Anaemia prevalence and risk factors among children aged 6 to 23 months in rural China

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ABSTRACT

Introduction: Anaemia is a global public health problem among children. However, few studies have examined anaemia prevalence and risk factors among Chinese children of different ages, particularly in poor rural areas. This study investigated these two aspects among children aged 6 to 23 months in poor rural areas of China.

Methods: This cross-sectional study included 1132 children aged 6 to 23 months in three prefectures of the Qinba Mountains area. A finger prick blood test for haemoglobin and anaemia was conducted, along with household surveys of socio-demographic characteristics, illness characteristics, and feeding practices. Multiple linear and logistic regression analyses were used to determine predictors of anaemia.

Results: Overall, 42.6% of children in the study displayed anaemia. Children aged 6 to 11 months had the highest anaemia prevalence (53.6%). Anaemia risk factors differed among age-groups and throughout the overall sample. Bivariate and multivariable regression results showed that continued breastfeeding, any history of formula feeding, and consumption of iron-rich or iron-fortified foods were associated with anaemia prevalence. However, continued breastfeeding and any history of formula feeding had the greatest impact across age-groups (both P<0.05).

Conclusion: Anaemia remains a severe public health problem among children aged 6 to 23 months in rural China. Healthy feeding practices, nutritional health knowledge, and nutrition improvement projects are needed to reduce the burden of anaemia among children in rural areas of China.

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New knowledge added by this study

- The prevalence of anaemia among rural children was higher in the Qinba Mountains area than in the central and eastern areas of China.
- Anaemia prevalence varied among age-groups, and the lowest prevalence was observed in children aged 18 to 23 months.
- Continued breastfeeding, any history of formula feeding, and consumption of iron-rich or iron-fortified foods were associated with anaemia prevalence among children in rural China.

Implications for clinical practice or policy

- The government should more closely monitor anaemia among children in rural areas and introduce relevant policies to address this issue.
- Healthy feeding practices, nutritional health knowledge, and nutrition improvement projects are needed to reduce the burden of anaemia among children in rural China.

Introduction

Anaemia is a global health issue that affects one-quarter of the world's population; it is particularly prevalent among preschool-aged children in developing countries.[1] Approximately 47.4% of preschool-aged children worldwide display anaemia.[1] There are three categories of factors associated with anaemia: inherited disorders, infectious diseases, and micronutrient deficiencies.[2,3] Among these factors, iron deficiency is the most common cause,[4] especially in China.[5] There is evidence that iron deficiency anaemia affects developmental potential in children.[6,7]

Anaemia prevalence among children in China, particularly in poor rural areas, is higher than that in developed countries.[2,3] In the United States and the Netherlands, the rate is <10%.[2] The rate in urban areas of China is <20%,[8,9] whereas the prevalence in rural areas is more than double that in urban areas.[10-12] Thus, there is a need for considerable effort from the Chinese Government to ensure that regional anaemia prevalence among children aged <5 years are below 10% by 2030.[13]

Few studies have examined factors associated with anaemia among children of different ages, particularly in poor rural areas of China. Previous studies have shown that anaemia may be associated with the demographic, social, and health characteristics of children and their families.[14-17] Feeding practices have also been associated with anaemia in children.[11,18-20] However, few studies have extensively analysed anaemia prevalence and associated factors among children of different ages in rural China.[16,21,22] For example, one study explored risk factors for anaemia in children aged 0 to 5 months and those aged 6 to 36 months; however, the age ranges were excessively broad.[14] In another study exploring risk factors for anaemia in children aged <36 months, stratified according to age, relatively few potential associated factors (eg, socio-demographic and illness characteristics) were considered; there was no consideration of other potential associated factors, such as complementary feeding.[18]

This study was therefore conducted to explore anaemia prevalence and risk factors among children aged 6 to 23 months in poor rural areas of China; analyses were performed focusing on the overall sample and with stratification according to age. Therefore, we established three objectives: to examine anaemia prevalence among children in the study area; to identify socio-demographic and illness characteristics associated with anaemia in children; and to explore feeding practices associated with anaemia in children.

Methods

Sample selection

This study was conducted in 22 nationally designated poverty-stricken counties (all of which are now out of poverty) within three prefectures in the Qinba Mountains area of northwest China. By the end of 2015 in the survey year, the total population of the sample area was 8 464 200, including a rural population of 4 716 100 (55.7%). The per capita income was 20 939 yuan, which was less than half of the national per capita income (42 359 yuan) in the same period in China.[23] Sample villages and households were selected in two stages. First, from each of the 22 counties, all townships (ie, the middle level of administration between county and village) that met the criteria were selected to participate in the study, with two exceptions: the township in each county containing the county government (which represents the level of county development), as well as townships containing <800 people. In total, 115 of 400 townships were included in this study. Second, in each sample township, we selected random villages with ≥10 children. All children in our target age range (6-23 months) were enrolled in the study, including premature but not congenitally abnormal children; thus, we included 1694 children and their households. Because one prefecture did not survey feeding practices, the corresponding analysis only included 1210 participants from the other two sample prefectures. In total, 1132 participants (children and their households) fully completed the survey (response rate of 93.6%).

