Dietary pattern and its' association with anemia among infants aged 6-23 months in central-south China.

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Abstract

Background: Anemia is widely prevalent among children, and this study aim to understand dietary patterns and its' association with anemia.

Methods: A cross-sectional design in two waves were conducted at Mayang in 2015 and in 2018. The diet data was collected by questionnaire, and dietary patterns were designed by using principal component analysis. Hemoglobin (Hb) was measured to assess the status of anemia. The association between the dietary patterns and anemia was assessed using the logistic regression model.

Results: Four dietary patterns were identified among infants aged 6-23 months in central-south China. Diversified pattern:mainly tubers, dairy products, bean and bean products; traditional pattern: cereals, water and soup, and other vegetables and fruits; breast milk pattern: mainly breast milk but less powered formulas; and multi-nutrient powders pattern: mainly multi-nutrient powders. The prevalence of anemia among infant reduced from 29.49% in 2015 to 20.26% in 2018. The top quartile (Q4) of diversified pattern and multi-nutrient powders pattern deminished the risk of anemia by 45% (OR = 0.55, 95% CI: 0.30 to 0.99, P = 0.047) and 59% (OR = 0.41,95% CI: 0.22 to 0.78, P = 0.006) compared to the lowest quartile (Q1), while the breast milk pattern had a 3.26-fold greater risk of anemia than the lowest quartile (Q1) (OR = 3.26,95%CI:1.83 to 5.81, P <0.001).

Conclusions: Four dietary patterns were identified among infants aged 6-23 months in central-south China. The pattern with a variety of food groups should be strengthened to improve anemia among infants.

Background

Anemia is widely prevalent among children, which has short- and long-term effects on health and development, such as increasing growth retardation, decreasing immunity and intelligence, and even having effects on children's adulthood health[1]. The study reported in 2011, 18.1% of children under five were suffering from anemia in the global [2]. In China, the prevalence of anemia was 12.6% among children under five in 2012, especially for children aged 6 to 23 months, there were 20.5–28.2% of those children suffering from anemia[3].

Infancy is the most vigorous period of children's growth and development, and the critical period of complementary feeding. The majority of studies had reported that insufficient intake of iron from diet was the most important reason of anemia in infancy[4–6]. In addition, some studies also reported that the interaction between different foods had impacted on absorption of iron, which may one of reasons for anemia. For example, the iron from plant food have a lower absorption rate because the phytic acid and oxalic acid in plant food can form insoluble combination and reduce the absorption rate of iron[1]. However, most of researchers focused on the association of individual food or nutrient with anemia among infant in previous studies[4], and neglected the potential for interactions between total dietary intake and foods or nutrients.

The dietary patterns analysis, an investigation method based on the complex source of diet and the total dietary consumption, is a popular analytical method for assessing associations between diet and their impact on health[7, 8]. The previous study from Singapore had reported that four dietary patterns labeled Predominantly breast milk, Guidelines, Easy-to-prepare foods, and Noodles and seafood were observed infant aged 6- to 12-months[9]. And other studies also shown that the dietary patterns among infants had association with weight[10], caries[11], bone mass[12], and intelligence quotient[13]. But few studies clarified the dietary patterns related to anemia of infant.

In this study, we aim to :1) identify the dietary patterns among infant aged 6–23 months in central-south China; 2) clarify the association of dietary patterns with anemia.

Methods

Study design

A cross-sectional design in two waves was conducted at maternal and child hospital of the Mayang in 2015 and in 2018. The Mayang was a minority nationality [autonomous county](#), located in Midwest of China. The county consist of 18 towns or communities and the total [birth numbers](#) were 3988 in 2018.

The population of this study consisted of caregivers with children aged 6 to 23 months, involving the five towns or communities of the Mayang. The sample size was calculated by the following formula:

$$n = \frac{u^2_{\alpha/2} \pi (1 - \pi)}{\sigma^2}$$

According to the Report of Nutrition Development for Children Aged 0-6 in China[3], the prevalence of anemia among [children](#) aged 6 to 23 months was approximately 25%. In this study, $\pi=0.25$, $\delta=5\%$, $\alpha=0.05$, $n \approx 290$. The sample size increased to 300 considering the missing of objectives.

