakes of meat, milk and fast foods, and often associated with higher risk of obesity, diabetes and hypertension. Longitudinal studies using the China Health and Nutrition Survey (CHNS) data reported dramatic changes in dietary patterns, reflecting the shift from the traditional agricultural society to a modern commercial and industrialization society [22, 23]. By contrast, dietary patterns among Chinese ethnic minority groups are less clear and understudied. With a focus on disease prevention and health promotion, Healthy China Initiative (2019–2030) has proposed 15 special campaigns including a balanced diet action [24]. This action again emphasizes the need to implement dietary guidance and nutrition intervention, as well as to provide

community nutrition instructors. Yet, physical and human resources for health are often scarce, especially for ethnic minorities living in rural areas. As a type of important resource, social capital should be considered when planning nutrition promotion interventions.

There are 15 ethnic minority groups native to Yunnan Province, Southwest China. Most of them live in areas with a backward economy and poor public transportation. Benefited from China's targeted poverty alleviation policy in recent years, the local economy has developed at a high speed, which would also lead to dramatic changes in social connections and diets. Therefore, we hypothesize that bonding and bridging social capital may have different roles on the nutrition transition in this context. The purpose of this study was to identify and characterize dietary patterns, as well as to examine their associations with social capital in the ethnic minority groups.

Materials and methods

Study design

Between May and September 2019, we conducted a cross-sectional survey among adults of three ethnic minority groups in Yunnan Province, which were A Chang, De Ang and Jing Po. According to the sixth national census in 2010, total population for each of the minorities were less than 150,000 and most of them live in certain border towns [25]. Participants were recruited using a multi-stage sampling method. First, three towns had the largest population of A Chang, De Ang or Jing Po were chosen as the study sites. Then, two villages were randomly selected from each town with the Probability Proportional to Size method. Finally, based on local household registration information, 150 households were randomly selected from each village. All adults of the sampled households were invited to participate the survey, except those who were on a prescribed diet or who had serious illnesses.

The sample size was determined from careful power analysis considering the following four factors: a prevalence of hypertension of 15%, a desired precision of 3%, a type I error of 0.05 and the population of each ethnic minority group. Since hypertension is the most prevalent nutrition-related disease in the ethnic minorities, the prevalence we determined in a prior study was used to calculate the sample size [26]. The minimum sample size per minority group ranged from 538 to 554. We aimed at recruiting 580 participants per site, considering potential of 5% non-response. Data were collected through a face-to-face interview by trained local health workers. Altogether, 1813 participants completed the survey with a response rate of 85%. The study was approved by the Institutional Review Board at Yunnan Center for Disease Control and Prevention (2019–01). Before administrating the survey, signed informed consent was obtained from all the participants.

Dietary assessment and dietary patterns

Dietary intakes in the past 12 months were assessed using the Food Frequency Questionnaire (FFQ) developed by the Institution of Nutrition and Health, Chinese Centers for Disease Control and Prevention, which has been widely used in previous national nutrition survey [27]. The FFQ consists of 100 detailed food items, covering most of the commonly consumed foods in China. Based on the frequency and amount of food intakes reported by individual participants, daily intake of each food item was calculated. Due to the low intake of some food items, these 100 detailed food items were then grouped into 20 food groups according to the China Food Composition Table for further analysis [28]. These food groups were rice, wheat, tubers, beans, vegetables, salt vegetable, mushrooms, fruits, milk, red meat, poultry, organ meat, fish, eggs, cakes, nuts, snacks, beverages, salt and oil.

Dietary patterns were identified using factor (principal component) analysis based on the daily consumptions of the 20 food groups. Principal component analysis is a data driven technique that reduces the dimension of the data and groups correlated variables, to form new components. The number of factors retained was determined by eigenvalue (>1.0), scree plot, factor interpretability, and the variance explained ($>5\%$). The factors were rotated by an orthogonal rotation to achieve a simpler structure with greater interpretability. Factor loadings, which presenting the correlations between food groups and factors, were calculated for each food group across the two factors. Higher loadings indicate a higher shared variance with the factor. Factor loadings of $> |0.25|$ represent the food groups that most strongly related to the identified factor. Dietary patterns were named according to the food groups showing high loadings for each factor. Pattern-specific scores were then calculated and assigned to each participant. Factor scores for each pattern were categorized into quartiles (quartiles 1 and 4 representing low and high adherence to each dietary pattern, respectively).