Data collection

Survey data were collected in three waves in November 2015, April 2016, and February 2017. After identification of the primary caregiver responsible for a child's diet and care, well-trained enumerators collected information through one-on-one questionnaire interviews with the primary caregiver.

First, specific components of socio-demographic and illness characteristics were recorded in the survey. The socio-demographic characteristics included the child's age, sex, gestational age, and birth order; the primary caregiver's identity; maternal education and age; and whether the family received social security support (ie, government welfare for the lowest

中國農村地區6至23月齡兒童貧血患病率調查及風險因素分析

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引言：兒童貧血是全球公共衞生問題。然而，對於中國不同年齡的兒童，尤其於貧困農村地區的兒童，鮮有研究調查其貧血患病率及相關影響因素。本研究旨在瞭解中國貧困農村地區6至23月齡兒童的貧血患病率，並探討貧血風險因素。

方法：本研究基於項目團隊對秦巴山地區3個縣1132名6至23月齡兒童的橫截面調查數據。我們通過指尖採血收集兒童的血紅蛋白及貧血資訊，並基於家庭問卷對兒童的社會學人口特徵、患病狀況和餵養方式進行調查。我們採用多元線性迴歸和邏輯迴歸判斷預測兒童貧血的因素。

結果：總體而言，樣本兒童貧血率為42.6%，其中，6至11月齡組的兒童貧血患病率最高，約為53.6%。貧血風險因素在不同年齡組樣本及總體樣本中存在顯著差異。雙因素和多因素迴歸結果顯示，持續性母乳餵養、配方奶餵養以及食用含豐富鐵質或鐵強化食物與兒童貧血患病率相關。然而，相較其他因素，持續性母乳餵養和配方奶餵養在不同年齡組兒童中影響最大（兩者均為P<0.05）。

結論：中國農村地區6至23月齡的兒童貧血問題仍較為嚴峻。為改善當地兒童貧血狀況，我們建議加強健康餵養方式的指導，提升餵養人的營養知識，並開展更多營養改善項目。

income families nationwide). Illness characteristics comprised any history of fever, cold, or diarrhoea in the previous 2 weeks.

Second, detailed information regarding the child's feeding practices was collected via dietary recall, using a series of questions based on the 'Indicators for assessing infant feeding practices' compiled by the World Health Organization (WHO).[24] The following definitions were used: continued breastfeeding, proportion of children aged 6 to 23 months who had received breast milk during the previous day; any history of formula feeding, proportion of children who had ever been formula-fed; minimum dietary diversity, proportion of children aged 6 to 23 months who had consumed ≥4 of the 7 food groups under WHO's classification[24] during the previous day; minimum meal frequency, proportion of children aged 6 to 23 months who consumed a meal at a standard frequency during the previous day, considering their breastfeeding status (two times for breastfed infants aged 6 to 8 months, three times for breastfed children aged 9 to 23 months, and four times for non-breastfed children aged 6 to 23 months); minimum acceptable diet, proportion of children aged 6 to 23 months who consumed a meal that met standards for minimum dietary diversity and minimum meal frequency during the previous day; and consumption of iron-rich or iron-fortified foods, proportion of children who consumed iron-rich or iron-fortified foods specifically designed for children aged 6 to 23 months during the previous day.

Third, each child's haemoglobin (Hb) concentration and anaemia status were assessed by trained nurses from the Xi'an Jiaotong University, who performed tests on fingertip blood samples collected from all children. These analyses were performed using the HemoCue Hb201 haemoglobin analyser (HemoCue Inc, Ängelholm, Sweden), which is accurate, rapid, and convenient for children in remote rural areas.[11,15,21,25] Its measurement accuracy is 1 g/L.[18] We confirmed that the sample villages' altitudes were below 1000 m; therefore, no adjustments to measured Hb concentrations were required. Anaemia status was determined according to Hb concentration and divided into four categories: non-anaemic, Hb concentration ≥110 g/L; mild, 100-109 g/L; moderate, 70-99 g/L; and severe, <70 g/L.[26] Children with severe anaemia were referred to a local hospital for treatment.

Statistical analysis

Statistical analysis was performed using STATA version 15.0 (Stata Corporation, College Station [TX], United States). The children's socio-demographic and illness characteristics, feeding practices, and anaemia statuses were summarised using descriptive statistics. In bivariate analyses, P values for differences in mean Hb concentration between subgroups were estimated using *t* tests. The Pearson Chi squared test was also used to compare categorical variables between anaemia and non-anaemia groups. Multiple linear regression analyses were performed to identify covariates that were significantly associated with Hb concentration. Multiple logistic regression analysis was used to identify predictors of anaemia. The threshold for statistical significance was set at $P<0.05$.