The total of 312 and 311 children aged 6 to 23 months were recruited in 2015 and in 2018 by multistage sampling technique. For first wave, five towns or communities were firstly selected at random in Mayang according to the total number of birth last year. Secondly, five villages were randomly selected in each town or community according to the total number of birth last year. The total of 25 villages was selected. Lastly, 10 to 15 children aged 6 to 23 months were randomly selected in each village lining up to children's age. The second wave was conducted in 2018. The participants and method of sampling were consistent with the first wave. The number of birth was from maternal and child annual health report of Mayang.

Dietary data

The questionnaires asked caregivers about children's consumption in the previous 24h. Total of 15 types of foods were recorded according to guide to infant feeding and nutrition of China[14] in this study. These foods included: breast milk, powered formulas, milk powder and fresh milk, water and soup, sugar water and drink, cereals, tubers, dark leaf vegetables and fruits, other vegetables and fruits, meat, egg, dairy products, bean and bean products, nut and multi-nutrient powders. The frequency of breast milk, powered formulas, milk powder, fresh milk and multi-nutrient powders were recorded in previous 24h, and other foods were recorded as yes or no (0=no and 1=yes). This food list was similar in both wave of survey. The questionnaires of dietary data collection were implemented through interviews by trained investigators.

Dietary patterns analysis

We used principal component analysis to identify dietary patterns. To understand the dietary patterns from 2015 to 2018, we combined both data sets before running the principal component analysis. Firstly, the frequency of 15 foods were included analysis of principal component analysis. The Kaiser-Meyer-Olkin statistic was used to analyze the compliance of variables. Then the number of dietary patterns was identified based on the eigenvalue (>1) and screen plot, factor interpretability, and variance explained. The food with factor loadings of $> |0.3|$ were considered to significantly contribute to the identified factors. Lastly, the standardized scores which represent the sum of intakes of food weighted by their factor loadings were calculated for each child. The higher factor score in each pattern indicated that the participant was more related to this dietary pattern. Factor scores were categorised into four quartiles. Q1 indicates that the dietary pattern was weakly related to the dietary pattern and Q4 indicates that the dietary pattern was strongly related to the dietary pattern.

Dietary patterns assessment

World Health Organization infant and young child feeding indicators were used to assess dietary patterns[15]. Total 8 indicators was included in World Health Organization infant and young child feeding indicators. Definitions and parameters for child feeding associated with each indicator were used to disaggregate the data by the specified age groups. Children's age was in group of 6 to 23 months in our study; therefore, four evaluation indicators were used, including: minimum dietary diversity, minimum meal frequency, minimum acceptable diet, consumption iron-fortified food.

Anemia assessment

The blood sample was collected by pricking children's fingers to obtain capillary blood. Hemoglobin (Hb) was measured by [microchemical reaction](#) method. The hemoglobin concentration was detected by using

hemoglobin machine which made from Hemocue AB Company of Sweden with model hemocue 301. The result was expressed in g/dL. The cut off points for anemia were: for children aged 6 to 23 months, normal Hb levels ≥ 11.0 g/dL, anemia < 11.0 g/dL.

Other related variables

Information about infant included: sex (boy or girl), age (6-11 months, 12-17 months and 18-23 months), birth weight (normal or low birth weight), gestational age (term or premature), fever and diarrhea in the previous 2 weeks (yes or no). Information about caregivers included: caregivers' groups (parents or grandparents and others), educational level (illiteracy, primary, junior, and senior and above), occupations (homemakers or others), and ethnicity (Han and others or Miao). These information was collected by same questionnaire with dietary questionnaire.