Measurements of social capital

Social capital for individual participants was assessed using the Personal Social Capital Scale 16 (PSCS-16). This scale consists of 16 items with 8 items measuring the bonding capital (including network, trust, resource ownership and reciprocity) and eight items measuring bridging capital, embedded in two types of social organizations (political and economic organizations; recreational and cultural organizations). Responses for each item were ranked on a five-point Likert scale. Mean scores for the bridging and bonding capital were calculated and used in the following descriptive and regression analysis. In previous studies in China, Cronbach's α of the scale ranged from 0.81 to 0.87 [29, 30]. Correlation analysis showed that the alpha coefficient in this study was 0.87. The PSCS-16 can be found in [S1 Table](#).

Covariates

Sociodemographic characteristics of the participants were incorporated in the analyses as potential confounders, including age, sex, ethnicity, education and income. Age was divided into five groups (18–34, 35–44, 45–54, 55–64 and ≥ 65 years) in the descriptive statistics, while treated as a continuous variable in the regression analyses. Education was classified as three levels (illiteracy, primary school, middle school or higher). Income was measured by household income per capita in the last 12 months and divided into four categories (<5000 , 5000–9999, 10000–14999, >15000 Yuan).

Data analysis

Correlation analyses were used to calculate Cronbach's α of the social capital scale. Categorical variables (e.g., age and sex) are presented as percentage, while variables (e.g., social capital scores) were presented as mean and standard deviation (SD). Chi-square tests were used to examine the trend in sociodemographic characteristics across the quartiles of dietary patterns. Linear regression analyses were used to estimate the associations between social capital and dietary pattern scores with potential confounders adjusted. All statistical analyses were performed with SAS Software 9.4 (SAS Institute, Cary, North Carolina, USA). Statistical significance was set at $P < 0.05$.

Results

Sociodemographic characteristics of the participants are presented in [Table 1](#). The total sample included 745 men and 1068 women. The proportions of participants aged 18–34, 35–44, 45–

Table 1. Sociodemographic characteristics of the participants.

| Characteristics | Men | Women | Total |
|---------------------------|------------|-------------|--------------|
| Sex, N (%) | 745 (41.1) | 1068 (58.9) | 1813 (100.0) |
| Age in years, N (%) | | | |
| 18–34 | 155 (8.5) | 148 (8.2) | 303 (16.7) |
| 35–44 | 182 (10.0) | 201 (11.1) | 383 (21.1) |
| 45–54 | 153 (8.4) | 282 (15.6) | 435 (24.0) |
| 55–64 | 155 (8.5) | 302 (16.7) | 457 (25.2) |
| ≥65 | 100 (5.5) | 135 (7.4) | 235 (12.9) |
| Ethnicity, N (%) | | | |
| A Chang | 233 (12.9) | 377 (20.8) | 610 (33.6) |
| De Ang | 291 (16.1) | 320 (17.7) | 611 (33.7) |
| Jing Po | 221 (12.2) | 371 (20.5) | 592 (32.7) |
| Education, N (%) | | | |
| Illiteracy | 143 (7.9) | 466 (25.7) | 609 (33.6) |
| Primary school | 419 (23.1) | 440 (24.3) | 859 (47.4) |
| Middle school or higher | 183 (10.1) | 162 (8.9) | 345 (19.0) |
| Income (Yuan/Year), N (%) | | | |
| <5000 | 192 (10.6) | 253 (14.0) | 445 (24.5) |
| 5000–9999 | 267 (14.7) | 438 (24.2) | 705 (38.9) |
| 10000–14999 | 148 (8.2) | 203 (11.2) | 351 (19.4) |
| ≥15000 | 138 (7.6) | 174 (9.6) | 312 (17.2) |

<https://doi.org/10.1371/journal.pone.0256078.t001>

54, 55–64, and 65 years or older were 16.7%, 21.1%, 24.0%, 25.2% and 12.9%, respectively. Each of the three ethnic minority group accounted for one third of the sample. Nearly 65% of the participants had an annual income less than 10,000 RMB Yuan (equivalent to 1,400 US dollars), and over 80% only had primary education or no formal education.

Table 2 summarizes the two dietary patterns among the participants. The first one was labeled as the traditional pattern, which characterized by high intakes of tubers, poultry, rice, fruits, vegetables and low intakes of oil and salt. The other one which highly correlated with egg, nut, beverage and snack intakes, was named as the modern pattern. The two dietary patterns explained 28.3% of the total variance in dietary consumptions.

Table 2. Factor loadings of the food groups in the two dietary patterns.

| Traditional | Factor loadings | Modern | Factor loadings |
|------------------------|-----------------|------------|-----------------|
| Tubers | 0.68 | Eggs | 0.65 |
| Poultry | 0.68 | Nuts | 0.64 |
| Fruits | 0.66 | Beverages | 0.54 |
| Rice | 0.53 | Snacks | 0.50 |
| Vegetables | 0.53 | Oil | 0.43 |
| Mushrooms | 0.52 | Cakes | 0.42 |
| Fish | 0.49 | Organ meat | 0.40 |
| Beans | 0.40 | Red meat | 0.37 |
| Salt vegetables | 0.29 | Salt | 0.34 |
| Salt | -0.26 | Vegetables | -0.27 |
| Oil | -0.25 | | |
| Variance explained (%) | 18.7 | | 9.6 |

Note: Absolute value <0.25 are not presented in the table for simplicity.

