# Association between dietary patterns and anaemia in adults from Jiangsu Province in Eastern China

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The objective of the present study was to investigate the association between food patterns and anaemia among Chinese adults. It was a cross-sectional household survey undertaken in 2002. The sample contained 2849 men and women aged 20 years and above, and had a response rate of 89·0 %. Factor analysis was used to identify food patterns based on a food-frequency questionnaire. Logistic regression was used to relate food patterns to anaemia. A four-factor solution explained 30·5 % of the total variance. After adjusting for socio-demographic factors and four distinct food patterns, the 'traditional' (rice, vegetable, wheat flour), 'sweet tooth' (drinks, cake) and 'healthy' (whole grains, fruits, vegetables) patterns were independently associated with anaemia. 'Traditional' and 'sweet tooth' patterns were positively associated with anaemia, whereas the association with 'healthy' food pattern was negative. No association was observed between the 'macho' pattern (meat and alcohol) and anaemia. Compared with the lowest quartile (Q1) of the 'traditional' pattern, the highest quartile (Q4) had a higher risk of anaemia (men: odds ratio (OR) 2·60, 95 % CI 1·38, 4·88; women: OR 3·40, 95 % CI 2·14, 5·39). For the 'sweet tooth' pattern, compared with the lowest quartile (Q1), the OR of the highest quartile was 2·34 (95 % CI 1·47, 3·73) for men and 2·02 (95 %CI 1·31, 3·13) for women. The fourth quartile of healthy food was associated with a lower risk of anaemia (men: OR 0·50, 95 % CI 0·31, 0·79; women: OR 0·51, 95 % CI 0·34, 0·75). Women in the north had a higher risk of anaemia (OR 2·49, 95 %CI 1·80, 3·43). Food patterns were associated with anaemia in this area with a high prevalence of anaemia.

**Food pattern: Factor analysis: Anaemia: China**

Iron-deficiency anaemia is a health problem mainly affecting developing countries despite the fact that its causes are well known (ACC/SCN, 2000). The prevalence of anaemia is 15·2 % in China (Li *et al.* 2005). No appropriate preventive measure has yet been taken against this public health problem. The only measure tried has been Fe-fortified soya sauce, which was supplied on the market in some areas in China as recently as 2004 (Chen *et al.* 2005). Thus, the prevention of anaemia is still a challenge.

Several factors are found to be associated with anaemia, but the leading causes in developing countries are iron deficiency, infectious diseases and other nutritional deficiencies that influence Hb metabolism (World Health Organization, 2001). Iron-deficiency anaemia is mainly associated with the amount of Fe in the diet, chemical forms of Fe, enhancers and inhibitors of Fe bioavailability, and individual Fe status (Harvey *et al.* 2000; Heath & Fairweather-Tait, 2002; Boccio & Iyengar, 2003). Vitamin A deficiency, folate deficiency and infection are found to be associated with iron-deficiency anaemia (Semba & Bloem, 2002). The present knowledge about the link between dietary factors and risk of iron-deficiency anaemia is focused on individual nutrients or food items. In real life, people eat a variety of different foods, which give several nutrients a chance to interact. In addition, foods contain both inhibitors and enhancers of Fe bioavailability, which may interact.

There is a growing interest in the relation between dietary patterns and disease, for example cardiovascular disease, type 2 diabetes and colon cancer (Jacques & Tucker, 2001; Hu, 2002). Factor analysis, cluster analysis and the use of dietary indices are the main methods of determining dietary patterns (Hu, 2002). In recent years, several reviews on the application of factor analysis in nutritional epidemiology have been published (Togo *et al.* 2001; Kant, 2004; Newby & Tucker, 2004). Many of these published studies focus on the association between dietary pattern and cancer, diabetes and obesity. To better understand the association between diet and anaemia, it is important to describe the association between food patterns and anaemia. No study has been reported that describes this relationship by using factor analysis.

The objective of the present study is to investigate dietary patterns in relation to risk of anaemia using household survey data from Jiangsu, China.

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## Materials and methods

### Sample

In 2002, China launched a national study in nutrition and health under the approval of the Chinese Ministry of Health. A multistage cluster sampling method was used to select the participants. The data presented in this article are based on a subsample from Jiangsu province, one of the economically booming areas in China, with a population of 73·6 million. The rural sample was selected from six counties (Jiangyin, Taicang, Suining, Jurong, Sihong, Haimen). From each of the six counties, three towns were randomly selected. The urban sample was selected from two prefecture capital cities (Nanjing, Xuzhou). Three streets were randomly selected from each prefecture.