Statistical analyses

The data are expressed as numbers and percentages for categorical variables. Significant differences were assessed by χ^2 . The association between the related factors and anemia was assessed using the logistic regression model. Firstly, the bivariate logistic regression analysis was performed to analyze the age, sex, birth weight, gestational age, episode of diarrhea or fever in the previous 2 weeks, and dietary patterns of children as well as caregivers' group, educational level, occupations, ethnicity. Then, factors with a value of $P \leq 0.10$ in bivariate analysis were included in the multivariable logistic regression model. Odds ratio (OR) with 95% confidence interval (CI) were calculated to determine the strength of associations. A value of $P < 0.05$ was considered indicative of statistical significance. All analyses were performed using Statistical Product and Service Solutions 13.

Results

The surveys in 2015 and 2018 included 312 and 311 children aged 6 to 23 months. The Table 1 shown the characteristics of infants and caregivers. Nearly 60% of infants were boys. Over 95% were normal birth weight and term. About 85% of caregivers' ethnicity were Miao. Higher proportion (37.82%) of infants aged 6 to 11 months in 2015, while higher proportion of infants (44.69%) aged 17 to 23 months in 2018. The prevalence of fever and diarrhea in previous 2 weeks in 2015 were higher than that in 2018. The proportion of parents as caregivers and the educational level of caregivers increased in 2018, but the proportion of homemakers as caregivers' occupation decreased. In addition, the prevalence of anemia was higher in 2015 (29.49%) than 2018 (20.26%).

Table 1

The characteristics of the infant aged 6 to 23 months and their caregivers in central-south China

Characteristics	Total		2015 (n = 312)		2018 (n = 311)		P
	n	%	n	%	n	%	
Infant							
Sex							
Boys	366	58.75	183	58.65	183	58.84	0.962
Girls	257	41.25	129	41.35	128	41.16	
Age							
6-11months	187	30.02	118	37.82	69	22.19	< 0.001
12-17months	195	31.30	92	29.49	103	33.12	
18-24months	241	38.68	102	32.69	139	44.69	
Birth weight							
Normal	594	95.35	299	95.83	295	94.86	0.562
Low birth weight	29	4.65	13	4.17	16	5.14	
Gestational age							
Term	597	95.83	303	97.12	294	94.53	0.105
Premature	26	4.17	9	2.88	17	5.47	
Fever in the previous 2 weeks							
No	487	78.17	208	66.67	279	89.71	< 0.001
Yes	136	21.83	104	33.33	32	10.29	
Diarrhea in the previous 2 weeks							
No	552	88.60	268	85.90	284	91.32	0.034
Yes	71	11.40	44	14.10	27	8.68	
Caregivers							
Groups							
Parents	364	58.43	170	54.49	194	62.38	0.046
Grandparents and others	259	41.57	142	45.51	117	37.62	

Characteristics	Total		2015 (n = 312)		2018 (n = 311)		P
	n	%	n	%	n	%	
Educational level							
Illiteracy	140	22.47	84	26.92	56	18.01	< 0.001
Primary	233	37.40	169	54.17	64	20.58	
Junior	199	31.94	48	15.38	151	48.55	
Senior and above	51	8.19	11	3.53	40	12.86	
Occupations							
Homemakers	535	85.87	302	96.79	233	74.92	< 0.001
Others	88	14.13	10	3.21	78	25.08	
Ethnicity							
Han and others	96	15.41	47	15.06	49	15.76	0.811
Miao	527	84.59	265	84.94	262	84.24	
Anemia							
No	468	75.12	220	70.51	248	79.74	0.009
Yes	155	24.88	92	29.49	63	20.26	

Table 2 shown that four dietary patterns were identified in infant aged 6 to 23 months accounting for 47.86% of the explained variance. The pattern 1 included various foods, which was characterized mainly by high consumption frequency of tubers, dairy products, bean and bean products, nut, dark leaf vegetables and fruits, meat and egg, named as diversified pattern. The pattern 2 was positively correlated with intake of cereals, water and soup, other vegetables and fruits, meat, multi-nutrient powders, but negatively correlated with intake of milk powder and fresh milk, namely traditional pattern. The pattern 3 was associated with high intakes of breast milk, but low intakes of powered formulas, and milk powder and fresh milk, named as breast milk pattern. The pattern 4 had high positive loadings for multi-nutrient powders, sugar water and drink, powered formulas, and negative loadings for dark leaf vegetables and fruits, and cereals, named multi-nutrient powders pattern.