<https://doi.org/10.1371/journal.pone.0256078.t002>

Table 3. Sociodemographic characteristics of the participants across quartiles of the dietary patterns.

| | Dietary Pattern Quartiles | | | | P for trend |
|------------------------|---------------------------|------|------|------|-------------|
| | Q1 | Q2 | Q3 | Q4 | |
| N | 454 | 453 | 453 | 453 | |
| Traditional | | | | | |
| Men (%) | 39.7 | 39.5 | 41.5 | 43.7 | 0.17 |
| Age <45 years (%) | 30.4 | 42.8 | 34.4 | 43.7 | 0.13 |
| Illiteracy (%) | 34.1 | 35.1 | 21.1 | 34.0 | 0.66 |
| Income <10000 Yuan (%) | 55.7 | 63.6 | 64.5 | 69.9 | <0.01 |
| Modern | | | | | |
| Men (%) | 37.0 | 42.2 | 40.8 | 44.4 | 0.06 |
| Age <45 years (%) | 29.3 | 39.1 | 40.2 | 42.8 | <0.01 |
| Illiteracy (%) | 48.0 | 33.1 | 30.2 | 23.0 | <0.01 |
| Income <10000 Yuan (%) | 79.1 | 70.6 | 63.8 | 40.2 | <0.01 |

<https://doi.org/10.1371/journal.pone.0256078.t003>

Table 3 shows the sociodemographic characteristics of the participants across quartiles of the dietary patterns. People with lower income (<10000 Yuan per year) were more likely to consume the traditional diets. In contrast, people who preferred the modern pattern were younger (<45 years), had higher educational levels (primary school or higher) and income (\geq 10000 Yuan per year).

Table 4 presents bonding and bridging social capital scores by sociodemographic characteristics. Mean scores of bonding and bridging social capital were 21.3 and 19.9, respectively.

Table 4. Social capital scores by sociodemographic characteristics.

| | Bonding capital Mean (SD) | Bridging capital Mean (SD) |
|-------------------------|---------------------------|----------------------------|
| All | 21.3 (5.3) | 19.9 (5.7) |
| Sex | | |
| Men | 21.8 (5.4) | 19.8 (5.8) |
| Women | 20.9 (5.2) | 20.0 (5.7) |
| P | <0.01 | 0.50 |
| Age in years | | |
| 18–34 | 22.4 (5.1) | 19.8 (5.6) |
| 35–44 | 22.1 (5.2) | 20.1 (5.8) |
| 45–54 | 21.3 (5.5) | 20.2 (5.9) |
| 55–64 | 21.0 (5.2) | 20.0 (5.8) |
| \geq 65 | 19.4 (5.0) | 19.1 (5.5) |
| P | <0.01 | 0.18 |
| Education | | |
| Illiteracy | 19.1 (5.8) | 20.1 (5.6) |
| Primary school | 22.0 (5.2) | 19.3 (5.8) |
| Middle school or higher | 23.6 (5.0) | 20.4 (5.8) |
| P | <0.01 | <0.01 |
| Income (RMB Yuan) | | |
| <5000 | 20.1 (5.6) | 19.5 (5.9) |
| 5000–9999 | 20.5 (5.4) | 20.6 (5.9) |
| 10000–14999 | 21.7 (5.8) | 20.1 (5.9) |
| \geq 15000 | 24.4 (5.9) | 18.8 (5.6) |
| P | <0.01 | <0.01 |

<https://doi.org/10.1371/journal.pone.0256078.t004>

Table 5. Associations of dietary pattern scores with social capital.

| Dietary patterns | Bonding | | Bridging | |
|------------------|---------------------------|-------|---------------------------|-------|
| | β (95% CI) | SE | β (95% CI) | SE |
| Traditional | | | | |
| Model 1 | -0.028 (-0.037, -0.020) * | 0.004 | -0.004 (-0.012, 0.004) | 0.004 |
| Model 2 | -0.029 (-0.039, -0.019) * | 0.005 | -0.005(-0.013, 0.004) | 0.004 |
| Modern | | | | |
| Model 1 | 0.083 (0.075, 0.091) * | 0.004 | -0.022 (-0.030, -0.015) * | 0.004 |
| Model 2 | 0.066 (0.058, 0.075) * | 0.004 | -0.017 (-0.024, -0.010) * | 0.003 |

Model 1: Crude model; Model 2: Adjustment for sex, age, education, income and ethnicity; CI: Confidence Interval, SE: Standard Error

* $P < 0.05$.

