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Anemia Prevalence and its Associated Factors in Children under 5 Years Old in Western China: A Scoping Review

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Anemia Prevalence and its Associated Factors in Children under 5 Years Old in Western China: A Scoping Review

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Key messages:

1. As the lowest economically developed regions, Western China is also special of its multi-ethnic communities, vast territory and frequent natural disasters.
2. Western China faces the critical challenge of high anemia prevalence in child, combined with low public awareness and clinical ability for treatment and control.
3. Our review highlight a 40% prevalence of anemia in child throughout the west region, which is much higher than the national average childhood anemia rate.
4. Regional contexts, individual sociodemographic characteristics and feeding behaviors, as well as nutritional program interventions play important roles in prevalence of childhood anemia in Western China.
5. More studies are needed to inform targeted preventive strategies to identify causes of the high prevalence of anemia among child in Western China.

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Anemia Prevalence and its Associated Factors in Child under 5 Years Old in Western China: A Scoping Review

Abstract

Background: Iron deficiency Anemia has been disproportionately affecting child in low- and middle-income areas; Western China is a typical example. Given the high heterogeneity of results regarding anemia-related studies, we conducted a scoping review of the evidence regarding anemia prevalence and associated factors in child under 5 years old in Western China.

Methods: We searched seven specialized databases for peer-reviewed journal articles and theses on the prevalence of anemia in child under 5 years old in Western China. This review focused on research published between Jan 1, 2011 and June 30, 2021. Two reviewers independently screened titles and abstracts, and three reviewed full texts of relevant articles for data extraction and quality assessment.

Results: Among the 59 articles included in the review, most were cross-sectional studies (42, 71.19%). The prevalence of anemia in preschool child (under 5 years old) in Western China ranged from 3.69% to 75.74% (median 39.62% [IQR 25.67-52.10]); the highest levels were in Qinghai province: 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]); the highest levels were reported in the subgroup of infants aged 6-24 months. Regional contexts, individual sociodemographic characteristics and feeding behaviors, as well as nutritional program interventions were reported as factors associated with the prevalence of anemia among preschool child in Western China.

Conclusion: The prevalence of anemia in preschool child in Western China is concerningly high. For this multi-ethnic and economically underdeveloped region, more high-quality and prospective studies are needed to inform evidence-based and targeted preventive strategies to decrease the high prevalence of anemia among child.

Key Words: Anemia, Iron-Deficiency, Preschool Child, China, Review

BACKGROUND

Child under the age of five are at a critical stage of physical and intellectual development[1]. However, anemia may disproportionately affect child at this age in low-and middle-income countries (LMICs), with potentially irreversible effects on cognitive and motor function even after iron supplementation[2-4]. Iron deficiency

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anemia (IDA) is usually the predominant cause (more than 90%) of early childhood anemia in middle income developing countries such as China[5]. Despite overall improvements in child health in China over the past 3 decades, the prevalence of anemia among child younger than 5 years in rural areas, especially in western rural areas, is still high[6 7]. According to the national survey in the China Population Nutrition and Health Status Monitoring, four of the five provinces with anemia rates of child aged 0-5 years higher than the national average are from Western China[8].

Western China includes 12 provinces, municipalities, and autonomous regions and covers about 72% of the country's total area, but only has 27.2% of the country's total population[9 10]. There are 44 ethnic minorities living in Western China with different customs and living habits. Most anemia-related studies in Western China were conducted in a specific area and the research designs were diverse. It is more than a decade ago that system reviews summarized the findings regarding childhood anemia in Western China[11 12].

Given the high heterogeneity of published studies regarding anemia in Western China, we performed a scoping review to summarize the findings regarding anemia prevalence and factors associated with anemia in child under 5 years old in Western China. A scoping review is recommended in cases where the body of literature has not yet been comprehensively reviewed, or when it has a complex or heterogeneous nature not amenable to a systematic review[13 14]..

METHODS

Overview

We conducted a systematic search to identify studies regarding the prevalence of anemia and factors associated with anemia in child under 5 years old in Western China. Our scoping review followed the methodological framework suggested by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines (PRISMA-ScR)[15].

Search strategy and selection criteria

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We searched seven online databases: PubMed, Web of Science, Medline (Ovid), Google scholar as well as CNKI, WanFang Data, and VIP (the three primary databases for biomedical research in mainland China). Scientific publications published from 1 January 2011 to 30 June 2021 were included. The search terms for articles published in English were (anemia OR anaemia OR iron deficiency anemia OR IDA OR nutritional anemia) AND (infants OR child OR preschool) AND (China OR Chinese); accordingly, the search terms for articles published in Chinese were (贫血 OR 缺铁性贫血 OR 营养性贫血) AND (婴儿 OR 婴幼儿 OR 幼儿 OR 儿童). We carefully examined reference lists of published articles to find other related publications not identified in the database search.

Publications were deemed eligible for inclusion only if the article reported the prevalence rate of anemia in child under 5 years old in Western China, which includes 12 provinces (autonomous regions and municipalities): Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang according to National Bureau of Statistics of China (Figure 1)[16]. The sample size of eligible studies needed to be greater than 50 – studies under this size were considered not having adequate statistical power for generalization[17]. We excluded clinical studies in selected samples (e.g., premature) or specific types of anemia (e.g., aplastic anemia). We included all the relevant scientific publications including original articles and all types of theses written in English or Chinese. All types of review publications which related to childhood anemia in Western China were also included to identify key themes and trends in the literature.

Publication selection

EndNote X9 was used to manage search results and delete duplicates. The literature search was done independently by two researchers (YF and FQ). As the wide range of geographic locations in Western China cannot be defined by search terms, the two researchers screened the title and abstract of the publications independently. For several articles from the same database/study population, only the article with the best quality and most relevant to the topic of this review were included (For the articles with the same data sources, the articles with high quality score were preferentially selected, the quality assessment method was described in detail in the next sub-

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section). Disagreements on whether publications met the inclusion criteria were resolved through discussion among the two researchers or, if necessary, by including a third researcher (LY) to make the final decision.

Quality assessment

The Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data[18] was used to assess methodological quality of original studies. The two researchers gave a rating from 'yes' 'no' to 'unclear' based on nine criteria items including sample frame, study participants, sample size, subjects and the setting, data analysis, identification of the condition, condition measure, statistical analysis, and response rate. Each of the item was identified by a score from 0 (unclear) to 2 (yes), and a total quality score was obtained by summing all items. The quality of the literature was evaluated independently by two researchers (LY and FQ), and if the differences $\leq$ 2 then the average is taken; otherwise, the final score was obtained after a discussion with a third researcher (YF). Total scores ranged from 0 to 18 and studies with a total score of less than 13 were excluded. For grey literature such as conference abstracts and theses, they were not applicable to these criteria, so the final decision was made by the two researchers (YF and LY) after reading the full text in details.

Role of the funding source

The funder of the study had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

RESULTS

Database search results

As shown in Figure 2, the search yielded 4815 articles (4811 from the database search, 4 from other sources), excluding 1456 duplicates. After title and abstract screening, 228 remained in the analysis, while 3135 irrelevant records were removed. 117 articles were excluded because they did not meet the inclusion criteria, another 11 articles were removed due to using the same database. After the quality assessment of the remaining 100 articles, 42 were excluded. Finally, 58 studies were eligible and included in this scoping review (including 3 Master's theses, and 55 reports of original research). There

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were no relevant reviews on anemia in child under five years of age in Western China in the last decade, as we mentioned in the introduction.

The majority of studies were cross sectional studies (n=41, 70.69%), followed by prospective cohort studies (n=6, 10.34%), surveillance studies (n=5, 8.62%), randomized controlled trials (RCTs) (n=3, 5.17%), and quasi-experiments (n=3, 5.17%). The manner of reporting data varied across the studies, and we report data in their original format, see in Appendix Table.