The six counties and two prefectures represented a geographically and economically diverse population with gross domestic product ranging from 3221 Yuan/capita/year (US$403) to 35 169 Yuan/capita/year (US$4396; mean US$1993, SD 1510; Jiangsu Bureau of Statistics, 2002). Nanjing, Jurong, Taicang and Jiangyin are in the South. The south has higher gross domestic product than the north (24 702 v. 7183 Yuan).

In each town/street, two villages/neighbourhoods were further randomly selected. In each village/neighbourhood, thirty households were randomly selected. All members in the households were invited to take part in the study. Written consent was obtained from all the participants. In the study presented here, we only analysed data for adults aged 20 years and above. The total sample included 1308 men and 1541 women, of whom 711 came from the urban area. The response rate was 89·0 %.

### Measurements

*Anaemia.* Hb level was measured by the cyanmethaemoglobin method (Dallman, 1984). Blood sample collection, transportation, storage and testing in standardised laboratories in each province were performed according to protocol developed by the Chinese Center for Disease Control and Prevention. All reagents and blood-sampling tools were provided by, and the quality of examination was supervised by professionals from, the Center. Anaemia was defined as a Hb level of below 13 g/dl for men and 12 g/dl for women (World Health Organization, 2001).

*Dietary data, health habits and socio-demographic information.* Participants were interviewed in their homes by trained health workers from the local Center for Disease Control and Prevention. The interviews took approximately 2 h to complete and included questions on diet, socio-demographic information, health habits such as cigarette smoking and physical activity, and other lifestyle factors. Diet over the previous year was investigated using a series of detailed questions regarding the usual frequency and quantity of intake of thirty-three foods and beverages. This was further merged into twenty-five food items in the analysis because of the low intake of some food items. Portion size for each food was established by reference to food models. Subjects were asked to recall the frequency of consumption of individual food items (number of times per day, per week, per month, per year) and the estimated portion size, using local weight units (1 liang = 50 g) or natural units (cups). Intakes of foods were converted into g/week and were used in the further analysis. Vitamin and Fe supplements were included in the questionnaire. Because these are very seldom used in the area, they were not included in the analysis.

The food-frequency questionnaire has been validated (Zhao *et al.* 2002). According to the validation study, the food-frequency questionnaire is a useful method for collecting individual food consumption information in a face-to-face interview, but is not useful in self-administered surveys owing to the current educational level of the majority in the Chinese population.

Dietary patterns were identified by factor analysis, using standard principal component analysis method (Kim & Mueller, 1978). Factors were rotated with an orthogonal (varimax) rotation to improve interpretability and minimise the correlation between the factors. The number of factors retained from each food classification method was determined by factor interpretability and the amount of variance explained by each factor. Labelling of the factors was primarily descriptive and based on our interpretation of the pattern structures.

Participants were assigned pattern-specific factor scores. Scores for each pattern were calculated as the sum of the products of the factor loading coefficient and the standardised weekly intake of each food associated with that pattern. Only foods with factor loadings of more than 0·20 and less than $-0·20$ were included in calculation of pattern scores because these items represent the foods most strongly related to the identified factor.

Socio-economic status (SES) was assessed by the question 'What was your family's income per person in 2001?' The response categories for the question were less than 800, 800–1999, 2000–4999, 5000–9999, 10 000–19 999 and more than 20 000 Yuan. SES was constructed from income, 'low' being less than 1999 Yuan, 'medium' being 2000–4999 Yuan and 'high' being more than 5000 Yuan.

### Statistical analyses

Factor scores were divided into quartiles. The scores (intakes) increased from quartile 1 (Q1) to quartile 4 (Q4). The chi-squared test was used to compare the difference between categorical variables. Logistic regression was used to determine the association between food pattern and anaemia adjusted for socio-demographic factors including residence, age, socioeconomic status, region and education. Multivariate linear regression was used to describe the associations between Hb and factor scores. All the analyses were performed using SPSS 11·0 (SPSS Inc., Chicago, IL, USA).