<https://doi.org/10.1371/journal.pone.0256078.t005>

Bonding social capital scores were higher among men and those who were younger, had higher income or education levels. No such associations were observed for the bridging capital scores.

Associations of dietary pattern scores with bonding and bridging capital are presented in Table 5. After adjustment for sex, age, education, income and ethnicity, the traditional dietary pattern scores were negatively associated with bonding capital ($\beta = -0.029$; 95%CI: -0.039, -0.019), while the modern dietary pattern scores were positively associated with bonding capital ($\beta = 0.066$; 95%CI: 0.058, 0.075) and negatively associated with bridging capital ($\beta = -0.017$; 95%CI: -0.024, -0.010).

Discussion

The cross-sectional study examined the associations between dietary patterns and two types of individual social capital among ethnic minority adults in Southwest China. Two distinct dietary patterns were identified: the traditional (healthy) and the modern (unhealthy). We found that the modern pattern was positively correlated with bonding capital but negatively correlated with bridging capital. Our findings highlight the potential roles of social capital on healthy eating. To our best knowledge, this study is one of the first to assess the influence of social capital on dietary patterns among ethnic minority groups in China.

Traditional Chinese diets usually consist of a carbohydrate staple (e.g., wheat in the north and rice in the south), moderate amounts of animal-source foods, beans and a lot of vegetables [31, 32]. Because of this, it is considered to be well-balanced, rich in fiber and low in saturated fatty acids [33]. Longitudinal studies show that the traditional Chinese dietary pattern is negatively associated with weight gain [23, 34]. The traditional pattern we identified in this study shares large features with those in previous studies, except for the high loadings for poultry and fruits. It's probably because these ethnic minority groups live in sub tropic mountain areas where abounds with fruits and family poultry farming is also very common there. By contrast, the modern dietary pattern (also known as western pattern) is an energy-dense diet, characterized by a high intake of eggs, meats, sweets and fast foods. A robust and positive association between modern pattern and obesity has so far been established both in developed and developing countries, and its other health risks are gradually recognized [35, 36]. Thus, identifying dietary patterns in a given population can provide guidance for nutrition intervention and education. Consistent with previous studies, we found that the modern pattern is more prevalent among younger people and those who have higher income and education [20, 37]. This finding emphasizes the need to pay more attention to these subgroups in the future. In general,

the dietary pattern analysis reveals the challenges of unhealthy eating among the ethnic minority groups in Southwest China.

Another important finding of this study is that the modern dietary pattern is positively associated with bonding capital. This result is something different from previous studies. In these studies, people with higher individual social capital are more likely to have interest in healthy eating, consume more vegetables and fruits or adhere to a Mediterranean diet [38, 39]. This discrepancy may be due to specific social contexts in different studies. At individual level, social capital can be defined as the sum of resources that are available in one's social networks. Social capital may influence health-related behaviors through social norms, values and attitudes prevalent in the networks [13, 40]. That is to say, the effects of social capital on dietary behaviors are largely determined by how most network members perceive healthy eating [41]. In developed countries, people usually have relatively high knowledge and awareness about good nutrition [42]. As a result, social capital in different networks always show protective effects on healthy eating. In contrast, life of the ethnic minority groups in the study has just transited from a subsistence level to a well-level. In this case, both the participants and the homogenous individuals (e.g., their family and friends) would care more about "eat satisfied" instead of "eat healthy". This might explain why bonding social capital is related with unhealthy dietary pattern in this study. A similar finding also appears in a child nutrition study from India [43]. Therefore, the influences of bonding social capital on dietary behaviors should be evaluated in different social contexts.

Moreover, our finding that bridging social capital is a protective factor for healthy eating is consistent with existing literatures. Those studies show that participating in social organizations (the process to build bridging social capital) is correlated with better self-rated health, mental health and protective behaviors [44–46]. According to social capital theory, bridging social capital allows for the generation of ideas and innovations that would be unlikely to manifest among like-minded individuals such as family members and close friends [47]. This is especially important for healthy eating promotion among the public, for which the spread of updated and accurate nutrition knowledge is essential. From this point of view, bridging social capital may promote healthy eating by improving the access of external health information and services [48]. A recent community-based randomized trial in Nepal shows that nutrition education combined with social capital development has better effects on diet quality and growth among children than nutrition education alone [49]. Furthermore, the relationships between bridging social capital and dietary intakes may be more impactful in socioeconomic disadvantaged populations. For example, a study from Netherland shows that having bridging social capital reduce the likelihood to report overweight and obesity in low educated adults [14]. A possible explanation is that health information and services within the social network is indispensable for the low educated to prevent weight gain, but not for the educated ones. In this study, bridging social capital scores are insignificant across sex or age groups, which is inconsistent with previous studies [50]. This probably because the male young adults usually migrate to work for most of the year, which may reduce their participation in local organizations. Thus, for the ethnic minority groups living in less developed areas of Southwest China, influences of local organizations especially from ethnic cultural organizations should be fully recognized and cultivated when designing nutrition intervention programs.