Regional distribution of anemia prevalence in child

Overall, the reported prevalence of childhood anemia in Western China ranged from 3.69% to 75.74% (median 39.62% [IQR 25.67-52.10]) (Table 1). The publications were from six western provinces (Gansu: n=8; Sichuan: n=8; Shaanxi: n=8; Guizhou: n=7; Yunnan: n=5; Qinghai: n=5), five western autonomous regions (Xinjiang: n=6; Tibet: n=1; Inner Mongolia: n=4; Guangxi: n=3; Ningxia: n=2), and one western municipality (Chongqing: n=2). Child in Qinghai province had the highest anemia prevalence, ranged from 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]). In addition, one study based on the child samples from the twelve westernmost regions of China found that the anemia prevalence was 49.00%[a57].

Among the publications included in this review, 30 articles reported anemia prevalence in rural areas which ranged from 3.69% to 72.75% (41.70% [27.20-48.87]) while only 8 articles reported anemia prevalence in urban areas which ranged from 2.29% to 44.00% (13.78% [8.33-23.38]). Five studies compared anemia rates between rural areas and urban areas, among which, two studies found the anemia prevalence in child was significantly higher in rural areas than those in urban areas[a2, a8]. However, two study in Xinjiang province found the opposite result in 2012-2014[a18, a31], and one study in Xinjiang province found there was no statistically difference between child in rural and urban areas in 2018[a3].

In Figure 3, we also plotted a time trend for the prevalence of childhood anemia in different provinces based on the time of each study. Overall, from 2005 to 2019, the child anemia prevalence in 8 provinces have been shown a slow downward trend although there were some upward fluctuations. Anemia prevalence levels in all 8

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provinces in 2005 were around or even above 50% and then were decreased to less than 50% in 2018, except Qinghai province.

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Table 1 Regional distribution of anemia prevalence among child under 5 years old in Western China [i] (n=51)

Western China		Total prevalence, %		Range of reported prevalence in child by regional distribution, %	
		Median (IQR)	Range	Rural [n=30]	Urban [n=8]
Province	Qinghai	67.80% (64.70-72.75)	59.10-75.74%[a24, a29, a49, a51, a54]	59.10-72.75% [a49, a54]	-
	Shaanxi	46.20% (35.12-49.31)	32.00-54.26%[a6, a17, a26, a28, a34, a39, a48, a50]	32.00-54.26% [a6, a26, a28, a34, a39, a48, a50]	-
	Guizhou	37.50% (31.24-50.63)	14.90-57.60%[a9, a11, a15, a20, a37, a44, a54]	27.20-53.67% [a11, a15, a44, a54]	-
	Yunnan	29.55% (14.58-35.20)	13.22-47.15%[a8, a21, a23, a36, a38]	34.58%[a8 iv]	2.29%[a8 iv]
	Gansu	27.20% (19.01-49.90)	3.69-74.30% [a5, a13, a32, a33, a40, a44, a53, a54 ii]	3.69-47.13% [a5, a32, a40, a44, a54]	21.44%[a13 iv]
	Sichuan	24.53% (15.65-36.82)	6.16-51.90% [a1, a2, a4, a12, a16, a44, a52, a54 ii]	7.40-51.90%[a1, a2, a12, a44, a54]	4.29-17.06%[a2, a4]
Autonomous regions	Xinjiang	45.00% (27.49-57.11)	9.81-67.30%[a3, a18, a25, a31, a44, a54]	9.91-57.79% [a3, a18, a31, a44, a54]	9.68-44.00%[a3, a18, a31]
	Inner Mongolia	37.61% (29.26-42.55)	16.60-45.00%[a19, a41, a44, a54]	16.60-45.00%[a41, a44, a54]	-
	Tibet	-	41.70%[a43 iv]	41.70%[a43 iv]	-
	Ningxia	-	26.4-44.46% [a14, a54 v]	26.4%[a14 iv]	-
	Guangxi	-	15.60-45.76%[a44, a45, a54 vi]	15.60-45.76%[a44, a45, a54]	-
Municipality	Chongqing	-	51.7-53.20% [a22, a54 v]	-	-
One research including all of the twelve provinces		-	49.00%[a57 iv]	49.00%[a57 iv]	-
In total		39.62% (25.67-52.10)	3.69-75.74%[a1-a6, a8-a26, a28-a34, a36-a45, a47-a51, a54, a56-a58]	41.70% (27.20-48.87); 3.69-72.75% [iii]	13.78% (8.33-23.38); 2.29-44.00%[a2-a4, a8, a13, a18, a30, a31]

Notes: for references see Appendix reference list.

i Anemia was defined as the WHO standard for infants aged 6–60 months (WHO, 2011)[20] and the Chinese standard for infants aged 0–5 months (the China Pediatrics Association, 2013)[37]: Hemoglobin (Hb) level is below 90 g/L for infants aged 30–119 days, below 100 g/L for infants aged 120–179 days, and below 110 g/L for infants aged 180 days (i.e., 6 months) to 60 months.

ii Affected by Wenchuan Earthquake.

iii The references as follows: a1-a3, a5, a6, a8, a10-a12, a14, a15, a18, a26, a28, a30-a32, a34, a39-a41, a43, a45, a47-a50, a54, a56, a57.

iv Reported as point estimate only, as n=1.

v Reported as range only, as n=2.

vi Reported as range only, as n=3.

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Table 2 Sociodemographic distribution of anemia prevalence among child under 5 years old in Western China

	Prevalence	
	Median (IQR)	Range
Age (months) [n=35]		
0~	11.78% (7.90-17.87)	1.70-46.10%[a10, a11, a38, a40, a44, a58]
6~	50.09% (34.35-59.04)	17.71-72.50%[a1, a5, a8, a9, a11, a14, a15, a20-a23, a26-a28, a29-a31, a33, a38, a40, a41, a44, a47, a49, a55, a56, a58]
12~	33.90% (23.56-47.29)	6.73-69.30%[a1, a2, a5, a7-a9, a12, a15, a20-a23, a27, a29-a31, a33, a35-a38, a40, a41, a44, a46, a47, a49, a55, a58]
24~	17.50% (10.95-24.55)	4.65-67.20%[a2, a7-a9, a29, a31, a35-a37, a40, a44, a46, a58]
36~	12.29% (6.25-24.07)	4.00-64.70% [a2, a7-a9, a35-a37, a40, a44, a46]
48~60	12.95% (6.93-18.60)	4.42-64.80% [a2, a7-a9, a35-a37, a40, a44, a46]
Gender [n=32]		
Boys	36.60% (25.68-47.96)	3.47-71.10%[a1-a3, a5, a6, a9, a11-a15, a21-a23, a25, a26, a28, a31-a34, a36-a40, a43-a45, a48, a55, a58]
Girls	31.38% (22.62-45.87)	3.37-62.90% [a1-a3, a5, a6, a9, a11-a15, a21-a23, a25, a26, a28, a31-a34, a36-a40, a43-a45, a48, a55, a58]
Ethnicities [n=8]		
Han	—	6.92-62.70%[a5, a9, a14, a24, a31, a38]
Hui	—	21.71-53.10%[a5, a14, a24, a31]
Tibetan	—	35.42-78.10%[a5, a24]
Miao	—	9.2-60.04%[a9, a15]
Dai	—	23.42-29.55%[a36, a38]
Others*	—	3.88-77.20%[a5, a9, a15, a24, a31, a38]

Note: Others include Dongxiang, Dong, Shui, Maonan, Tu, Uygur, Kazak, Bulang, Jinuo, Jingpo, Deang, Achang, Dulong, Nu, Pumi, Lisu, Lahu, Hani, Va, Naxi and Bai ethnicities.

Sociodemographic distribution of anemia prevalence in child

In Table 2, most studies reported the anemia rates of infants aged 6-24 months. Infants aged 6-12 months had a higher prevalence than other age groups. The prevalence of anemia in boys and girls under 5 years old was similar, which ranged from 3.47% to 71.10% for boys (36.40% [25.19-47.78]) and from 3.37% to 62.90% for girls (30.86% [22.60-45.30]). The prevalence of anemia in Tibetans was higher than those in other ethnic groups.