## Results

Table 1 shows the sample characteristics. The prevalence of anaemia was 18·3 % and 31·5 % for men and women, respectively. The south had a higher prevalence of anaemia than the north (29·0 % v. 21·5 %).

Four food patterns were obtained by factor analysis. Factor loadings (equivalent to simple correlations between the food items and the dietary patterns) for the four food patterns and the name assigned to each pattern are presented in Table 2. The 'traditional' pattern (factor 1) loaded heavily on rice

**Table 1.** Sample characteristics

| | | Male | | Female | |
|---|---|---|---|---|---|
| | | *n* | % | *n* | % |
| Total | | 1308 | 45·9 | 1541 | 54·1 |
| Age group (years) | 20–30 | 164 | 12·5 | 201 | 13·0 |
| | 31–40 | 314 | 24·0 | 399 | 25·9 |
| | 41–50 | 319 | 24·4 | 379 | 24·6 |
| | 51–60 | 255 | 19·5 | 283 | 18·4 |
| | ≥61 | 256 | 19·6 | 279 | 18·1 |
| Residence | Urban | 330 | 25·2 | 381 | 24·7 |
| | Rural | 978 | 74·8 | 1160 | 75·3 |
| Region | South | 702 | 53·7 | 802 | 52·0 |
| | North | 606 | 46·3 | 739 | 48·0 |
| Education | Primary | 471 | 36·0 | 886 | 57·5 |
| | Junior school | 569 | 43·5 | 464 | 30·1 |
| | High school | 213 | 16·3 | 166 | 10·8 |
| | University | 55 | 4·2 | 24 | 1·6 |
| Socio-economic status | Low | 419 | 32·3 | 495 | 32·4 |
| | Medium | 413 | 31·9 | 500 | 32·7 |
| | High | 464 | 35·8 | 532 | 34·8 |
| Anaemia | | 240 | 18·3 | 485 | 31·5 |

and fresh vegetable and inversely on wheat flour. Factor 2 ('macho') was characterised by various kinds of animal foods and alcohol, i.e. foods commonly eaten by men. Factor 3 ('sweet tooth') contained cake, milk, yoghurt and drinks. Factor 4 ('healthy') included whole grains, fruit, root vegetables and fresh and pickled vegetables. The four factors explained 30·5 % of the variance in intake (10·6 %, 8·6 %, 5·9 % and 5·4 % for factors 1 to 4, respectively).

Compared with the lowest quartile (Q1) of the 'traditional' pattern, the highest quartile (Q4) had a higher mean age (Table 3). For the other three food patterns, the highest quartile groups had a lower mean age. The high-SES group had the highest percentage of 'traditional', 'macho' and 'sweet tooth' food in the fourth quartile, whereas the low-SES group had the highest proportion in both the highest quartile of 'healthy' food and the lowest quartile of 'traditional' and 'sweet tooth' foods. Urban residents had a higher proportion in the

highest quartile of 'macho' and 'sweet tooth' food compared with the rural residents (39·8 % and 49·6 % *v.* 20·1 % and 16·8 %, respectively). Men had a higher intake of 'macho' food, whereas women had a higher intake of 'sweet tooth' (for both food patterns, *P*<0·01). No gender difference was observed in the 'healthy' pattern. The regional differences in food pattern were large. People from the north had a lower proportion of the 'traditional' pattern and a higher proportion of the 'healthy' pattern.

The mean intake of animal food was 59·9 g/d (data not shown). The highest animal food intake (119 g/d) was found in fourth quartile of the 'macho' pattern. In all the other groups, the mean intake of animal food was below 90 g/d. In the fourth quartile of the 'healthy' pattern, the mean intakes of fresh vegetables and fruits were 310 and 114 g/d, respectively (Table 3).

Table 4 shows the prevalence of anaemia across the quartiles of the four food factors. Factors 1 and 3 were positively associated with the prevalence of anaemia. Men from first quartile of the 'traditional' pattern had the lowest prevalence of anaemia (7·7 %), compared with 24·8 % in the fourth quartile group. The prevalence of anaemia in fourth quartile of the 'healthy' food group was half that in the first quartile, for both men and women. A trend of negative association between 'macho' food and anaemia was found among men, although it was not statistically significant. Men from the first quartile of the 'macho' food group had the highest prevalence of anaemia (23·6 %), compared with 16·9 % in the fourth quartile group. There was, however, no such association among women. The highest prevalence of anaemia (42·4 %) was found in the group of women in first quartile of the 'healthy' pattern.