Table 2

Factor loadings for dietary patterns among infants aged 6 to 23 months in central-south China

Food	Diversified pattern	Traditional pattern	Breast milk pattern	Multi-nutrient powders pattern
Breast milk			0.712	
Powered formulas			-0.687	0.312
Milk powder and fresh milk		-0.431	-0.375	
Water and soup		0.551		
Sugar water and drink				0.356
Cereals		0.567		-0.330
Tubers	0.703			
Dark leaf vegetables and fruits	0.546			-0.344
Other vegetables and fruits		0.493		
Meat	0.440	0.470		
Egg	0.369			
Dairy products	0.696			
Bean and bean Products	0.658			
Nut	0.642			
Multi-nutrient powders		0.389		0.593

The infant and young child feeding indicators of World Health Organization by four quartiles of dietary patterns was listed in Table 3. The children in the top quartile (Q4) of diversified pattern had higher rate of minimum dietary diversity ($P < 0.001$) and minimum acceptable diet ($P < 0.001$). The children in the top quartile (Q4) of traditional pattern had higher rate of minimum dietary diversity ($P < 0.001$), minimum acceptable diet ($P < 0.001$), and consumption iron-fortified food ($P < 0.001$). The children in the top quartile (Q4) of breast milk pattern had higher rate of minimum dietary diversity ($P < 0.05$), minimum meal frequency ($P < 0.05$) and minimum acceptable diet ($P < 0.05$). However, the children in the top quartile (Q4) of multi-nutrient powders pattern had lower rate of minimum dietary diversity ($P < 0.05$), minimum meal frequency ($P < 0.05$) and minimum acceptable diet ($P < 0.001$), but higher rate of consumption iron-fortified food ($P < 0.001$).

Table 3

The frequency of World Health Organization infant and young child feeding indicators in the four quartiles of dietary patterns

Total		Minimum dietary diversity		Minimum meal frequency		Minimum acceptable diet		Consumption iron-fortified food	
n		n	%	n	%	n	%	n	%
Diversified pattern									
Q1	154	2	1.30**	91	59.09	2	1.30**	107	69.48
Q2	159	81	50.94	101	63.52	56	35.22	113	71.07
Q3	158	127	80.38	97	61.39	78	49.37	115	72.78
Q4	152	149	98.03	96	63.16	94	61.84	92	60.53
Traditional pattern									
Q1	155	60	38.71**	78	50.32	32	20.65**	86	55.48**
Q2	157	80	50.96	110	70.06	56	35.67	107	68.15
Q3	159	96	60.38	107	67.30	66	41.51	114	71.70
Q4	152	123	80.92	90	59.21	76	50.00	120	78.95
Breast milk pattern									
Q1	156	68	43.59*	87	55.77*	38	24.36*	106	67.95
Q2	156	103	66.03	87	55.77	54	34.62	114	73.08
Q3	155	101	65.16	104	67.10	70	45.16	104	67.10
Q4	156	87	55.77	107	68.59	68	43.59	103	66.03
Multi-nutrient powders pattern									
Q1	156	93	59.62*	108	69.23*	68	43.59**	57	36.54**
Q2	155	103	66.45	104	67.10	71	45.81	110	70.97
Q3	164	93	56.71	95	57.93	53	32.32	131	79.88
Q4	148	70	47.30	78	52.70	38	25.68	129	87.16
*P < 0.05, **P < 0.001; <i>p</i> for trend									