Results

Socio-demographic characteristics, illness characteristics, and feeding practices

Table 1 presents the socio-demographic and illness characteristics of the 1132 children. Of these, 51.0% were boys, 5.2% were born prematurely, and more than half were first-born (54.9%). Additionally, more than half of the primary caregivers (68.9%) were the children's mothers; the remaining primary caregivers were the children's grandmothers. Less than one-quarter of the children's mothers (22.5%) had >9 years of education, and more than half of them (59.4%) were aged ≤28 years. Social security support was received by 11.9% of the participating families. Approximately half of the children (55.6%) had been sick (with fever, cold, or diarrhoea) in the previous 2 weeks.

Table 1 also presents the feeding practices of the children; notably, 29.8% and 86.6% of the children had continued breastfeeding and any history of formula feeding, respectively. With respect to complementary feeding, most children (80.9%) consumed iron-rich or iron-fortified foods; however, approximately 65.0% and 44.2% of the children met the standard requirements for minimum dietary diversity and meal frequency, respectively. Moreover, only 19.9% of the children met the standard requirement for a minimum acceptable diet. All children were divided into three age-groups: 6 to 11 months (n=343), 12 to 17 months (n=472), and 18 to 23 months (n=317).

Prevalence of haemoglobin concentration and anaemia

Table 2 presents the children's Hb concentrations and anaemia prevalence; the mean and standard deviation of their Hb concentration was 110.95 ± 0.42 g/L. Overall, 42.6% of the children had anaemia, including 21.6% with mild anaemia, 20.1% with moderate anaemia, and 0.8% with severe anaemia. A similar pattern was observed upon stratification according to age: few children had severe anaemia, and approximately one-quarter of children displayed mild or moderate anaemia in 6 to 11 months and 12 to 17 months age-groups.

TABLE 1. Detailed socio-demographic characteristics, illness characteristics, and feeding practices*

	6-11 Months (n=343)	12-17 Months (n=472)	18-23 Months (n=317)	Overall (n=1132)
Socio-demographic characteristics				
Male sex	182 (53.1%)	241 (51.1%)	154 (48.6%)	577 (51.0%)
Premature birth	12 (3.5%)	30 (6.4%)	17 (5.4%)	59 (5.2%)
First-born child	184 (53.6%)	264 (55.9%)	173 (54.6%)	621 (54.9%)
Mother is primary caregiver	276 (80.5%)	323 (68.4%)	181 (57.1%)	780 (68.9%)
Maternal education >9 years	81 (23.6%)	105 (22.2%)	69 (21.8%)	255 (22.5%)
Maternal age ≤28 years	201 (58.6%)	289 (61.2%)	182 (57.4%)	672 (59.4%)
Family received social security support	42 (12.2%)	53 (11.2%)	40 (12.6%)	135 (11.9%)
Illness characteristics				
Ever sick (fever, cold, or diarrhoea) in previous 2 weeks	168 (49.0%)	282 (59.7%)	179 (56.5%)	629 (55.6%)
Feeding practices				
Continued breastfeeding	202 (58.9%)	112 (23.7%)	23 (7.3%)	337 (29.8%)
Any history of formula feeding	270 (78.7%)	421 (89.2%)	289 (91.2%)	980 (86.6%)
Minimum dietary diversity	147 (42.9%)	327 (69.3%)	262 (82.6%)	736 (65.0%)
Minimum meal frequency	125 (36.4%)	247 (52.3%)	128 (40.4%)	500 (44.2%)
Minimum acceptable diet	40 (11.7%)	119 (25.2%)	66 (20.8%)	225 (19.9%)
Consumption of iron-rich or iron-fortified foods	229 (66.8%)	409 (86.7%)	278 (87.7%)	916 (80.9%)

* Data are shown as No. (%)

TABLE 2. Prevalence of haemoglobin concentrations and anaemia prevalence*

	6-11 Months (n=343)	12-17 Months (n=472)	18-23 Months (n=317)	Overall (n=1132)
Hb concentration, g/L	106.85 ± 0.72	111.10 ± 0.64	115.18 ± 0.78	110.95 ± 0.42
Anaemia status	184 (53.6%)	205 (43.4%)	93 (29.3%)	482 (42.6%)
Severe anaemia	6 (1.8%)	1 (0.2%)	2 (0.6%)	9 (0.8%)
Moderate anaemia	88 (25.7%)	97 (20.6%)	43 (13.6%)	228 (20.1%)
Mild anaemia	90 (26.2%)	107 (22.7%)	48 (15.1%)	245 (21.6%)

Abbreviation: Hb = haemoglobin

* Data are shown as mean ± standard deviation for continuous variables or No. (%) for categorical variables

As age increased across the groups (from 6-11 months to 12-17 months, and then to 18-23 months), the mean Hb concentration increased, whereas anaemia prevalence decreased. The mean and standard deviation Hb concentrations in the three groups (from youngest to oldest) were 106.85 ± 0.72 g/L, 111.10 ± 0.64 g/L, and 115.18 ± 0.78 g/L, respectively. Furthermore, children aged 6 to 11 months had the highest anaemia prevalence (53.6%), followed by children aged 12 to 17 months (43.4%) and then children aged 18 to 23 months (29.3%).