Results from logistic regression show that, after adjusting for socio-demographic factors, factor 1 ('traditional'), factor 3 ('sweet tooth') and factor 4 ('healthy') were independently associated with anaemia in both genders (Table 5). Factors 1 and 3 were positively associated with anaemia. Compared with the lowest quartile (Q1) of factor 1, the highest quartile (Q4) had a higher risk of anaemia (men: odds ratio (OR) 2·60, 95 % CI 1·38, 4·88; women: OR 3·40, 95 % CI 2·14, 5·39).

**Table 2.** Factor loadings* for four food patterns among adults in Jiangsu, China (*n* 2849)

| Factor 1: 'Traditional' | | Factor 2: 'Macho' | | Factor 3: 'Sweet tooth' | | Factor 4: 'Healthy' | |
|---|---|---|---|---|---|---|---|
| Food or food group | Factor loading | Food or food group | Factor loading | Food or food group | Factor loading | Food or food group | Factor loading |
| Rice | 0·81 | Poultry | 0·56 | Cake | 0·60 | Whole grains | 0·54 |
| Fresh vegetables | 0·57 | Beer | 0·53 | Juice | 0·58 | Fruits | 0·49 |
| Pork | 0·37 | Beef, lamb | 0·46 | Beverage‡ | 0·48 | Pickled vegetables | 0·46 |
| Fish | 0·21 | Deep-fried products | 0·45 | Milk | 0·48 | Tofu | 0·44 |
| Root vegetables | −0·32 | Pork | 0·44 | Yoghurt | 0·44 | Fresh vegetables | 0·37 |
| Wheat flour† | −0·78 | Liver | 0·43 | Beef, lamb | 0·30 | Root vegetables | 0·34 |
| | | Alcohol | 0·43 | Nut | 0·26 | Milk | 0·31 |
| | | Eggs | 0·38 | Poultry | 0·25 | Eggs | 0·30 |
| | | Fish | 0·26 | Fruits | 0·23 | Fish | 0·24 |
| | | Nuts | 0·23 | Pickled vegetables | −0·20 | Wheat flour | 0·23 |
| | | Fruits | 0·22 | Alcohol | −0·27 | Milk powder | 0·22 |
| | | Tofu | 0·22 | | | Beer | −0·21 |

* Factor loadings are equivalent to a simple correlation between the food items and the factor. Higher loadings (absolute value) indicate that the food shares more variance with that factor. The sign of the loading determines the direction of the relationship of each food to the factor. Food groups with absolute values of less than 0·20 are excluded from the table for simplicity. Only one food item (cheese) is missing owing to low factor loading.

† Wheat flour includes noodles and steamed dumplings.

‡ Beverage includes soft drinks, coffee and tea.

**Table 3.** Sample characteristics for the lowest (Q1) and highest (Q4) quartiles of four food patterns among adults in Jiangsu, China (n 2849)