The result of the association between the related factors and anemia among infants by logistic regression model was described in Table 4. The risk of anemia in 2018 was decreased 14% compared to 2015 (OR = 0.86,95%CI:0.74 to 1.00, P = 0.047).The top quartile (Q4) of diversified pattern deminished the risk of anemia by 45%(OR = 0.55,95%CI:0.30 to 0.99, P = 0.047) compared to the lowest quartile (Q1). The multi-nutrient powders pattern in the top quartile (Q4) reduced the risk of anemia by 59%(OR = 0.41,95%CI:0.22 to0.78, P = 0.006) compared to the lowest quartile (Q1). Nevertheless, The top quartile (Q4) of breast milk pattern had a 3.26-fold greater risk of anemia than the lowest quartile (Q1) (OR = 3.26,95%CI:1.83 to5.81, P < 0.001).

Table 4

The association between the related factors and anemia among infants age 6 to 23 months in central-south China.

Factors	N	n	%	COR(95%CI)	P	AOR(95%CI)	P
Year							
2015	312	92	29.49	1		1	
2018	311	63	20.26	0.85(0.75,0.96)	0.008	0.86(0.74,1.00)	0.047
Diarrhea							
No	551	131	23.77	1		1	
Yes	71	24	33.80	1.64(0.96,2.78)	0.068	1.76(1.00,3.09)	0.050
Diversified pattern							
Q1	154	49	31.82	1		1	
Q2	159	42	26.42	0.77(0.47,1.25)	0.293	0.83(0.49,1.41)	0.487
Q3	158	39	24.68	0.70(0.43,1.15)	0.162	0.98(0.57,1.70)	0.957
Q4	152	25	16.45	0.42(0.24,0.73)	0.002	0.55(0.30,0.99)	0.047
Breast milk pattern							
Q1	156	26	16.67	1		1	
Q2	156	25	16.03	0.95(0.52,1.74)	0.878	1.04(0.56,1.94)	0.900
Q3	155	42	27.10	1.86(1.07,3.22)	0.027	2.00(1.12,3.58)	0.020
Q4	156	62	39.74	3.30(1.94,5.60)	< 0.001	3.26(1.83,5.81)	< 0.001
Multi-nutrient powders pattern							
Q1	156	44	28.21	1		1	
Q2	155	44	28.39	1.01(0.62,1.65)	0.972	0.80(0.47,1.37)	0.425
Q3	164	42	25.61	0.88(0.53,1.44)	0.601	0.71(0.40,1.26)	0.245
Q4	148	25	16.89	0.52(0.30,0.90)	0.020	0.41(0.22,0.78)	0.006
*: Only factors with a value of $P \leq 0.10$ in a bivariate analysis were shown in the table. N: The total; n: number of anemia. 1: Reference category. COR: crude odds ratio; AOR :adjusted odds ratio.							

The constituent ratio among the four quartiles of dietary patterns in 2015 and 2018 was further show in Fig. 1. The results displayed that significant differences of the constituent ratio among the four quartiles for diversified pattern, breast milk pattern and multi-nutrient powders pattern were found for 2015 vs

2018. Moreover, higher proportion of children in the top quartile (Q4) for multi-nutrient powders pattern and breast milk pattern were found in 2015, while higher proportion of children in the top quartile (Q4) for diversified pattern was found in 2018.

Discussion

Our study identified four dietary patterns among infants aged 6 to 23 months in central- south China. Diversified pattern was characterized mainly by high consumption various foods. Traditional pattern was positively correlated with intake of cereals, water and soup, other vegetables and fruits, meat. Breast milk pattern was associated with high intakes of breast milk. Multi-nutrient powders pattern had high positive loadings for multi-nutrient powders. The prevalence of anemia among infant reduced from 29.49% in 2015 to 20.26% in 2018. The risk of anemia in 2018 was decreased compared to 2015. The diversified pattern and multi-nutrient powders pattern deminished the risk of anemia, while breast milk pattern increased risk of anemia.