Bivariate analysis of socio-demographic and illness characteristics

Table 3 shows the bivariate associations of Hb concentration/anaemia prevalence with the children's socio-demographic and illness characteristics, stratified according to age. Among children aged 12 to 17 months, birth order and health status were significantly associated with Hb concentration/anaemia prevalence; however, the associations were not statistically significant in the other two age-groups or the overall sample. Among children aged 12 to 17 months, Hb concentrations were significantly higher in first-born children than in non-first-born children (P=0.020). Moreover, among children aged 12 to 17 months, children who had been sick in the previous 2 weeks were more likely to display anaemia, compared with children who had not been sick (P=0.029).

TABLE 3. Prevalence of haemoglobin concentrations and anaemia, stratified according to socio-demographic and illness characteristics*

	6-11 Months (n=343)		12-17 Months (n=472)		18-23 Months (n=317)		Overall (n=1132)	
	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia
Sex								
Female	106.60 ± 12.58	87/161 (54.0%)	112.03 ± 13.72	94/231 (40.7%)	114.68 ± 13.56	46/163 (28.2%)	111.23 ± 13.70	227/555 (40.9%)
Male	107.07 ± 13.98	97/182 (53.3%)	110.21 ± 14.08	111/241 (46.1%)	115.71 ± 14.30	47/154 (30.5%)	111.69 ± 14.47	255/577 (44.2%)
P value	0.744	0.891	0.155	0.240	0.513	0.653	0.513	0.263
Premature birth								
No	107.02 ± 13.05	177/331 (53.5%)	110.86 ± 13.74	197/442 (44.6%)	114.92 ± 13.79	89/300 (29.7%)	110.81 ± 13.87	463/1073 (43.2%)
Yes	102.17 ± 19.70	7/12 (53.3%)	114.57 ± 16.13	8/30 (26.7%)	119.76 ± 15.63	4/17 (23.5%)	113.54 ± 17.60	19/59 (32.2%)
P value	0.415	0.740	0.229	0.056	0.228	0.589	0.246	0.098
First-born child								
No	106.36 ± 12.77	87/159 (54.7%)	109.41 ± 14.31	99/208 (47.6%)	115.38 ± 14.62	41/144 (28.5%)	110.14 ± 14.35	227/511 (44.4 %)
Yes	107.27 ± 13.81	97/184 (52.7%)	112.43 ± 13.48	106/264 (40.2%)	115.02 ± 13.34	52/173 (30.1%)	111.62 ± 13.85	255/621 (41.1%)
P value	0.528	0.711	0.020	0.105	0.822	0.758	0.080	0.255
Mother is primary caregiver								
No	109.27 ± 14.68	33/67 (49.3%)	111.14 ± 13.97	58/149 (38.9%)	116.43 ± 14.36	33/136 (24.3%)	112.83 ± 14.52	124/352 (35.2%)
Yes	106.26 ± 12.93	151/276 (54.7%)	111.08 ± 13.92	147/323 (45.5%)	114.24 ± 13.53	60/181 (33.1%)	110.11 ± 13.82	358/780 (45.9%)
P value	0.128	0.422	0.965	0.180	0.171	0.086	0.003	0.001
Duration of maternal education, y								
≤9	107.09 ± 13.34	137/262 (52.3%)	110.81 ± 14.21	165/367 (45.0 %)	115.41 ± 14.05	69/248 (27.8%)	111.00 ± 14.25	371/877 (42.3%)
>9	106.09 ± 13.32	47/81 (58.0%)	112.10 ± 12.84	40/105 (38.1%)	114.36 ± 13.49	24/69 (34.8%)	110.80 ± 13.54	111/255 (43.5%)
P value	0.556	0.366	0.381	0.211	0.574	0.261	0.838	0.727
Maternal age, y								
>28	108.30 ± 12.85	70/142 (49.3%)	110.85 ± 14.51	79/183 (43.2%)	115.81 ± 13.76	39/135 (28.9%)	111.52 ± 14.08	188/460 (40.9%)
≤28	105.83 ± 13.58	114/201 (56.7%)	111.10 ± 13.92	126/289 (43.6%)	114.71 ± 14.04	54/182 (30.0%)	110.57 ± 14.09	294/672 (43.8%)
P value	0.087	0.175	0.763	0.927	0.489	0.880	0.265	0.336
Family received social security support								
No	106.89 ± 13.30	163/301 (54.2%)	110.84 ± 14.06	187/419 (44.6%)	114.94 ± 14.08	84/277 (30.3%)	110.79 ± 14.16	434/997 (43.5%)
Yes	106.60 ± 13.63	21/42 (50.0%)	113.13 ± 12.70	18/53 (34.0%)	116.85 ± 12.76	9/40 (22.5%)	112.20 ± 13.54	48/135 (35.6%)
P value	0.897	0.613	0.226	0.140	0.386	0.310	0.259	0.079
Ever sick (fever, cold, or diarrhoea) in previous 2 weeks								
No	106.07 ± 12.85	98/175 (56.0%)	111.94 ± 13.99	71/190 (37.4%)	114.45 ± 11.73	40/138 (29.0%)	110.59 ± 13.43	209/503 (41.6%)
Yes	107.66 ± 13.79	86/168 (51.2%)	110.54 ± 13.87	134/282 (47.5%)	115.74 ± 15.39	53/179 (29.6%)	111.25 ± 14.60	273/629 (43.4%)
P value	0.272	0.372	0.285	0.029	0.396	0.904	0.427	0.531