| | Factor 1: 'Traditional'† | | Factor 2: 'Macho'† | | Factor 3: 'Sweet tooth'† | | Factor 4: 'Healthy'† | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Q1 | Q4 | Q1 | Q4 | Q1 | Q4 | Q1 | Q4 |
| Age | | | | | | | | |
| Mean | 43·6 | 47·8 | 51·5 | 43·1 | 46·8 | 44·3 | 49·0 | 46·5 |
| SD | 0·5 | 0·5 | 0·5 | 0·5 | 0·5 | 0·5 | 0·5 | 0·5 |
| Hb | | | | | | | | |
| Mean | 14·0 | 13·2 | 13·4 | 13·4* | 13·7 | 13·3 | 13·0 | 13·8 |
| SD | 0·6 | 0·6 | 0·6 | 0·6 | 0·6 | 0·6 | 0·6 | 0·6 |
| Gender | | | | | | | | |
| Male (n 1308) | 26·0 | 29·3 | 17·2 | 35·8 | 34·8 | 22·1 | 26·3 | 24·5* |
| Female (n 1541) | 24·1 | 21·3 | 31·6 | 15·8 | 16·7 | 27·5 | 23·8 | 25·4 |
| Socio-economic status | | | | | | | | |
| Low (n 914) | 56·1 | 8·2 | 36·9 | 17·7 | 34·4 | 11·1 | 18·5 | 30·8 |
| Medium (n 913) | 16·6 | 32·1 | 23·4 | 27·3 | 27·2 | 21·3 | 25·3 | 21·5 |
| High (n 996) | 4·2 | 33·4 | 15·4 | 29·8 | 14·7 | 41·4 | 30·1 | 23·5 |
| Education | | | | | | | | |
| Primary (n 1357) | 28·0 | 24·0 | 35·1 | 15·4 | 27·1 | 14·8 | 29·0 | 21·7 |
| Junior school (n 1033) | 24·3 | 25·1 | 15·6 | 32·4 | 26·6 | 26·8 | 22·9 | 24·5 |
| High school (n 379) | 17·7 | 27·2 | 16·6 | 35·6 | 17·7 | 46·7 | 19·5 | 33·8 |
| University (n 79) | 16·5 | 31·6 | 15·2 | 43·0 | 3·8 | 70·9 | 10·1 | 44·3 |
| Residence | | | | | | | | |
| Urban (n 711) | 22·8 | 18·7 | 13·8 | 39·8 | 14·8 | 49·6 | 10·8 | 38·1 |
| Rural (n 2138) | 25·7 | 27·1 | 28·7 | 20·1 | 28·4 | 16·8 | 29·7 | 20·6 |
| Region | | | | | | | | |
| South (n 1504) | 0·8 | 39·0 | 18·6 | 26·1 | 16·4 | 32·2 | 34·6 | 19·9 |
| North (n 1345) | 52·1 | 9·3 | 32·1 | 23·7 | 34·6 | 16·9 | 14·1 | 30·8 |

| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Food intake (g/d) | | | | | | | | | | | | | | | | |
| Animal foods | 33 | 40 | 87 | 78 | 18 | 20 | 119 | 80 | 52 | 64 | 89 | 70 | 58 | 60 | 69 | 69 |
| Rice | 87 | 78 | 467 | 143 | 273 | 190 | 280* | 165 | 294 | 207 | 263 | 134 | 342 | 170 | 231 | 162 |
| Wheat flour | 377 | 176 | 22 | 34 | 156 | 205 | 144* | 173 | 220 | 233 | 84 | 118 | 64 | 129 | 213 | 214 |
| Whole grains | 16 | 31 | 4 | 18 | 12 | 33 | 8 | 14 | 15 | 31 | 10 | 25 | 1 | 3 | 24 | 38 |
| Fresh vegetables | 154 | 105 | 375 | 205 | 263 | 164 | 251* | 176 | 317 | 226 | 243 | 133 | 193 | 100 | 310 | 233 |
| Fruits | 66 | 66 | 72* | 129 | 37 | 50 | 96 | 125 | 50 | 104 | 107 | 106 | 28 | 34 | 114 | 140 |
| Milk | 4 | 26 | 26 | 83 | 26 | 90 | 16 | | 1 | 10 | 64 | 112 | 2 | 12 | 44 | 104 |

† The 'traditional' pattern includes rice and vegetables; the 'macho' pattern includes animal foods and alcohol; the 'sweet tooth' pattern includes cake, drinks, milk and yoghurt; the 'healthy' pattern includes mainly whole grains, fruits, vegetables, tofu and tubers.
‡ Adjusted for age and sex.
* $P > 0.05$.

For factor 3, compared with the lowest quartile (Q1), the OR of highest quartile was 2·34 for men and 2·02 for women. Factor 4 ('healthy') was inversely associated with anaemia. The fourth quartile of healthy food was associated with a lower risk of