Associated factors with childhood anemia

A total of 27 articles were conducted on associated factors of childhood anemia, controlling for confounding factors. We broadly grouped the hot associated factors into the following seven categories with descending frequency of studies: child

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characteristics, caregivers' feeding behaviors, maternal characteristics, family characteristics, nutritional interventions, child health care, and caregivers' feeding knowledge (see Figure 4).

Child characteristics, feeding behaviors, and maternal characteristics were research highlights. Specifically, with regard to child characteristics, 17 articles reported the association between child age and anemia, and most indicated that the risk of anemia increased with age in child younger than 24 months[a5, a10, a11, a55]. Eight articles reported the influence of different ethnic background on childhood anemia. Specifically, child of Hui, Miao, Maonan, and Tibetan ethnic groups were at higher risk of anemia than Han child[a14, a15, a50], while child of Dongxiang and Mongolian ethnic groups were at lower risk of anemia than Han child[a5, a42]. With regard to feeding behaviors, 7 articles reported the effect of breastfeeding status on anemia: 2 articles reported a higher prevalence of anemia in child who were artificially fed compared to mixed breastfeeding[a5, a57], and the other 5 articles reported a higher prevalence of anemia in child who were continuous exclusively breastfed compared to mixed breastfeeding when child reached six months of age[a11, a20, a26, a28, a42]. With regard to maternal characteristics, 6 articles reported the positive effect of maternal education on reducing childhood anemia. Furthermore, 8 articles reported the effects of the Ying Yang Bao (YYB, a nutrition pack from a national nutritional intervention program)[19] supplement on anemia, including 3 randomized controlled trials, 2 cohort studies, 2 cross-sectional studies, and 1 community-based intervention trial (quasi-experiment). All the 8 articles support supplemental feeding with YYB has a significant protective effect on the prevention of anemia in child.

DISCUSSION

In this scoping review, we report a descriptive synthesis of studies that have investigated anemia in child under 5 years old in Western China. Our findings highlight a higher prevalence of anemia (around 40%) in child under five years of age throughout the west region when compared with the published national childhood anemia rate (12%) in China[8]. Although in China progress has been made regarding the prevalence of childhood anemia in recent years, childhood anemia is still a relevant public health

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challenge in Western China that deserves extensive attention and more research (WHO, 2011)[20]. Regional contexts, individual sociodemographic characteristics and feeding behaviors, as well as nutritional program interventions play important roles with regard to the prevalence of childhood anemia in Western China.

We found that childhood anemia prevalence in western regions of China is more prevalent compared to other regions in China, which is consistent with a previous study[6]. According to the National Development and Reform Commission, the division of eastern, central, and western regions of China is based on the level of economic development, policy implementation, and geographical location. Western regions is less economically developed in comparison with eastern and central regions[21]. The western regions only contribute to 20% of the National Economic GDP (Gross Domestic Product) in 2019[21]. Moreover, anemia rates varied largely across different areas within the western regions; for example, the highest reported anemia prevalence was in Qinghai province ranging from 59% to 75%, while the lowest were in Sichuan province ranging from 16% to 37%.

Subgroups of child in families characterized as belonging to a minority group showed higher anemia rates compared to subgroups of child in families characterized as belonging to the majority Han ethnic group in Western China. As a multi-ethnic area, the minority group population in the western region accounts for about 71% of the national minority population, and the geographical area in Western China that is considered to be populated by people with a minority group background accounts for about 90% of the total area in the west[22]. A number of studies on the prevalence of anemia among child from different ethnic groups in the western region have been included in this scoping review, among which relatively more studies have focused on the Hui, Tibetan, Miao, and Dai ethnic subgroups. Those studies reported that Hui, Tibetan, and Miao subgroups child had significantly higher prevalence of anemia than Han majority child[23-25]. Moreover, the western minority group areas include 319 of the 592 national poverty-stricken counties in China[26], thus have the highest poverty rate. It is known that the intergenerational transmission of poverty happens with the typical cycle of poverty-malnutrition-poverty in developing countries[27]. Therefore, we need to be alert to the high prevalence of anemia among child in western minority group areas since it can be entangled with poverty to form a mutually causal and vicious cycle.

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By summarizing the results of the studies, it was shown that the prevalence of anemia was highest in child aged 6-24 months, which is consistent with the finding from WHO[28]. The prevalence of anemia was higher in child who continued to be exclusively breastfed at this age compared to those who had timely supplementation. This might be explained by infants' changing needs of nutrition at different developmental stages. The iron reserves in the liver of full-term infants can fulfill their needs from birth to 4-6 months of age, while after 6 months of age, the nutrients in breast milk can no longer meet the child's needs for iron and other micronutrients during rapid growth and development. If caregivers do not add adequate and appropriate complementary food timely, there could be a higher prevalence of anemia in child 6-24 months of age[29].

To improve the nutrition and health status of infants and child in poor areas, and increase the spread and implementation of science-based feeding knowledge among parents of young child, in October 2012, the Chinese government launched a major Primary Health Care project - aiming to prevent malnutrition and anemia in infants and toddlers in poor areas[30-32]. The project provides free nutrition packages, called "Ying Yang Bao" (YYB), for infants and toddlers aged 6-24 months in poor areas, and promotes scientific knowledge and proper feeding skills for infants and toddlers[19]. In 2013, 187 counties in Western China were covered by the YYB project[33], and the anemia rate decreased from 32.9% in 2012 to 17.6% in 2017[34]. These results were illustrated in Figure 3 (above) regarding the included studies covering eight provinces; also, the prevalence of childhood anemia in the western region as a whole has been decreasing year by year.

To our knowledge, this is one of the few review studies in recent years that focuses specifically on anemia in child in Western China. Our study also shows the limitations of the literature in this field. First, during the database search, we identified that there were fewer relevant studies for Western China, compared to the rest of China (228 vs. 3363). Although the number of relevant studies on childhood anemia in China was not small, many of the studies were community- or hospital-based research in the eastern and central regions of China. It is also worth noting that there is a large research gap in child anemia research in different provinces or ethnic groups within the western regions. Second, there were only two randomized controlled trials (RCT) among all included

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studies (2 vs. 59). Most of included articles are cross-sectional studies, which only investigated the prevalence of anemia but did not explore the causality of anemia or propose active and effective measures. Even if there are measures, they tend to be general health education without considering targeted audience[35 36]. Third, the uneven study design and quality of studies on childhood anemia in the western region contribute to the high heterogeneity. More than 40% (41 vs. 96) of the studies that met inclusion criteria were excluded due to poor research quality. The quality evaluation scores of articles in Chinese are mostly lower than those of articles in English. Fourth, we were unable to produce pooled regional or overall prevalence estimates because of the large heterogeneity observed in research designs of the publications, therefore, only median and quartiles are reported in this review.

Conclusions

This study provides a holistic review of preschool child's anemia research in Western China. The prevalence of anemia in child in Western China is still relatively high. The studies included in this review were highly heterogeneous. For such a multi-ethnic and economically disadvantaged region, interventions need to be tailored to the local ethnic and regional characteristics. In light of our findings, more high-quality and prospective studies are urgently needed to inform targeted and evidence based preventive strategies to identify causes of the high prevalence of anemia among child in remote and poor areas such as Western China, as well as to provide timely public health service to this socially and economically disadvantaged population. International and interdisciplinary collaborations are encouraged to incorporate both local and international perspectives in multiple disciplines to produce new knowledge and provide effective practical suggestions.

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Authorship: Huan Zhou formulated the research questions and designed the study; Yefan Du, Huan Zhou, and Ruixue Ye designed the search strategy. Yefan Du, Ying Liao, and Fangqun Leng conducted the search, retrieved publications, screened full text, and assessed the quality of the articles. Yefan Du wrote the draft of the manuscript, with specific sections collaborated by Ying Liao, and Fangqun Leng. Ying Liao and Yefan Du produced all figures and tables. Huan Zhou, Yuping Mao, and Hein Raat reviewed the manuscript. All authors critically revised the manuscript and agreed to the published version of the manuscript.