Abbreviation: Hb = haemoglobin

* Data are shown as mean ± standard deviation for continuous variables or No. (%) for categorical variables

A similar trend was observed regarding the relationship of Hb concentration/anaemia prevalence with the primary caregiver; however, the only statistically significant result was observed in the overall sample. In summary, the Hb concentration was lower (P=0.003) and anaemia prevalence was higher (P=0.001) among children whose primary caregiver was their mother, compared with children who had a different primary caregiver. Furthermore, in the overall sample and all age-groups, there were no significant binary associations between the Hb concentration/anaemia prevalence and variables such as sex, premature birth, maternal education and age, or receipt of social security support.

Bivariate analysis of feeding practice variables

Table 4 shows the bivariate associations of Hb

TABLE 4. Prevalence of haemoglobin concentrations and anaemia, stratified according to feeding practices*

	6-11 Months (n=343)		12-17 Months (n=472)		18-23 Months (n=317)		Overall (n=1132)	
	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia	Hb concentration, g/L	Anaemia
Continued breastfeeding								
No	108.47 ± 13.29	70/141 (49.7%)	112.87 ± 13.84	138/360 (38.3%)	115.25 ± 13.97	82/294 (27.9%)	112.97 ± 13.97	290/795 (36.5%)
Yes	105.72 ± 13.27	114/202 (56.4%)	111.10 ± 13.92	67/112 (59.8%)	114.30 ± 13.35	11/23 (47.8%)	106.20 ± 13.21	192/337 (57.0%)
P value	0.061	0.215	<0.001	<0.001	0.747	0.043	<0.001	<0.001
Any history of formula feeding								
No	104.11 ± 13.51	47/73 (64.4%)	104.92 ± 12.51	32/51 (62.8%)	112.21 ± 10.86	13/28 (46.4%)	105.88 ± 13.01	92/152 (60.5%)
Yes	107.59 ± 13.20	137/270 (50.7%)	111.85 ± 13.91	173/421 (41.1%)	115.47 ± 14.16	80/289 (27.7%)	111.74 ± 14.09	390/980 (39.8%)
P value	0.052	0.038	0.001	0.003	0.150	0.037	<0.001	<0.001
Minimum dietary diversity								
No	106.04 ± 13.67	105/196 (53.6%)	110.45 ± 14.09	63/145 (43.5%)	114.10 ± 15.61	19/55 (34.6%)	108.77 ± 14.38	191/396 (48.2%)
Yes	107.94 ± 12.81	75/147 (51.0%)	111.39 ± 13.85	142/327 (43.4%)	115.61 ± 13.55	74/262 (28.2%)	112.13 ± 13.80	291/736 (39.5%)
P value	0.187	0.399	0.502	0.996	0.563	0.351	<0.001	0.005
Minimum meal frequency								
No	105.86 ± 13.75	118/218 (54.1%)	109.92 ± 13.30	105/225 (46.7%)	115.15 ± 14.42	54/189 (28.6%)	110.08 ± 14.27	277/632 (43.8%)
Yes	108.58 ± 12.40	66/125 (52.8%)	112.18 ± 14.40	100/247 (40.5%)	115.23 ± 13.18	39/128 (30.5%)	112.06 ± 13.79	205/500 (41.0%)
P value	0.061	0.812	0.077	0.176	0.960	0.716	0.018	0.339
Minimum acceptable diet								
No	106.61 ± 13.53	163/303 (53.8%)	110.79 ± 14.12	156/353 (44.2%)	115.15 ± 14.29	71/251 (28.3%)	110.60 ± 14.35	390/907 (43.0%)
Yes	108.70 ± 11.60	21/40 (52.5%)	112.01 ± 13.32	49/119 (41.2%)	115.30 ± 12.45	22/66 (33.3%)	112.39 ± 12.92	92/225 (40.9%)
P value	0.298	0.877	0.398	0.566	0.930	0.423	0.070	0.567
Consumption of iron-rich or iron-fortified foods								
No	105.30 ± 14.00	65/114 (57.0%)	104.27 ± 12.06	42/63 (66.7%)	114.51 ± 10.87	12/39 (30.8%)	106.66 ± 13.40	119/216 (55.1%)
Yes	107.62 ± 12.94	119/229 (52.0%)	112.15 ± 13.90	163/409 (39.9%)	115.27 ± 14.30	81/278 (29.1%)	111.97 ± 14.07	363/916 (39.6%)
P value	0.139	0.377	<0.001	<0.001	0.697	0.834	<0.001	<0.001

Abbreviation: Hb = haemoglobin

* Data are shown as mean ± standard deviation for continuous variables or No. (%) for categorical variables

concentration/anaemia prevalence with feeding practices. The associations varied among age-groups and in the overall sample. Children with any history of formula feeding had higher Hb concentrations and lower rates of anaemia, compared with children who had never received formula (both P<0.001); these differences were statistically significant in all age-groups. Children who had continued breastfeeding displayed lower Hb concentrations and higher rates of anaemia, compared with children who had stopped breastfeeding (both P<0.001); these differences were statistically significant among children aged 12 to 17 months (both Hb concentration and anaemia prevalence) and 18 to 23 months (anaemia prevalence only).