**Table 4.** Unadjusted prevalence (%) of anaemia across quartiles (Q1–Q4) of four food factors in Jiangsu, China (n 2849)*

| | Q1 | Q2 | Q3 | Q4 | P |
| --- | --- | --- | --- | --- | --- |
| Men | | | | | |
| Factor 1: 'Traditional' | 7·7 | 17·7 | 22·6 | 24·8 | <0·001 |
| Factor 2: 'Macho' | 23·6 | 19·8 | 15·5 | 16·9 | 0·074 |
| Factor 3: 'Sweet tooth' | 12·6 | 21·2 | 21·5 | 21·5 | 0·002 |
| Factor 4: 'Healthy' | 28·5 | 20·1 | 11·0 | 12·5 | <0·001 |
| Women | | | | | |
| Factor 1: 'Traditional' | 18·1 | 34·5 | 38·3 | 33·8 | <0·001 |
| Factor 2: 'Macho' | 30·5 | 30·3 | 34·3 | 30·9 | 0·583 |
| Factor 3: 'Sweet tooth' | 21·5 | 26·3 | 38·9 | 34·1 | <0·001 |
| Factor 4: 'Healthy' | 42·4 | 29·7 | 30·8 | 23·5 | <0·001 |

* The 'traditional' pattern includes rice and vegetables; the 'macho' pattern includes animal foods and alcohol; the 'sweet tooth' pattern includes cake, drinks, milk and yoghurt; the 'healthy' pattern includes mainly whole grains, fruits, vegetables, tofu and tubers.

anaemia (men: OR 0·50, 95 % CI 0·31, 0·79; women: OR 0·51, 95 % CI 0·34, 0·75). No association was observed between 'macho' food and anaemia. Women from the north had a 2·49 times higher risk of being anaemic than women from the south. Use of a multivariate linear regression model including the four factors and socio-demographic factors showed similar results. The associations between Hb and the factor scores were significant except for factor 2. The regression coefficients were −2·81, −0·06, −0·80 and 2·17 for factors 1 to 4, respectively (data not shown).

## Discussion

In a cross-sectional study, we investigated the association between dietary patterns and anaemia among adults in Jiangsu, China. Of the four food patterns we obtained, the 'traditional' and 'sweet tooth' food patterns were positively associated with anaemia, whereas the 'healthy food' pattern was inversely associated with anaemia.

The present study had its strengths and limitations. It included an economically and geographically diverse population with a high prevalence of anaemia. This made it possible to study the association between food patterns

**Table 5.** Odds ratio* from multivariate logistic regression assessing associations between food factors and anaemia in Jiangsu, China (*n* 2849)

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Odds ratio | 95 % CI | *P* | Odds ratio | 95 % CI | *P* |
| **Residence** | | | | | | |
| Urban | 1 | | | 1 | | |
| Rural | 1·23 | 0·80, 1·90 | 0·345 | 1·03 | 0·75, 1·41 | 0·866 |
| **Age group (years)** | | | | | | |
| 20–30 | 1 | | | 1 | | |
| 31–40 | 1·06 | 0·54, 2·07 | 0·864 | 0·46 | 0·31, 0·68 | <0·001 |
| 41–50 | 2·11 | 1·13, 3·95 | 0·019 | 0·71 | 0·47, 1·07 | 0·106 |
| 51–60 | 2·09 | 1·09, 4·00 | 0·026 | 0·62 | 0·40, 0·98 | 0·039 |
| ≥ 61 | 3·34 | 1·71, 6·50 | <0·001 | 0·78 | 0·48, 1·24 | 0·293 |
| **Socio-economic status** | | | | | | |
| Low | 1 | | | 1 | | |
| Medium | 1·07 | 0·68, 1·67 | 0·770 | 2·08 | 1·49, 2·89 | <0·001 |
| High | 0·81 | 0·50, 1·31 | 0·393 | 1·95 | 1·35, 2·82 | <0·001 |
| **Education** | | | | | | |
| Primary | 1 | | | 1 | | |
| Junior | 0·87 | 0·60, 1·26 | 0·450 | 0·90 | 0·65, 1·23 | 0·500 |
| Senior | 0·72 | 0·42, 1·23 | 0·226 | 0·85 | 0·55, 1·30 | 0·444 |
| University | 0·53 | 0·20, 1·40 | 0·201 | 0·33 | 0·10, 1·09 | 0·068 |
| **'Traditional' pattern†** | | | | | | |
| Q1 | 1 | | | 1 | | |
| Q2 | 1·90 | 1·06, 3·38 | 0·030 | 2·27 | 1·55, 3·33 | <0·001 |
| Q3 | 1·87 | 0·99, 3·55 | 0·054 | 3·18 | 2·06, 4·90 | <0·001 |
| Q4 | 2·60 | 1·38, 4·88 | 0·003 | 3·40 | 2·14, 5·39 | <0·001 |
| **'Macho' pattern†** | | | | | | |
| Q1 | 1·00 | 0·00, 0·00 | 0·212 | 1 | | |
| Q2 | 0·83 | 0·52, 1·33 | 0·436 | 0·85 | 0·62, 1·16 | 0·296 |
| Q3 | 0·64 | 0·40, 1·04 | 0·074 | 1·10 | 0·79, 1·53 | 0·567 |
| Q4 | 0·96 | 0·60, 1·52 | 0·854 | 0·97 | 0·65, 1·44 | 0·875 |
| **'Sweet tooth' pattern†** | | | | | | |
| Q1 | 1 | | | 1 | | |
| Q2 | 1·48 | 0·95, 2·29 | 0·080 | 1·24 | 0·82, 1·87 | 0·302 |
| Q3 | 1·47 | 0·92, 2·34 | 0·105 | 2·22 | 1·45, 3·40 | <0·001 |
| Q4 | 2·34 | 1·47, 3·73 | 0·000 | 2·02 | 1·31, 3·13 | 0·002 |
| **'Healthy' pattern†** | | | | | | |
| Q1 | 1 | | | 1 | | |
| Q2 | 0·71 | 0·48, 1·05 | 0·083 | 0·57 | 0·40, 0·80 | 0·001 |
| Q3 | 0·37 | 0·23, 0·60 | <0·001 | 0·68 | 0·48, 0·97 | 0·034 |
| Q4 | 0·50 | 0·31, 0·79 | 0·004 | 0·51 | 0·34, 0·75 | 0·001 |
| **Region** | | | | | | |
| South | 1 | | | 1 | | |
| North | 0·77 | 0·49, 1·21 | 0·261 | 2·49 | 1·80, 3·43 | <0·001 |