Several limitations of the study should be addressed. First, data used for this study are cross-sectional, thus causal inferences cannot be warranted. Second, the dietary assessments are based on food consumption in the past 12 months, and recall bias cannot be eliminated. Third, although socioeconomic factors are adjusted in the regression models, potential factors at contextual levels for both diets and social capital are not fully considered. Last but not least, we only measured bonding and bridging social capital in this study. Additional studies are

needed to examine social capital in more detail, including their relationships with dietary practices. Despite the limitations, findings of this study provide useful data for researchers to understand the dietary behaviors of ethnic minority groups in Southwest China and their relations with social capital.

Conclusions

In conclusion, a modern dietary pattern is identified among the ethnic minority groups in Southwest China, which may be attributable to the urbanization in recent years. Modern patterns characterized by high consumptions of animal-source foods, oil and beverages have been proved to be correlated with increased risk of non-communicable diseases in the literature. In this study, we find that the modern pattern is positively associated with bonding social capital but negatively associated with bridging social capital. Our findings highlight the need to further understand the roles of different social capital on dietary behaviors when designing nutrition interventions.

Supporting information

S1 Table. Personal Social Capital Scale 16 (PSCS-16).
(PDF)

S1 Data.
(XLS)

Acknowledgments

The authors would like to thank the minority compatriots for their enthusiastic participation in our study. The authors also thank the entire research group including interviewers, nurses, laboratory staffs and volunteers.

Author Contributions

Conceptualization: Qiang Zhang, Zhitao Liu.

Data curation: Wenmin Hu, Yunfei Li.

Formal analysis: Juanjuan Li, Yuan Ruan.

Funding acquisition: Qiang Zhang, Zhitao Liu.

Investigation: Wenmin Hu, Baoqing Dao.

Methodology: Qiang Zhang, Zhitao Liu.

Project administration: Qingqing Wan, Xiangdong Min.

Resources: Baoqing Dao.

Software: Jiang Zhao, Yuan Ruan.

Supervision: Xinguang Chen, Xiangdong Min.

Writing – original draft: Qiang Zhang, Zhitao Liu.

Writing – review & editing: Xinguang Chen, Xiangdong Min.