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Figure legends

Figure 1 Location of the western region (red parts) in the map of China

Figure 2 Study selection profile

Note: Other resources referred to the studies scrutinized by the reference lists of published review articles, to locate additional relevant publications not identified during the database searches.

Figure 3 Time Trend of Anemia Prevalence in Eight Western Provinces (n=34)

Note: This figure used the time of each study conducted; only when the specific time of the study was not accounted for in the article, the time of publication of the article was chosen instead.

Figure 4 Frequency of studies on influencing factors of anemia in child under 5 years old in Western China (n=27).

Note:

1. The darker the color, the more research,
2. "Ying Yang Bao" is a free nutrition package provided by the Chinese government for infants and toddlers aged 6-24 months in the poor rural areas.

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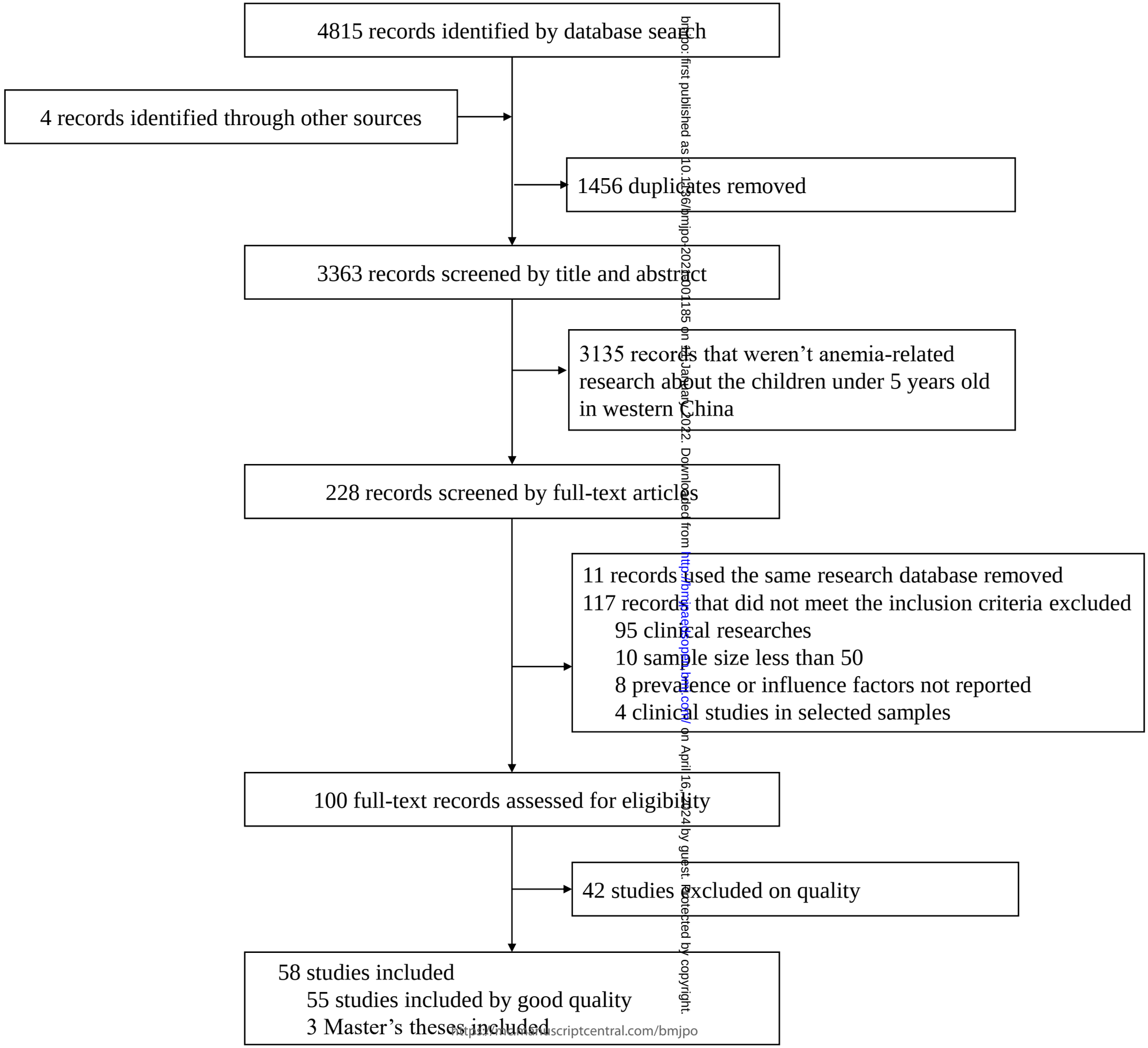

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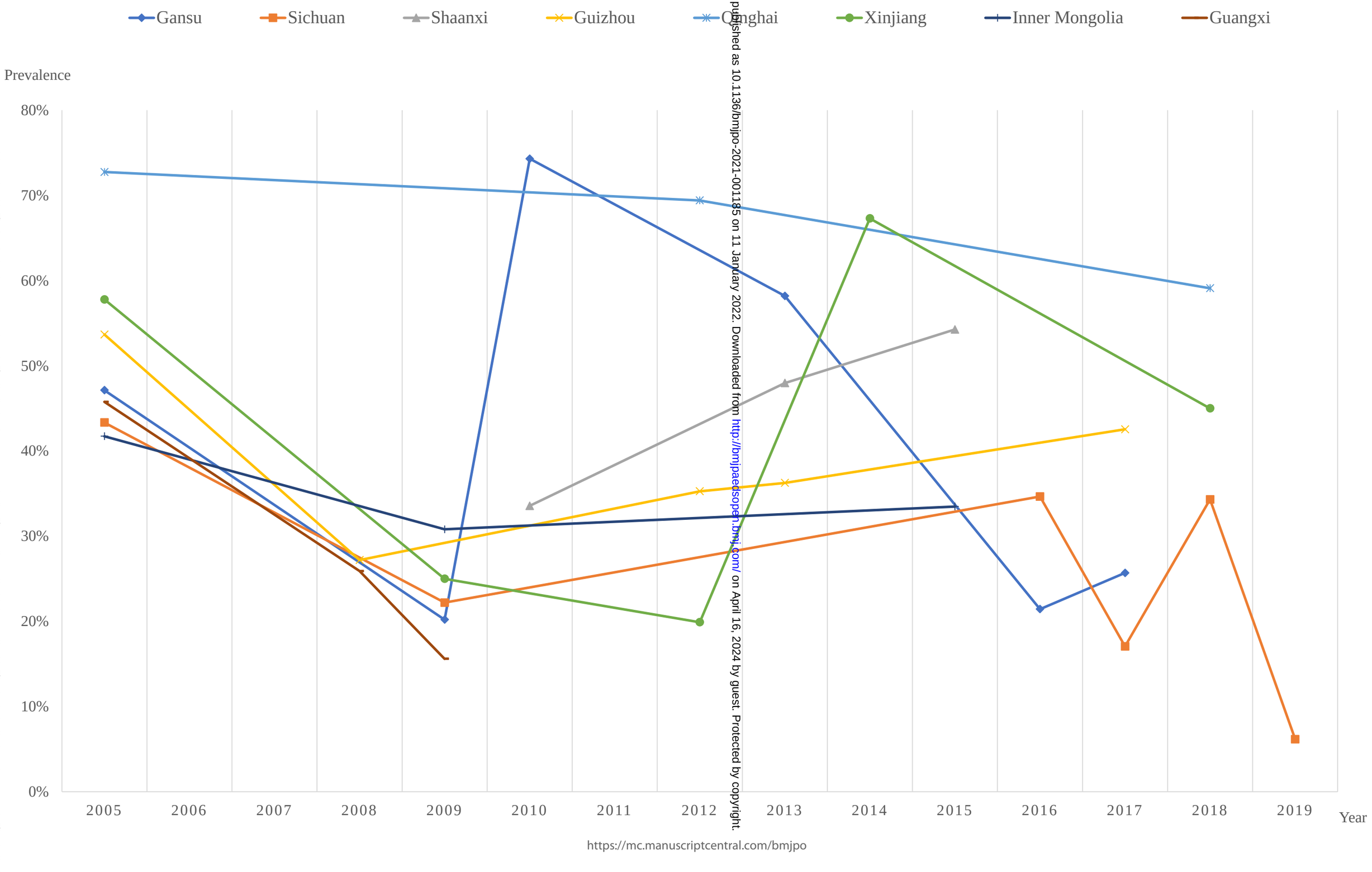