Additionally, observable complementary food–related variables were significantly associated with Hb concentration and anaemia prevalence. In the overall sample, children with feeding practices that met the minimum requirements for dietary diversity had significantly higher Hb concentrations (P<0.001) and lower rates of anaemia (P=0.005), compared with children whose feeding practices did not meet those requirements. Children with feeding practices that met the minimum meal frequency requirements had higher Hb concentrations (P=0.018), compared with children whose feeding practices did not meet those requirements. Regarding the consumption of iron-rich or iron-fortified foods, a significant positive association with Hb concentration and a significant negative association with anaemia prevalence was observed among children aged 12 to 17 months and in the overall sample (both P<0.001).

Multivariable analysis of socio-demographic and illness characteristics, and feeding practice variables

The results of multivariable analysis of the relationship between Hb concentration and anaemia prevalence are presented in Table 5. The initial multivariable model included variables related to socio-demographic and illness characteristics, continued breastfeeding, and any history of formula feeding; the results showed that Hb concentrations were significantly higher in first-born children (P=0.031) and significantly lower in children of younger mothers (P=0.032), but no factors were significantly associated with anaemia prevalence. Any history of formula feeding was positively associated with Hb concentration (P=0.031) and negatively associated with anaemia prevalence (odds ratio [OR]=0.59, 95% confidence interval [CI]=0.41-0.86; P=0.006), whereas continued breastfeeding was significantly negatively associated with Hb concentration (P=0.001) and positively associated with anaemia prevalence (OR=1.50, 95% CI=1.07-2.11; P=0.019). A subsequent multivariable model included socio-demographic and illness characteristics, as well as complementary food–related variables; the results showed that Hb concentration remained positively associated with first-born-child status (P=0.025) and younger maternal age (P=0.032), whereas consumption of iron-rich or iron-fortified foods was negatively associated with anaemia prevalence (OR=0.66, 95% CI=0.46-0.94; P=0.021). The final multivariable model included all variables; the results showed that continued breastfeeding was positively associated with anaemia prevalence (OR=1.75, 95% CI=1.21-2.51; P=0.003), whereas any history of formula feeding was negatively associated with anaemia prevalence (OR=0.57, 95% CI=0.38-0.87; P=0.010).

Discussion

In this analysis of 1132 children aged 6 to 23 months in a poor rural area of China, we found that the anaemia prevalence was high in the overall sample, although it varied among age-groups. Bivariate analysis of socio-demographic characteristics, illness characteristics, and feeding practices revealed diverse risk factors among age-groups and in the overall sample. Additionally, multivariable analysis showed that feeding practice–related variables were risk factors for anaemia prevalence. Compared with complementary food–related variables, continued breastfeeding and any history of formula feeding had much greater impacts across age-groups.

Anaemia prevalence among children in rural China

Our findings revealed that 42.6% of children in the overall sample displayed anaemia, and anaemia prevalence among children in rural China varied according to age. According to WHO guidelines, anaemia prevalence exceeding 40% is a 'severe public health problem'.[26] Previous studies revealed anaemia prevalence among children in rural areas of central China (29.7%) and eastern China (24.2%)[21,27]; the prevalence was higher among children in our sample, indicating that urgent attention is needed regarding anaemia among children in rural areas of western China. Furthermore, our results showed that anaemia prevalence decreased with increasing age, consistent with previous reports.[8,15,17,28] We found that anaemia prevalence was lower among children aged 18 to 23 months than among those aged 6 to 11 months or 12 to 17 months; this may have been related to the successful inclusion of complementary foods after 12 months of age. There is evidence that increasing iron intake from various foods contributes to a slow decrease in anaemia prevalence.[26] Overall, our findings imply substantial differences in anaemia prevalence according to age; thus, analyses of anaemia in children, along with its risk factors, should consider the effect of age (in months).

TABLE 5. Multivariable analysis of haemoglobin concentrations and anaemia prevalence