References

1. The Chinese nutrition society. the Chinese dietary guidelines. Beijing: The People's Medical Publishing House; 2016.
2. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019; 393(10184):1958–72. [https://doi.org/10.1016/S0140-6736\(19\)30041-8](https://doi.org/10.1016/S0140-6736(19)30041-8) PMID: 30954305; PubMed Central PMCID: PMC6899507.
3. Zhai FY, Du SF, Wang ZH, Zhang JG, Du WW, Popkin BM. Dynamics of the Chinese diet and the role of urbanicity, 1991–2011. *Obesity reviews: an official journal of the International Association for the Study of Obesity*. 2014; 15 Suppl 1:16–26. <https://doi.org/10.1111/obr.12124> PMID: 24341755; PubMed Central PMCID: PMC3868998.
4. Gao M, Wang F, Shen Y, Zhu X, Zhang X, Sun X. Trajectories of Mediterranean Diet Adherence and Risk of Hypertension in China: Results from the CHNS Study, 1997(–)2011. *Nutrients*. 2018; 10(12). Epub 2018/12/24. <https://doi.org/10.3390/nu10122014> PMID: 30572651; PubMed Central PMCID: PMC6315578.
5. Zhang Q, Chen X, Liu Z, Varma DS, Wan R, Zhao S. Diet diversity and nutritional status among adults in southwest China. *PLoS one*. 2017; 12(2):e0172406. <https://doi.org/10.1371/journal.pone.0172406> PMID: 28231308; PubMed Central PMCID: PMC5322886.
6. JS C. *Foundations of Social Theory*. Cambridge, MA: Harvard University Press; 1990.
7. Putnam R. *Making democracy work—civic traditions in modern Italy*. Princeton NJ: Princeton University Press; 1993.
8. Xue X, Cheng M. Social capital and health in China: exploring the mediating role of lifestyle. *BMC public health*. 2017; 17(1):863. <https://doi.org/10.1186/s12889-017-4883-6> PMID: 29110657; PubMed Central PMCID: PMC5674798.
9. De Clercq B, Abel T, Moor I, Elgar FJ, Lievens J, Sioen I, et al. Social inequality in adolescents' healthy food intake: the interplay between economic, social and cultural capital. *European journal of public health*. 2016. <https://doi.org/10.1093/eurpub/ckw236> PMID: 28040734.
10. Kritsotakis G, Chatzi L, Vassilaki M, Georgiou V, Kogevinas M, Philalithis AE, et al. Social capital, tolerance of diversity and adherence to Mediterranean diet: the Rhea Mother-Child Cohort in Crete, Greece. *Public health nutrition*. 2015; 18(7):1300–7. <https://doi.org/10.1017/S136898001400144X> PMID: 25089536.
11. Chen WL, Zhang CG, Cui ZY, Wang JY, Zhao J, Wang JW, et al. The impact of social capital on physical activity and nutrition in China: the mediating effect of health literacy. *BMC public health*. 2019; 19(1):1713. <https://doi.org/10.1186/s12889-019-8037-x> PMID: 31856789; PubMed Central PMCID: PMC6924071.
12. Hung N, Lau LL. The relationship between social capital and self-rated health: a multilevel analysis based on a poverty alleviation program in the Philippines. *BMC public health*. 2019; 19(1):1641. <https://doi.org/10.1186/s12889-019-8013-5> PMID: 31806012; PubMed Central PMCID: PMC6896750.
13. Johnson CM, Rostila M, Svensson AC, Engstrom K. The role of social capital in explaining mental health inequalities between immigrants and Swedish-born: a population-based cross-sectional study. *BMC public health*. 2017; 17(1):117. <https://doi.org/10.1186/s12889-016-3955-3> PMID: 28122593; PubMed Central PMCID: PMC5264487.
14. Kamphuis CBM, Oude Groeniger J, Poelman MP, Beenackers MA, van Lenthe FJ. How does bridging social capital relate to health-behavior, overweight and obesity among low and high educated groups? A cross-sectional analysis of GLOBE-2014. *BMC public health*. 2019; 19(1):1635. <https://doi.org/10.1186/s12889-019-8007-3> PMID: 31801497; PubMed Central PMCID: PMC6894329.
15. Carrillo-Alvarez E, Riera-Romani J, Canet-Velez O. Social influences on adolescents' dietary behavior in Catalonia, Spain: A qualitative multiple-cases study from the perspective of social capital. *Appetite*. 2018; 123:289–98. <https://doi.org/10.1016/j.appet.2018.01.008> PMID: 29317272.
16. Yang Y, Wang S, Chen L, Luo M, Xue L, Cui D, et al. Socioeconomic status, social capital, health risk behaviors, and health-related quality of life among Chinese older adults. *Health Qual Life Outcomes*. 2020; 18(1):291. Epub 2020/08/30. <https://doi.org/10.1186/s12955-020-01540-8> PMID: 32859207; PubMed Central PMCID: PMC7456043.
17. Van Horn L. Eating pattern analyses: the whole is more than the sum of its parts. *Journal of the American Dietetic Association*. 2011; 111(2):203. <https://doi.org/10.1016/j.jada.2010.12.005> PMID: 21272688.
18. Tryggvadottir EA, Medek H, Birgisdottir BE, Geirsson RT, Gunnarsdottir I. Association between healthy maternal dietary pattern and risk for gestational diabetes mellitus. *European journal of clinical nutrition*. 2016; 70(2):237–42. <https://doi.org/10.1038/ejcn.2015.145> PMID: 26350393.