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Associated Factors	Specific items associated with childhood anemia					
Children's Characteristics	Age in months (a1, a5, a6, a9-a11, a14, a15, a20, a21, a40, a41, a49, a54, a57, a58)	Ethics group (a5, a10, a14, a15, a24, a41, a49, a54)	Sex (a21, a43, a45, a54, a57, a58)	Low birth weight (a15, a56)	Premature (a11, a45)	Illness in the past two weeks (a28)
Feeding behaviors	Breastfeeding status (a5, a11, a20, a26, a28, a41, a56)	Duration of continuous breastfeeding (a1, a9, a28, a45)	First time of introducing supplementary food (a9, a15, a28)	Supplementary food diversity (a6, a11, a15, a24, a26, a49, a58)	Frequency of supplementary food addition (a26, a41)	First bite of food after birth (a45)
Maternal Characteristics	Education (a1, a41, a43, a45, a56, a57)	Gestational anemia (a10, a15, a54, a58)	Age (a6, a43, a56)	Occupation (a15, a21)	Iron supplementation during pregnancy (a11)	
Family characteristics	Annual household income per capita (a11, a15, a21, a56, a57)	Household environment (a24)	Family size (a54, a56)	Residence area (a15, a54)	Primary caregiver role (a15)	
Nutritional interventions	Ying Yang Bao (a15, a21, a27, a32, a41, a42, a47, a53)	Vitamin and mineral supplementation (a20, a24, a28, a58)	Home use of iron pots and pans (a54)			
Children's Health Care	Medical Examination (a9, a10)	Vaccination (a10)				
Feeding knowledge	Feeding knowledge (a1, a5)					

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Appendix Table: Data extraction for anemia studies of children under five years old in Western China

Article ID (1)	Reference (2)	Language (3)	Study design (4)	Time for data collection (5)	Study setting (6)	Target age (Months) (7)	Sample size (8)	Quality score [0-18] (9)
a1	Xiao SY et al, 2021	Chinese	cross sectional study	2018.04-2018.07	Liangshan Prefecture, Sichuan Province	6-24	1244	14.5
a2	Luo M et al, 2021	Chinese	cross sectional study	2019	Chengdu, Zigong, Panzhihua, Deyang, Luzhou, Leshan, Neijiang, Yibin, Guang'an, Suining, Guangyuan, Aba, Ganzi and Liangshan Prefecture, Sichuan Province	0-59	7534	14
a3	Gao Y et al, 2020	Chinese	cross sectional study	2018.03-2018.05	Xinjiang Autonomous Region	6-24	3837	15
a4	Xu W et al, 2020	Chinese	cross sectional study	2017.05-2019.07	Mianyang Prefecture, Sichuan Province	0-36	1090	13.5
a5	Li FY et al, 2019	Chinese	cross sectional study	2017.08	Gansu Province	6-24	3188	17
a6	Nie JC et al, 2019	Chinese	cohort study	2013-2016	Shaanxi Province	4-42	4722	15
a7	Yue L et al, 2019	Chinese	cross sectional study	2018.09-2018.10	Gannan Prefecture, Gansu Province	0-60	1327	15
a8	Zhu XX et al, 2019	Chinese	surveillance	2012-2018	Yunnan Province	0-59	35225	14
a9	Zheng YY et al, 2019	Chinese	surveillance	2013.09-2013.12	Guizhou Province	6-59	853	16
a10	Sun C et al, 2019	Chinese	cross sectional study	2014.10-2014.11	Liangshan Prefecture, Sichuan Province and Gannan Prefecture, Gansu Province	2-24	1065	15
a11	Chen Y et al, 2019	Chinese	cohort study	2017.08-2018.08	Zunyi Prefecture, Guizhou Province	0-11	672	17
a12	Liu HX et al, 2019	Chinese	cross sectional study	2016.01-2018.02	Jiangyou Prefecture, Sichuan Province	0-24	1264	13
a13	Dai SJ, 2019	Chinese	cross sectional study	2016.10-2017.09	Lanzhou Prefecture, Gansu Province	0-12	555	13

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Article ID (1)	Reference (2)	Language (3)	Study design (4)	Time for data collection (5)	Study setting (6)	Target age (Months) (7)	Sample size (8)	Quality score [0-18] (9)
a14	Li XQ et al, 2018	Chinese	cross sectional study	—	Ningxia Autonomous Region	6-24	2047	15.5
a15	Yu CY et al, 2018	Chinese	cross sectional study	2017.02-2018.01	Qiannan Prefecture, Guizhou Province	6-23	19498	17
a16	Li ZC, 2018	Chinese	cross sectional study	2018.01-2018.12	Panzhihua Prefecture, Sichuan Province	0-36	1500	13.5
a17*	Shang GMJ, 2018	Chinese	cross sectional study	2013.04-2013.10	Shangluo, Ankang, Hanzhong Prefecture, Shaanxi Province	8-10	650	—
a18	Liu GM et al, 2018	Chinese	surveillance	2012-2016	Korla and Shanshan County, Xinjiang Autonomous Region	0-59	19394	13
a19	Wang XR et al, 2017	Chinese	cross sectional study	2014-2016	Keyouzhong Banner, Ulanhot, Tuquan County, Xing'an League, Inner Mongolia Autonomous Region	4-24	2700	13
a20	Zhan CX et al, 2017	Chinese	cross sectional study	2013.07-2013.09	Guizhou Province	6-23	779	14.5
a21	Chen LQ et al, 2017	Chinese	cross sectional study	2014.10-2014.11	Jianchuan, Yiliang, Mojiang and Lushui County, Yunnan Province	6-23	1226	14
a22	Jiang QJ et al, 2017	Chinese	cross sectional study	2013.07	Chongqing Municipality	6-24	706	14.5
a23	Tang YB et al, 2016	Chinese	cross sectional study	2012.12	Lanping and Heqing County, Yunnan Province	6-23	642	13.5
a24	Zhang YF et al, 2016	Chinese	cross sectional study	2012.08	Huzhu, Minhe and Guinan County, Qinghai Province	6-23	4394	13.5
a25	Eysa ZRH et al, 2016	Chinese	cross sectional study	2014.06-2015.06	Altay Prefecture, Xinjiang Autonomous Region	0-36	793	14
a26	Luo RF et al, 2016	Chinese	cross sectional study	2013.04-2013.10	Shaanxi Province	6-12	1770	16.5
a27	Jiang QJ et al, 2016	Chinese	cohort study	2013.07-2014.07	Chongqing Municipality	6-24	706	15