* Odds ratio adjusted for all the variables in the table.
† Food patterns were categorised as quartiles from low (Q1) to high (Q4).

and anaemia. A validated food-frequency questionnaire was used in the study (Zhao *et al.* 2002). The limitation of the study is the potential confounders of anaemia that were not included in the study, for example infectious disease, environmental pollution and medication history. The prevalence of intestinal worm infestation is supposedly low (Xu *et al.* 2004). In China, anaemia can be caused by iron deficiency or thalassaemia, the latter being quite common in southern parts of China (Wang *et al.* 1987; Cai *et al.* 2002; Xu *et al.* 2004). Because of the limitations of the study, we do not have data on serum Fe level, which would be necessary in order to distinguish between these two causes of anaemia. In our research area, the prevalence is, however, low (Zeng & Huang, 1987).

Another limitation is the common one for factor analysis that has already been discussed (Hu, 2002; Newby & Tucker, 2004), for example that the results are strongly affected by subjective analytic but important decisions, such

as the number of factors to extract, the variance explained. As we used more than one member of each household, there could be some bias in the association between diet and anaemia owing to the common dietary habit of the household. The sizes of these families were, however, so similar (combination of (1) man and woman; (2) man or woman with one child) that we do not expect a bias, because the representation from each household is the same, namely two.

The daily intakes of cereals and vegetables are relatively high in China, on average 402 g and 276 g, respectively (Wang, 2005). The 'traditional' food pattern, characterised by a high intake of rice and vegetables, was positively associated with anaemia in our study. Men from first quartile of this pattern had the lowest prevalence of anaemia (7·7 %), compared with 24·8 % in the fourth quartile group. The same trend was observed among women. This is consistent with present knowledge. Rice and vegetable contain non-haem Fe. The bioavailability of non-haem Fe in these foods is low

(Hunt, 2002; Lopez & Martos, 2004). The fourth quartile of the 'traditional' food group was characterised by a high intake of rice (average intake 467 g/d), whereas the first quartile of the 'traditional' pattern had an intake of about 377 g/d of wheat flour. These represented two distinct staple patterns, based on either rice or wheat flour, which can be related to the regional differences between the north and south, as illustrated in Table 3. As the content of Fe in wheat flour is about twice as that in rice (Yang, 2005), this may also explain the difference in prevalence of anaemia according to the 'traditional' food pattern.