19. Zhang Q, Chen X, Liu Z, Varma DS, Wan R, Wan Q, et al. Dietary Patterns in Relation to General and Central Obesity among Adults in Southwest China. *International journal of environmental research and public health*. 2016; 13(11). <https://doi.org/10.3390/ijerph13111080> PMID: 27827895; PubMed Central PMCID: PMC5129290.
20. Yu C, Shi Z, Lv J, Du H, Qi L, Guo Y, et al. Major Dietary Patterns in Relation to General and Central Obesity among Chinese Adults. *Nutrients*. 2015; 7(7):5834–49. <https://doi.org/10.3390/nu7075253> PMID: 26184308; PubMed Central PMCID: PMC4517030.
21. Zhang J, Wang H, Wang Y, Xue H, Wang Z, Du W, et al. Dietary patterns and their associations with childhood obesity in China. *The British journal of nutrition*. 2015; 113(12):1978–84. <https://doi.org/10.1017/S0007114515001154> PMID: 25944159; PubMed Central PMCID: PMC4594803.
22. 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(11):1–13. <https://doi.org/10.3390/nu9111218> PMID: 29113113; PubMed Central PMCID: PMC5707690.
23. Xu X, Byles J, Shi Z, McElduff P, Hall J. Dietary pattern transitions, and the associations with BMI, waist circumference, weight and hypertension in a 7-year follow-up among the older Chinese population: a longitudinal study. *BMC public health*. 2016; 16:743. <https://doi.org/10.1186/s12889-016-3425-y> PMID: 27502827; PubMed Central PMCID: PMC4977626.
24. Bao Y, Meng S, Sun Y, Jie S, Lu L. Healthy China Action plan empowers child and adolescent health and wellbeing. *Lancet Public Health*. 2019; 4(9):e448. Epub 2019/09/09. [https://doi.org/10.1016/S2468-2667\(19\)30164-1](https://doi.org/10.1016/S2468-2667(19)30164-1) PMID: 31493841.
25. China National Bureau of Statistics. Data of the Sixth National Population Census. 2012.
26. Han X, Zhang Q, Liu Z, Li J, Yu S, Zhao S. The prevalence and practice management of hypertension in multi-ethnic minorities in Southwest China. *Chinese Journal of Hypertension*. 2018; 26(11):1078–83.
27. Li Y, Zhao L, Yu D, Wang Z, Ding G. Metabolic syndrome prevalence and its risk factors among adults in China: A nationally representative cross-sectional study. *PLoS one*. 2018; 13(6):e0199293. Epub 2018/06/20. <https://doi.org/10.1371/journal.pone.0199293> PMID: 29920555; PubMed Central PMCID: PMC6007893.
28. Yang Y. the China Food Composition Table. Beijing: Peking University Medical Press; 2018.
29. Xiao H, Zhang Y, Kong D, Li S, Yang N. Social Capital and Sleep Quality in Individuals Who Self-Isolated for 14 Days During the Coronavirus Disease 2019 (COVID-19) Outbreak in January 2020 in China. *Med Sci Monit*. 2020; 26:e923921. Epub 2020/03/21. <https://doi.org/10.12659/MSM.923921> PMID: 32194290; PubMed Central PMCID: PMC7111105.
30. Chen X, Wang P, Wegner R, Gong J, Fang X, Kaljee L. Measuring Social Capital Investment: Scale Development and Examination of Links to Social Capital and Perceived Stress. *Social indicators research*. 2015; 120(3):669–87. Epub 2015/02/05. <https://doi.org/10.1007/s11205-014-0611-0> PMID: 25648725; PubMed Central PMCID: PMC4310564.
31. Yu C, Shi Z, Lv J, Guo Y, Bian Z, Du H, et al. Dietary Patterns and Insomnia Symptoms in Chinese Adults: The China Kadoorie Biobank. *Nutrients*. 2017; 9(3). <https://doi.org/10.3390/nu9030232> PMID: 28335373; PubMed Central PMCID: PMC5372895.
32. Sun Q, Ma JS, Wang H, Xu SH, Zhao JK, Gao Q, et al. Associations between dietary patterns and 10-year cardiovascular disease risk score levels among Chinese coal miners—a cross-sectional study. *BMC public health*. 2019; 19(1):1704. <https://doi.org/10.1186/s12889-019-8070-9> PMID: 31856787; PubMed Central PMCID: PMC6923962.
33. Hu J, Oken E, Aris IM, Lin PD, Ma Y, Ding N, et al. Dietary Patterns during Pregnancy Are Associated with the Risk of Gestational Diabetes Mellitus: Evidence from a Chinese Prospective Birth Cohort Study. *Nutrients*. 2019; 11(2). <https://doi.org/10.3390/nu11020405> PMID: 30769927; PubMed Central PMCID: PMC6412704.
34. Shi Z, Yuan B, Hu G, Dai Y, Zuo H, Holmboe-Ottesen G. Dietary pattern and weight change in a 5-year follow-up among Chinese adults: results from the Jiangsu Nutrition Study. *The British journal of nutrition*. 2011; 105(7):1047–54. <https://doi.org/10.1017/S0007114510004630> PMID: 21106132.
35. Nyaradi A, Li J, Hickling S, Foster JK, Jacques A, Ambrosini GL, et al. A Western dietary pattern is associated with poor academic performance in Australian adolescents. *Nutrients*. 2015; 7(4):2961–82. <https://doi.org/10.3390/nu7042961> PMID: 25898417; PubMed Central PMCID: PMC4425183.
36. Farasati N, Siassi F, Koohdani F, Qorbani M, Abashzadeh K, Sotoudeh G. Western dietary pattern is related to premenstrual syndrome: a case-control study. *The British journal of nutrition*. 2015; 114(12):2016–21. <https://doi.org/10.1017/S0007114515003943> PMID: 26459000.
37. He Y, Li Y, Lai J, Wang D, Zhang J, Fu P, et al. Dietary patterns as compared with physical activity in relation to metabolic syndrome among Chinese adults. *Nutrition, metabolism, and cardiovascular diseases: NMCD*. 2013; 23(10):920–8. <https://doi.org/10.1016/j.numecd.2012.09.001> PMID: 23146360.