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Article ID (1)	Reference (2)	Language (3)	Study design (4)	Time for data collection (5)	Study setting (6)	Target age (Months) (7)	Sample size (8)	Quality score [0-18] (9)
a28	Sun L et al, 2015	Chinese	cross sectional study	—	Shaanxi Province	6-11	951	16.5
a29	Xu YY et al, 2015	Chinese	cross sectional study	2012.07	Yushu, Chenduo, Zhiduo, Nangqian, Zaduo and Qumalai County, Qinghai Province	0-35	978	13
a30	Yang MZ et al, 2014	Chinese	cross sectional study	2011.03-2011.07	Yunnan, Guizhou and Sichuan Province	6-24	3410	14.5
a31	Tang SW et al, 2014	Chinese	cross sectional study	2012.09-2012.11	Urumqi and Urumqi County, Xinjiang Autonomous Region	0-36	2138	15.5
a32	Chen R et al, 2014	Chinese	randomized controlled trial	2009-2010	Gansu Province	0-60	1218	14
a33	Dong CX et al, 2013	Chinese	cross sectional study	—	Yuzhong and Yongjing County, Gansu Province	6-23	837	14.5
a34	Yuan YY et al, 2013	Chinese	cross sectional study	—	Shaanxi Province	0-18	336	13.5
a35	Chen R et al, 2013	Chinese	surveillance	2006-2010	Qingshui, Kangle, Gulang and Longxi County, Gansu Province	0-59	4821	13
a36	Yao LQ et al, 2013	Chinese	cross sectional study	—	Xishuangbanna, Yuxi and Dehong Prefecture, Yunnan Province	0-59	2355	14.5
a37	Zhao SH et al, 2013	Chinese	cross sectional study	—	Danzhai, Huishui and Longli County, Guizhou Province	0-59	884	13
a38	Yao LQ et al, 2013	Chinese	cross sectional study	2009.06-2011.09	Yunnan Province	0-59	9850	16
a39	Sun LH et al, 2012	Chinese	cross sectional study	2010	Pucheng, Chunhua, Yuyang, Jia and Xixiang County, Shaanxi Province	3-60	1951	15
a40	Zhao WL et al, 2012	Chinese	cross sectional study	2009.08-2009.09	Longxi and Kangle County, Gansu Province	0-59	1398	16

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Article ID (1)	Reference (2)	Language (3)	Study design (4)	Time for data collection (5)	Study setting (6)	Target age (Months) (7)	Sample size (8)	Quality score [0-18] (9)
a41	Ma YY, 2012	Chinese	randomized controlled trial	2009.04-2009.08	Moridawa Banner, Oroqen Banner, Arong Banner and Zhalantun, Inner Mongolia Autonomous Region	6-24	1364	—
a42*	Zhao WL et al, 2012	Chinese	randomized controlled trial	—	Longxi and Kangle County, Gansu Province	0-59	1212	16.5
a43	Kang YY et al, 2012	Chinese	cross sectional study	2010.07-2010.08	Lhasa Prefecture, Tibet Autonomous Region	6-35	540	17
a44	Zhang JG et al, 2011	Chinese	cross sectional study	2009	Sichuan, Gansu and Guizhou Province, Inner Mongolia, Guangxi and Xinjiang Autonomous Region	0-59	8141	16.5
a45	Li ML, 2011	Chinese	cross sectional study	2008.10	Guangxi Autonomous Region	0-24	663	—
a46*	Zhao XF et al, 2011	Chinese	cross sectional study	2009.04	Pengzhou County, Sichuan Province, Kang County, Gansu Province, Ningqiang County, Shaanxi Province	0-59	466	13.5
a47	Huo JS et al, 2015	English	cohort study	2010.05-2011.11	Sichuan, Shaanxi and Gansu Provinces	6-23	4590	18
a48	Yang WF et al, 2012	English	cross sectional study	2010.03-2010.10	Shaanxi Province	0-18	336	16
a49	Huang YW et al, 2019	English	cross sectional study	2018.07	Huzhu County, Qinghai Province	6-23	754	17.5
a50	Luo RF et al, 2017	English	quasi-experiment	2013.04-2015.04	Shaanxi Province	6-11	1802	17.5
a51	Zhang YF et al, 2016	English	quasi-experiment	2012.08-2014.08	Huzhu and Guinan County in Qinghai Province	6-23	2593	16.5
a52	Yang F et al, 2015	English	cohort study	2009.06	Shifang Prefecture, Sichuan Province	0-59	2165	17
a53	Dong CX et al, 2013	English	quasi-experiment	2010.05-2011.10	Kang County, Gansu Province	6-24	1019	14.5

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Article ID (1)	Reference (2)	Language (3)	Study design (4)	Time for data collection (5)	Study setting (6)	Target age (Months) (7)	Sample size (8)	Quality score [0-18] (9)
a54	Gao WL et al, 2013	English	cross sectional study	2005.06-2005.08	Guizhou Prefecture, Gansu Province	0-35	6711	15
a55	Sun J et al, 2013	English	cross sectional study	2010.04-2010.05	Sichuan, Shaanxi and Gansu Provinces	6-23	1254	14
a56	Wang L et al, 2019	English	cohort study	2013-2017	The Qinba Mountain Area of China	6-12	1170	15.5
a57	Wang L et al, 2018	English	surveillance	2016-2017	Xinjiang, Tibet, Qinghai, Ningxia, Yunnan, Sichuan, Guangxi, Guizhou, Gansu and Shaanxi Province, Inner Mongolia Autonomous Region, and Chongqing Municipality	6-30	2380	15
a58	Wang J et al, 2015	English	cross sectional study	2010.08-2010.09	Zheng'an County, Guizhou Province, Wuding County, Yunnan Province and Zhen'an County, Shaanxi Province	12-35	1379	15

Notes: * Master's degree thesis.

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Anemia Prevalence and its Associated Factors in Children under 5 Years in Western China: A Systematic Review

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What is known about the subject?

- Iron deficiency anemia disproportionately affects infants and children in low- and middle-income areas.
- Western China, which covers 72% of China's total area and is home to 27% of the total population, is one of the least economically developed regions in the country.
- In China, 4 of the 5 provinces with the highest rates of childhood anemia are located in Western China.

What this study adds?

- In Western China, the median prevalence of anemia in children under 5 years is 40%, which is much higher than the national average.
- The highest prevalence rates (59.1% to 75.74%) were located in Qinghai province, and the highest levels were reported among children aged 6-24 months.
- Regional contexts, individual sociodemographic characteristics and feeding behaviors, and nutritional program interventions play important roles in the prevalence of childhood anemia in Western China.

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Anemia Prevalence and its Associated Factors in Children under 5 Years in Western China: A Systematic Review

Abstract

Background: Iron deficiency anemia disproportionately affects children in low- and middle-income areas; Western China is a prime example. Given the health risks associated with childhood anemia and the large heterogeneity of published studies on this subject, we conducted a systematic review of the evidence regarding anemia prevalence and associated factors in children under 5 years in Western China.

Methods: We searched for all relevant studies on the prevalence of iron deficiency anemia in children under 5 years in Western China, obtaining research between 1 January 2011 and 30 June 2021, in English and Chinese from Medline, Embase, PubMed, Web of Science, CNKI, WanFang Data, and VIP. Two reviewers independently screened titles and abstracts; three reviewed full texts of relevant articles for data extraction and performed quality assessments. The median prevalence was calculated by region overall, stratified by sex, age, and ethnic group. Associated factors and a linear trend chart were conducted to identify trends and research highlights.

Results: Among the 58 articles included, most were cross-sectional studies (41, 70.69%). The prevalence of anemia in children under 5 years in Western China ranged from 3.69% to 75.74% (median 39.62% [IQR 25.67-52.32]); the highest levels were in Qinghai province: 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]); the highest levels were reported in the subgroup of children aged 6-12 months (median 50.09% [IQR 34.35-59.04]). Regional contexts, individual sociodemographic characteristics and feeding behaviors, and nutritional program interventions were factors associated with anemia prevalence.

Conclusion: The prevalence of anemia in children under 5 years in Western China is concerningly high. For this multi-ethnic and economically underdeveloped region, more high-quality and prospective studies are needed to inform evidence based and targeted preventive strategies to decrease the high prevalence of anemia among young children.