Factor 2 was characterised by a high consumption of meat and alcohol. Meat has an important role in Fe balance, not only because of its haem Fe content, but also because it enhances non-haem Fe absorption (Hallberg & Rossander, 1984; Heath & Fairweather-Tait, 2002). There was a trend of a negative, albeit not significant, association between 'macho' food and anaemia among men. Those from the first quartile of 'macho' food had the highest prevalence of anaemia (23·6 %), compared with 16·9 % in the fourth quartile group. There was, however, no such association in women. This result was inconsistent with present knowledge about the association between meat, alcohol consumption and anaemia. The lack of such an association in our study may be attributable to the moderate consumption of meat in this population (mean daily intake of animal foods 59·9 g). In the Chinese population, the average intake of animal foods and fish is only 78·6 g (Wang, 2005). It is also possible that this food pattern, which contains foods such as egg and soyabean products (tofu) will inhibit the absorption of non-haem Fe (Lopez & Martos, 2004).

The 'sweet tooth' food pattern was found to be positively associated with anaemia. The prevalence of anaemia was higher for the highest quartile of the 'sweet tooth' food pattern compared with the lowest quartile (men: 21·5 % v. 12·6 %; women: 34·1 % v. 21·5 %). This food pattern is characterised by drinks, milk and cake. This finding is consistent with present knowledge. Ca and dairy products have been reported to have an inhibitory effect on non-haem absorption (Hallberg et al. 1991; Lopez & Martos, 2004). Tea has also been found to be a strong inhibitor of Fe absorption (Zijp et al. 2000; Nelson & Poulter, 2004). Although we did not have information on tea consumption in this study, the high consumption of drinks should theoretically be correlated with tea consumption because, in the food-frequency questionnaire interview, we defined tea as one of the components of drinks.

The highest quartile of the 'healthy food' pattern contained a large amount of vegetables and fruits, meeting the WHO recommendations (World Health Organization/Food and Agriculture Organization, 2003). At the same time, it also contained moderate amount of animal foods, some milk and whole grains. The risk of anaemia for people in the highest quartile of the 'healthy' food pattern was about 50 % lower than that in people from the lowest quartile. The inverse association between the 'healthy' food pattern and anaemia may partly be explained by the fact that this pattern contained fruit. Ascorbic acid in fruit may play a role as ascorbic acid has been reported to enhance non-haem Fe absorption (Lopez & Martos, 2004). Another factor may be that those having a 'healthy' food pattern may be more conscious about their health. As the food items included are cheap, these foods

are recommended by the Chinese Nutrition Association. The 'healthy' food pattern might also be a proxy of other lifestyle factors. Studies from other countries show that healthy food patterns are associated with a healthy lifestyle (Park et al. 2005). Lifestyle factors other than diet may be involved, such as seeking out health services.

In the present study, SES was found to be associated with the four food patterns. High-SES participants had a high intake of 'traditional', 'macho' and 'sweet tooth' foods. People from low-SES categories seemed to have a more healthy food choice: a high proportion of both a high intake of the 'healthy' pattern and a low intake of the 'sweet tooth' pattern. The risk of anaemia was lower in the low-SES group than the high-SES group.

The association between SES and anaemia in multivariate analysis among women may suggest that other factors in addition to the identified food patterns play a role in the epidemic of anaemia. It might be that the high-SES women use more refined foods containing less Fe. Although women from the north consumed more from the 'healthy' pattern and less from the 'traditional' and 'sweet tooth' patterns, in multivariate analysis adjusting for food patterns, women in the north had a 2·5-foldhigher risk of being anaemic than their counterparts in the south. This could be explained by the big economic difference between the south and the north. The gross domestic product of the north is only one third that of the south. The economic disparity may imply differences in the quality of housing, other environmental factors and health services between the two regions.

As the four food patterns include foods that both inhibit and enhance Fe absorption, the interactions between food components may play different roles in Fe absorption and give rise to different effects. The present study provides an insight into how food patterns are associated with anaemia in the Chinese context, although inferences about causal relationships cannot be made. Our results support the idea that choosing the right foods is important in the prevention of anaemia. Residence is an important factor that should be taken into account in intervening with anaemia. In the study area, anaemia intervention strategies could be different between the south and the north; for example, Fe-fortified wheat flour might be relevant in the north where it is the main staple foodstuff, but not in the south, where rice is dominant. Education on promoting healthy eating is encouraged in the prevention of anaemia.

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