38. Motohashi K, Kaneko Y, Fujita K, Motohashi Y, Nakamura A. Interest in dietary pattern, social capital, and psychological distress: a cross-sectional study in a rural Japanese community. *BMC public health*. 2013; 13:933. <https://doi.org/10.1186/1471-2458-13-933> PMID: 24099097; PubMed Central PMCID: PMC3851249.
39. Mieziene B, Emeljanovas A, Novak D, Kawachi I. The Relationship between Social Capital within Its Different Contexts and Adherence to a Mediterranean Diet Among Lithuanian Adolescents. *Nutrients*. 2019; 11(6). <https://doi.org/10.3390/nu11061332> PMID: 31197100; PubMed Central PMCID: PMC6627724.
40. L. B, I. K. *Social Epidemiology* (2nd). New York: Oxford University Press; 2014.
41. Motteli S, Siegrist M, Keller C. Women's social eating environment and its associations with dietary behavior and weight management. *Appetite*. 2017; 110:86–93. <https://doi.org/10.1016/j.appet.2016.12.014> PMID: 27986538.
42. Hamulka J, Wadolowska L, Hoffmann M, Kowalkowska J, Gutkowska K. Effect of an Education Program on Nutrition Knowledge, Attitudes toward Nutrition, Diet Quality, Lifestyle, and Body Composition in Polish Teenagers. The ABC of Healthy Eating Project: Design, Protocol, and Methodology. *Nutrients*. 2018; 10(10). <https://doi.org/10.3390/nu10101439> PMID: 30720795; PubMed Central PMCID: PMC6213798.
43. Vikram K. Social capital and child nutrition in India: The moderating role of development. *Health & place*. 2018; 50:42–51. Epub 2018/01/18. <https://doi.org/10.1016/j.healthplace.2017.12.007> PMID: 29339291; PubMed Central PMCID: PMC5834388.
44. Walker JL, Holben DH, Kropf ML, Holcomb JP Jr., Anderson H. Household food insecurity is inversely associated with social capital and health in females from special supplemental nutrition program for women, infants, and children households in Appalachian Ohio. *Journal of the American Dietetic Association*. 2007; 107(11):1989–93. <https://doi.org/10.1016/j.jada.2007.08.004> PMID: 17964321.
45. Chen H, Meng T. Bonding, Bridging, and Linking Social Capital and Self-Rated Health among Chinese Adults: Use of the Anchoring Vignettes Technique. *PloS one*. 2015; 10(11):e0142300. <https://doi.org/10.1371/journal.pone.0142300> PMID: 26569107; PubMed Central PMCID: PMC4646615.
46. Kim HH. Investigating the Associations between Ethnic Networks, Community Social Capital, and Physical Health among Marriage Migrants in Korea. *International journal of environmental research and public health*. 2018; 15(1). <https://doi.org/10.3390/ijerph15010147> PMID: 29342115; PubMed Central PMCID: PMC5800246.
47. Adams C. Toward an institutional perspective on social capital health interventions: lay community health workers as social capital builders. *Sociology of health & illness*. 2020; 42(1):95–110. <https://doi.org/10.1111/1467-9566.12992> PMID: 31674684.
48. Salehyar MH, Keenan L, Patterson S, Amin M. Conceptual understanding of social capital in a First Nations community: a social determinant of oral health in children. *International journal of circumpolar health*. 2015; 74(1):25417. <https://doi.org/10.3402/ijch.v74.25417> PMID: 28417804.
49. Miller LC, Neupane S, Joshi N, Lohani M, Rogers BL, Neupane S, et al. Multisectoral community development in Nepal has greater effects on child growth and diet than nutrition education alone. *Public health nutrition*. 2020; 23(1):146–61. Epub 2019/09/24. <https://doi.org/10.1017/S136898001900260X> PMID: 31544735.
50. Marlier M, Van Dyck D, Cardon G, De Bourdeaudhuij I, Babiak K, Willem A. Interrelation of Sport Participation, Physical Activity, Social Capital and Mental Health in Disadvantaged Communities: A SEM-Analysis. *PloS one*. 2015; 10(10):e0140196. <https://doi.org/10.1371/journal.pone.0140196> PMID: 26451731; PubMed Central PMCID: PMC4599734.