Key Words: Anemia, Iron-Deficiency, Preschool Child, China, Review

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BACKGROUND

Children under the age of 5 years are at a critical stage of physical and intellectual development[1]. However, anemia may disproportionately affect children at this age in low-and middle-income countries (LMICs), causing potentially irreversible effects on cognitive and motor function even after iron supplementation[2-4]. Iron deficiency anemia (IDA) is usually the predominant cause (more than 90%) of early childhood anemia in middle-income and developing countries, such as China[5]. Despite overall improvements to child health made in China over the past 3 decades, the prevalence of anemia among children younger than 5 years in western rural areas is still high[6 7]. According to a national survey, 4 of the 5 provinces with childhood anemia rates higher than the national average are in Western China[8]. If future policies and research do not address the high prevalence of childhood anemia in Western China, such health inequities will continue affecting children living in this region.

Western China includes 12 provinces (including autonomous regions and municipalities), covering about 72% of the country's area; however, only 27.2% of the country's population live in Western China[9 10]. There are 44 ethnic minority groups living in Western China, all with different customs and living habits. Understanding cultural differences between ethnic groups in Western China is crucial for children's health, as public health workers must make informed decisions on prevention efforts for these subgroups. However, most anemia-related studies in Western China have either been conducted in specific areas that do not capture the complete diversity of the region, or have used varied research methodologies. Furthermore, the literature on childhood anemia in Western China is dated, as the most recent reviews on this topic were conducted more than a decade ago[11 12].

Given the health risks associated with childhood anemia and the high heterogeneity of published studies on this topic, the objective of our study is to systematically review the medical literature on the prevalence of anemia among children under 5 years in Western China. We aim to achieve two objectives: first, to understand the overall and sub-regional anemia prevalence in Western China; and second, to identify the factors associated with childhood anemia and the trend of anemia prevalence in this region.

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METHODS

This systematic review was conducted according to PRISMA guidelines[13]. The project protocol was registered with PROSPERO.

Eligibility criteria

Studies were eligible for inclusion only if they stated the prevalence of children under 5 years with IDA in Western China. "Western China" is not a specific administrative division, but the region includes 12 provinces, autonomous regions, and municipalities: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang (Figure 1)[14]. As prevalence data may be sourced from different study designs, we included all relevant cross-sectional studies, randomized controlled trials (RCTs), cohort studies, and published surveillance data. If results based on the same data were presented in more than one publication, results from only one publication were included.

We excluded clinical studies or case reports of children in specific hospitals or communities, and studies with sample sizes less than 50 participants, as the results of these studies are hardly representative of the regional prevalence of anemia. We excluded studies on children in selective samples (premature, low birthweight, birth defects) or with specific types of anemia (aplastic anemia, thalassemia, megaloblastic anemia). Studies lacking clear presentation of prevalence or diagnostic criteria were also excluded.

Search strategy

Literature search strategies were developed using medical subject headings (MeSH) and text words related to childhood anemia. The search terms for studies published in English were (anemia OR anaemia OR iron deficiency anemia OR IDA OR nutritional anemia) AND (infants OR children OR preschool) AND (China OR Chinese). The search terms for studies published in Chinese were (贫血 OR 缺铁性贫血 OR 营养性贫血) AND (婴儿 OR 婴幼儿 OR 幼儿 OR 儿童). We searched Medline (Ovid interface, 1948 onwards), Embase, PubMed, Web of Science, CNKI, WanFang Data, and VIP. The literature search was limited to studies written in

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English and Chinese languages, published from 1 January 2011 to 30 June 2021. We carefully examined reference lists of published articles to find other related publications not identified in the database search.

Selection process

EndNote X9 was used to manage search results and delete duplicates. Two researchers (YF and FQ) independently screened the titles and abstracts identified through the search against the inclusion criteria. As the wide range of geographic locations in Western China cannot be defined by search terms, the two researchers screened the full text reports and determined whether studies met the inclusion criteria. Disagreements were resolved by including a third researcher (LY) to make the final decision.

Assessment of methodological quality

We used standardized forms from Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data[15] to determine the methodological quality of included studies. Two researchers (LY and FQ) independently evaluated 9 areas of study design, conduct, and analysis for each included study. Each of the 9 areas were qualified as "poor quality," "moderate quality," or "high quality," receiving a score from 0 (poor quality) to 2 (high quality). Researchers then discussed and made final quality assessments. Total quality scores ranged from 0 to 18 and studies that scored less than 13 were excluded.

Data abstraction

A standardized reporting form was used to extract data from each publication (Appendix Table 1). The form included: study ID, first author's name, year of publication, language, study design, year of data collection, place where the study was conducted, sample size, age range of study subjects, prevalence estimates (stratified by sex, age, and ethnic group), and quality score.

Data synthesis

The analysis consisted of four steps: (1) calculation of anemia prevalence estimate in children under 5 years of age per province (distinguishing between urban and rural areas if reported), using the median percentage with IQR; (2) stratification of

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prevalence estimates by sex, age, and ethnic group, separately; (3) collation of factors associated with childhood anemia; and (4) selection of one estimate per study-year, scatter chart plotting, and linear regression predictions. Data were analyzed with Stata version 16.0.

RESULTS

Description of studies

As shown in Figure 2, the search yielded 4815 articles (4811 from the database search, 4 from other sources), excluding 1456 duplicates. After title and abstract screening, 228 remained in the analysis. Next, 117 articles were excluded because they did not meet the inclusion criteria, and another 11 articles were removed due to duplicate data sources. After conducting quality assessments on the remaining 100 articles, 42 were excluded (see Appendix Table 2). In total, 58 studies (including 3 Master's theses and 55 reports of original research) met the eligibility criteria and were included in this review. The average quality assessment score of all included articles was 14.97 (± 1.41).

Most studies were cross sectional studies (n = 41, 70.69%), followed by prospective cohort studies (n =6, 10.34%), surveillance data (n=5, 8.62%), RCTs (n=3, 5.17%), and quasi-experiments (n=3, 5.17%). 29 studies were descriptive and the remaining 29 were analytical (reporting associated factors analyses). The manner of reporting data varied across the studies, and we report data in their original format (see Appendix Table 1).

Regional distribution of anemia prevalence in child

Overall, the reported prevalence of childhood anemia in Western China ranged from 3.69% to 75.74% (median 39.62% [IQR 25.67-52.32]) (Table 1). Studies were from 6 western provinces (Gansu: n=8; Sichuan: n=8; Shaanxi: n=8; Guizhou: n=7; Yunnan: n=5; Qinghai: n=5), 5 western autonomous regions (Xinjiang: n=6; Tibet: n=1; Inner Mongolia: n=4; Guangxi: n=3; Ningxia: n=2), and 1 western municipality (Chongqing: n=2). Children in Qinghai had the highest anemia prevalence, ranging from 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]). One study, sampling

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from all 12 provinces of Western China, found that the anemia prevalence was 49.00%[a57].

30 articles specifically reported anemia prevalence in rural areas, ranging from 3.69% to 72.75% (41.70% [27.20-48.87]). Only 8 articles specifically reported anemia prevalence in urban areas, which ranged from 2.29% to 44.00% (13.78% [8.33-23.38]). 5 studies compared anemia rates between rural and urban areas, among which, 2 studies identified childhood anemia prevalence was significantly higher in rural areas than in urban areas[a2, a8]. However, 2 studies in Xinjiang found the opposite result[a18, a31]. Figure 3 plots the scatter chart of anemia prevalence in Western China using time-point data extracted from included studies, making linear regression predictions. Overall, the prevalence of childhood anemia in western regions reveals a slow downward trend from 2005 to 2019.