In the present study, the diversified pattern with a variety of food groups had high consumption of tubers, dairy products, bean and bean products, nut, dark leaf vegetables and fruits, meat and egg, and had higher rate of minimum dietary diversity and minimum acceptable diet assessing by World Health Organization infant and young child feeding indicators, corresponded to the guidelines or healthy pattern by previous studies[11, 16]. The traditional pattern was characterized by high intake of cereals, water and soup, other vegetables and fruits, meat, and multi-nutrient powders, similar to the traditional Chinese adults dietary patterns [17–19]. The breast milk pattern resembles the “breastfeeding” pattern reported by Lim [9] and Smithers [20], which was characterized by higher intake of breast milk and lower intake of formula milk. Lastly, The multi-nutrient powders pattern characterized by high intakes of multi-nutrient powders, sugar water and drink, powered formulas has not been observed in other studies, and reflected a special dietary pattern in central-south China, which had association with multiple micronutrient supplementation in rural area of China. In China, multiple micronutrient supplementation called Ying Yang Bao (YYB), as a free program of government was developed in poor rural areas of China to improve children’s health since 2009 [21]. However, the multi-nutrient powders pattern had lower rate of minimum dietary diversity, minimum meal frequency and minimum acceptable diet. This result implies that the feeding practice of infants should be improved when the Yingyangbao program was implemented.

We also found the prevalence of anemia decreased from 2015 to 2018. By the logistic regression model, the results revealed the diversified pattern deminished the risk of anemia, while breast milk pattern increased the risk of anemia. The diversified pattern is to offer infants a variety of food groups. Different studies shown that dietary diversity reduced the risk of malnutrition among infant and children[22, 23], and promotion of dietary diversity as a nutrition intervention had been used by many areas [24]. The breast milk pattern with higher intake of breast milk increased risk of anemia among infants. The breast milk was the best ideal food of infant but the concentration of iron is relatively low, which cannot meet the need of rapid growth and development of children after age 6 months [25]. Besides, we found that the multi-nutrient powders pattern decreased the risk of anemia. The multi-nutrient powders pattern had high

intakes of multi-nutrient powders. The Yingyangbao program contained multi-nutrient powders had been proved to be an effective intervention in reducing anemia of children in rural areas of China [21, 26].

In addition, our study also show that children in 2015 had higher possibility of anemia than in 2018. On the one hand, children had higher proportion of diversified pattern which reduced the risk of anemia in 2018, and higher proportion of breast milk pattern which increased the risk in 2015. On the other hand, the decreasing prevalence of anemia from 2015 to 2018 may attribute to the higher proportion of children aged 18 to 24 months in 2018. Our previous study had demonstrated that the risk of anemia among children 6 to 12 months of age was higher than that of children 18 to 23 months of age[27].

A strength of this study is that we collected data from two wave of cross-sectional surveys. It clarifies four patterns and its association with anemia among infants. Limitations of our study include that the recall error with regard to questionnaire information cannot be fully eliminated in Cross-Sectional designs. Furthermore, some foods were exclude, such as oil, salt and snacks, and food intake cannot be accurately assessed in our dietary survey.

Conclusions

Four dietary patterns were identified among infants aged 6–23 months in central-south China. Diversified pattern and multi-nutrient powders pattern reduce the risk of anemia. However, the multi-nutrient powders pattern had lower rate of minimum dietary diversity, minimum meal frequency and minimum acceptable diet. The diversified pattern with a variety of food groups should be strengthened to improve anemia among infants.

Abbreviations

Hb
Hemoglobin ;
n
Number;
OR
Odds Ratio;
CI
Confidence Interval;
YYB
Ying Yang Bao.

Declarations

Ethics approval and consent to participate

The written informed consent for participation in the study was obtained from their guardian before the interview. The project was approved by Huaihua Women's Federation and Municipal Commission of Health and Family Planning.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

ZH conceived the research idea, collected the data, performed the statistical analyses and drafted the manuscript. AZ conceived the research idea and participated in data acquisition. All authors approved the final version.

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Figures

Figure 1

The constituent ratio among the four quartiles of dietary patterns, in 2015 and 2018. **: 2015 vs 2018, $P < 0.001$, compared by χ^2