	Model 1						Model 2						Model 3					
	Hb concentration			Anaemia			Hb concentration			Anaemia			Hb concentration			Anaemia		
	β	95% CI	P value	OR	95% CI	P value	β	95% CI	P value	OR	95% CI	P value	β	95% CI	P value	OR	95% CI	P value
Male sex	-0.30	-2.00 to 1.39	0.724	1.13	0.88-1.44	0.330	-0.34	-2.03 to 1.36	0.692	1.13	0.89-1.44	0.327	-0.29	-2.01 to 1.42	0.737	1.12	0.88-1.44	0.354
Premature birth	1.75	-2.49 to 6.00	0.414	0.71	0.40-1.24	0.229	1.93	-2.28 to 6.14	0.365	0.68	0.39-1.19	0.179	1.76	-2.47 to 5.99	0.410	0.70	0.40-1.24	0.221
First-born child	2.07	0.19-3.96	0.031	0.83	0.62-1.11	0.218	2.17	0.28-4.06	0.025	0.82	0.62-1.09	0.180	2.02	0.13-3.92	0.037	0.84	0.63-1.13	0.243
Mother is primary caregiver	-0.18	-2.23 to 1.87	0.861	1.17	0.85-1.61	0.348	-0.84	-2.84 to 1.16	0.405	1.29	0.95-1.75	0.101	-0.20	-2.24 to 1.84	0.846	1.16	0.85-1.60	0.350
Maternal education >9 years	-0.83	-2.92 to 1.25	0.429	1.16	0.84-1.62	0.367	-0.69	-2.77 to 1.38	0.508	1.12	0.80-1.57	0.497	-0.88	-2.95 to 1.18	0.397	1.17	0.84-1.63	0.355
Maternal age ≤28 years	-2.17	-4.15 to -0.20	0.032	1.29	0.97-1.72	0.084	-2.18	-4.17 to -0.19	0.032	1.29	0.97-1.71	0.078	-2.17	-4.16 to -0.17	0.034	1.29	0.96-1.72	0.091
Family received social security support	1.48	-0.86 to 3.83	0.211	0.69	0.46-1.05	0.086	1.48	-0.89 to 3.84	0.217	0.70	0.46-1.06	0.089	1.51	-0.85 to 3.86	0.208	0.69	0.46-1.05	0.085
Ever sick (fever, cold, or diarrhoea) in previous 2 weeks	0.30	-1.29 to 1.89	0.706	1.13	0.87-1.46	0.357	0.54	-1.04 to 2.12	0.499	1.09	0.85-1.40	0.510	0.39	-1.20 to 1.98	0.626	1.12	0.87-1.45	0.378
Continued breastfeeding	-3.67	-5.74 to -1.60	0.001	1.50	1.07-2.11	0.019							-3.69	-6.30 to -1.07	0.006	1.75	1.21-2.51	0.003
Any history of formula feeding	2.75	0.26-5.24	0.031	0.59	0.41-0.86	0.006							2.43	-0.54 to 5.40	0.107	0.57	0.38-0.87	0.010
Minimum dietary diversity							0.98	-1.05 to 3.01	0.341	0.92	0.68-1.24	0.576	0.75	-1.31 to 2.81	0.471	0.96	0.71-1.29	0.779
Minimum meal frequency							1.03	-1.20 to 3.26	0.362	1.00	0.69-1.44	0.986	-0.49	-2.90 to 1.92	0.688	1.29	0.87-1.91	0.200
Minimum acceptable diet							-0.57	-3.24 to 2.10	0.673	1.11	0.73-1.70	0.618	0.03	-2.70 to 2.75	0.984	1.01	0.65-1.57	0.970
Consumption of iron-rich or iron-fortified foods							2.97	0.82-5.12	0.007	0.66	0.46-0.94	0.021	0.60	-2.14 to 3.34	0.663	1.01	0.67-1.54	0.950
6-11 months	Ref																	
12-17 months	2.57	0.47-4.67	0.017	0.81	0.57-1.14	0.229	3.10	1.02-5.19	0.004	0.74	0.53-1.04	0.082	2.34	0.23-4.46	0.030	0.83	0.59-1.16	0.277
18-23 months	5.9	3.52-8.31	<0.001	0.48	0.33-0.71	<0.001	6.98	4.44-9.51	<0.001	0.42	0.29-0.62	<0.001	5.53	3.03-8.02	<0.001	0.52	0.36-0.77	0.001
Constant	107.12	103.23-111.01	<0.001	1.05	0.57-1.93	0.884	104.76	101.13-108.39	<0.001	1.14	0.68-1.89	0.622	106.83	102.30-111.36	<0.001	0.91	0.48-1.72	0.764
Observations	1132			1132			1132			1132			1132			1132		

Abbreviations: CI = confidence interval; Hb = haemoglobin; OR = odds ratio

Bivariate and multivariable analyses of risk factors of anaemia

Our bivariate analysis showed significant differences in risk factors for low Hb concentration and anaemia prevalence among children in the overall sample and in each age-group. These findings were consistent with the results of other studies regarding anaemia among children in China.[21,22] In particular, a study of children aged 6 to 23 months showed that complementary feeding practices meeting the minimum dietary diversity requirement were negatively associated with anaemia prevalence among children aged 12 to 17 months; however, the association was not statistically significant among children aged 6 to 11 months or 18 to 23 months. Additionally, complementary feeding practices meeting the minimum meal frequency requirement were negatively associated with anaemia prevalence in all age-groups.[22] Therefore, we conclude that the risk factors for anaemia prevalence in children differ according to age.

Our results also indicated that socio-demographic and illness characteristics were associated with anaemia prevalence among children in poor rural areas of China, consistent with previous findings.[11,17] Specifically, birth order and a history of illness in the previous 2 weeks were statistically significant risk factors for anaemia in children aged 12 to 17 months. Regarding health status, previous studies revealed that anaemia is positively associated with a history of recurrent illness, such as diarrhoea or fever.[11,19] We found that children who had been sick in the previous 2 weeks were more likely to display anaemia, presumably because they experienced a loss of appetite and had poor intestinal nutrient absorption.[27] The child's relationship with their primary caregiver was significantly associated with Hb concentration and anaemia prevalence in the overall sample. Previous studies showed greater dependence on breast milk among children whose primary caregiver was their mother; this dependence may lead to anaemia. Thus, the provision of adequate nutrition via complementary food is recommended.[29]

Bivariate and multivariable analyses showed that feeding practices (continued breastfeeding, any history of formula feeding, and consumption of iron-rich or iron-fortified foods) were associated with anaemia prevalence in poor rural areas of China. However, continued breastfeeding and any history of formula feeding had greater impacts on specific age-groups. Children who had continued breastfeeding displayed significantly lower Hb concentrations and higher rates of anaemia, both in the overall sample and among children aged 12 to 17 months or 18 to 23 months. These findings are consistent with the results of previous studies.[30-32] Although the importance of breastfeeding for children before the age of 2 is widely recognised, empirical studies have shown that prolonged breastfeeding (ie, beyond 6 months of age) is positively associated with anaemia in children aged <2 years.[31,32] Increases in total breastfeeding duration are associated with decreases in iron stores, implying late introduction or poor quality of complementary foods in children, as well as maternal anaemia.[31,33] Accordingly, although there remains a need to encourage breastfeeding, careful monitoring of maternal and infant anaemia should be implemented, along with timely introduction of appropriate complementary foods to infants by 6 months of age; maternal diets and nutritional supplementation should also be improved.[33] Children with any history of formula feeding had a higher Hb concentration and lower anaemia prevalence in each age-group, as well as the overall sample, consistent with previous findings.[11,19,34] Formula feeding protects against anaemia in children, presumably because most commercially available formulas are fortified with micronutrients (eg, iron).[27] Children with any history of formula feeding would have received additional iron, which have may helped to improve their anaemia status.[11] Therefore, high-iron formulas are recommended for infants aged >6 months.[35]

In the overall sample, children with feeding practices that minimum dietary diversity standards and children who consumed iron-rich or iron-fortified foods were less likely to display anaemia. These results are consistent with the findings of studies in other rural areas of China.[16,20,22] Regarding minimum dietary diversity, the WHO recommends that children aged 6 to 23 months receive a variety of foods to ensure that their nutrient requirements are met.[36] A child's needs with respect to the type and quantity of complementary foods increase with monthly age.[37] Other studies have shown that the addition of complementary food in moderate amounts protects against anaemia.[18,30] After 6 months of age, sources of iron for anaemia prevention are mainly derived from complementary foods.[19,20,22] The consumption of iron-rich foods can reduce the risk of anaemia by improving iron storage and subsequent Hb production.[19] The results of some studies have highlighted the importance of high-energy foods rich in iron, including beans, dark green leafy vegetables, meat, and viscera. These foods constitute sources of haem iron, which has better bioavailability.[18] Therefore, caregivers should receive information concerning the importance of iron-rich complementary foods before they begin introducing complementary foods to their children.[37]

However, there is evidence that many children in rural China do not meet the standards for complementary feeding recommended by the WHO.[18,22,24] Family income level substantially impacts nutritional intake.[20] Although formula and complementary foods are widely available, they may not be prioritised in poor rural households.[22] Because parents in such households often lack nutritional knowledge, they may assume that nutrient deficiency is unlikely; this belief can lead to inappropriate feeding in many children.[20] Therefore, active intervention is needed; effective communication methods should be established to provide nutritional health knowledge and social support for family nutrition.

Limitations

This study had several important limitations. First, we could not determine whether seasonal or temporal factors were associated with anaemia. Although we had some seasonal and temporal data regarding the three survey waves, key information was unavailable; thus, we could not confirm the findings of Luo et al.[11] Second, although previous studies indicated that anaemia during pregnancy is a risk factor for anaemia in children,[38,39] the present study lacked data regarding maternal anaemia during pregnancy; thus, we could not explore this relationship. Third, we only assessed any history of formula feeding, rather than ongoing formula feeding, which may have led to inaccurate results. Additional studies are needed to address these limitations.

Conclusion

Anaemia remains a severe public health problem among children aged 6 to 23 months in rural China. Continued breastfeeding was significantly positively associated with anaemia prevalence, whereas any history of formula feeding and the consumption of iron-rich or iron-fortified foods were significantly negatively associated with anaemia prevalence. Although we could not make causal inferences on the basis of findings in this cross-sectional study, our analysis provided key information concerning factors associated with anaemia prevalence among children of various ages in rural China; these findings will help to guide clinical practice and support policy formulation.

Author contributions

Concept or design: L Zeng, W Zheng, Q Gao.
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Critical revision of the manuscript for important intellectual content: Q Gao, N Qiao.

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

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Ethics approval

This study protocol was approved by the Sichuan University Institutional Review Board of China (Protocol ID: 2013005-01). All caregivers of the children under investigation provided oral informed consent before participating in this study.

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