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Table 1 Regional distribution of anemia prevalence among child under 5 years in Western China [i] (n=54[vii])

Western China		n (pooled n)	Total prevalence, %		Range of reported prevalence in child by regional distribution, %	
			Median (IQR)	Range	Rural [n=30]	Urban [n=8]
Province	Qinghai	5 (15430)	67.80% (64.70-72.75)	59.10-75.74%[a24, a29, a49, a51, a54]	59.10-72.75%[a49, a51, a54]	—
	Shaanxi	8 (12518)	46.20% (35.12-49.31)	32.00-54.26%[a6, a17, a26, a28, a34, a39, a48, a50]	32.00-54.26%[a6, a26, a28, a34, a39, a48, a50]	—
	Guizhou	7 (37538)	37.50% (31.24-50.63)	14.90-57.60%[a9, a11, a15, a20, a37, a44, a54]	27.20-53.67%[a11, a15, a44, a54]	—
	Yunnan	5 (49298)	29.55% (14.58-35.20)	13.22-47.15%[a8, a21, a23, a36, a38]	34.58%[a8 iv]	2.29%[a8 iv]
	Gansu	8 (23067)	27.20% (19.01-49.90)	3.69-74.30%[a5, a13, a32, a33, a40, a44, a53 ii , a54]	3.69-47.13%[a5, a32, a40, a44, a54]	21.44%[a13 iv]
	Sichuan	8 (29649)	24.53% (15.65-36.82)	6.16-51.90%[a1, a2, a4, a12, a16, a44, a52 ii , a54]	7.40-51.90%[a1, a2, a4, a44, a54]	4.29-17.06%[a2, a4]
Autonomous regions	Xinjiang	6 (41014)	45.00% (27.49-57.11)	9.81-67.30%[a3, a18, a25, a31, a44, a54]	9.91-57.79%[a3, a18, a31, a44, a54]	9.68-44.00%[a3, a18, a31]
	Inner Mongolia	4 (18916)	37.61% (29.26-42.55)	16.60-45.00%[a19, a41, a44, a54]	16.60-45.00%[a41, a44, a54]	—
	Tibet	1 (540)	—	41.70%[a43 iv]	41.70%[a43 iv]	—
	Ningxia	2 (8758)	—	26.4-44.46%[a14, a54 v]	26.4%[a14 iv]	—
	Guangxi	3 (15515)	—	15.60-45.76%[a44, a45, a54 vi]	15.60-45.76%[a44, a45, a54]	—
Municipality	Chongqing	2 (7417)	—	51.7-53.20%[a22, a54 v]	—	—
One research including all the twelve provinces		1 (2380)	—	49.00%[a57 iv]	49.00%[a57 iv]	—
In total		54 (180981)	39.62% (25.67-52.32)	3.69-75.74%[a1-a6, a8-a26, a28-a34, a36-a41, a43-a58]	41.70% (27.20-48.27); 3.69-72.75%[iii]	13.78% (8.33-23.38); 2.29-44.00%[a2-a4, a8, a13, a18, a30, a31]

Notes: for references see Appendix reference list.

i Anemia is defined by the WHO standard (WHO, 2011)[16] and the Chinese standard (the China Pediatrics Association, 2010)[17] as a hemoglobin (Hb) level is below 145 g/L for children aged 0 to 29 days, below 90 g/L for children aged 1 to 3 months, below 100 g/L for children aged 4 to 6 months, or below 110 g/L for children aged 6 to 59 months is considered anemia.

ii Affected by Wenchuan Earthquake.

iii The references as follows: a1-a3, a5, a6, a8, a10-a12, a14, a15, a18, a26, a28, a30-a32, a34, a39-a41, a43, a45, a47-a50, a53, a56, a57.

iv Reported as point estimate only, as n=1.

v Reported as range only, as n=2.

vi Reported as range only, as n=3.

vii 4 of the total 58 studies are not included in this table because they do not report overall anemia prevalence by province.

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Table 2 Sociodemographic distribution of anemia prevalence among children under 5 years in Western China

	Prevalence	
	Median (IQR)	Range
Age (months) [n (pooled n) = 35(126486)]		
0~	11.78% (7.90-17.87)	1.70-46.10%[a10, a11, a38, a40, a44, a58]
6~	50.09% (34.35-59.04)	17.71-72.50%[a1, a5, a8, a9, a11, a14, a15, a20-a23, a26-a28, a29-a31, a33, a38, a40, a41, a44, a47, a49, a55, a56, a58]
12~	33.90% (23.56-47.29)	6.73-69.30%[a1, a2, a5, a7-a9, a12, a15, a20-a23, a27, a29-a31, a33, a35-a38, a40, a41, a44, a46, a47, a49, a55, a58]
24~	17.50% (10.95-24.55)	4.65-67.20%[a2, a7-a9, a29, a31, a35-a37, a40, a44, a46, a58]
36~	12.29% (6.25-24.07)	4.00-64.70% [a2, a7-a9, a35-a37, a40, a44, a46]
48~60	12.95% (6.93-18.60)	4.42-64.80% [a2, a7-a9, a35-a37, a40, a44, a46]
Sex [n (pooled n) = 32(84782)]		
Boys	36.60% (25.68-47.96)	3.47-71.10%[a1-a3, a5, a6, a9, a11-a15, a21-a23, a25, a26, a28, a31-a34, a36-a40, a43-a45, a48, a55, a58]
Girls	31.38% (22.62-45.87)	3.37-62.90% [a1-a3, a5, a6, a9, a11-a15, a21-a23, a25, a26, a28, a31-a34, a36-a40, a43-a45, a48, a55, a58]
Ethnic group [n (pooled n) = 8(44323)]		
Han	—	6.92-62.70%[a5, a9, a14, a24, a31, a38]
Hui	—	21.71-53.10%[a5, a14, a24, a31]
Tibetan	—	35.42-78.10%[a5, a24]
Miao	—	9.2-60.04%[a9, a15]
Dai	—	23.42-29.55%[a36, a38]
Others*	—	3.88-77.20%[a5, a9, a15, a24, a31, a38]

Note: * Others include Dongxiang, Dong, Shui, Maonan, Tu, Uygur, Kazak, Bulang, Jinuo, Jingpo, Deang, Achang, Dulong, Nu, Pumi, Lisu, Lahu, Hani, Va, Naxi, and Bai minority groups.

Sociodemographic distribution of anemia prevalence in children

Table 2 provides a sociodemographic overview of studies reporting prevalence of anemia in children younger than 5 years in Western China. Most studies reported prevalence of anemia in children aged 6-24 months (n=32). Children aged 6-12 months had a higher prevalence than other age groups (50.09% [34.35-59.04]). The rates of anemia in boys and girls under 5 years were similar, ranging from 3.47% to 71.10% for boys (36.60% [25.68-47.96]) and 3.37% to 62.90% for girls (31.38% [22.62-45.87]).

Associated factors with childhood anemia

Figure 4 displays the 27 articles that conducted analysis on associated factors of childhood anemia, controlling for confounding factors. We grouped associated factors into the 7 categories (reported by descending frequency of studies): children characteristics, feeding behaviors, maternal characteristics, family characteristics, nutritional interventions, child health care, and feeding knowledge.

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Children characteristics, feeding behaviors, and maternal characteristics were the most common associated factors. Regarding children characteristics, 17 articles reported associations between children age and anemia, and most indicated that children younger than 24 months had an increased risk of anemia[a5, a10, a11, a55]. 8 articles reported association between ethnic group and childhood anemia. Specifically, Hui, Miao, and Tibetan children were at higher risk of anemia than Han children[a14, a15, a50]. Regarding feeding behaviors, 7 articles reported effects of breastfeeding on anemia: 2 articles reported a higher prevalence of anemia in children who were exclusively fed formula compared to children who received a mix of formula and breastmilk[a5, a57]; the other 5 articles reported a higher prevalence of anemia in children who were exclusively breastfed after reaching 6 months, compared to children who received mixed breastfeeding after 6 months[a11, a20, a26, a28, a42]. Regarding maternal characteristics, 6 articles reported positive effects of maternal education on reducing childhood anemia. Furthermore, 8 articles reported the effects of Ying Yang Bao (YYB, a nutrition pack)[18] on anemia, all reporting that supplemental feeding with YYB has a significant protective effect on the prevention of childhood anemia.

DISCUSSION

In this review, we report a descriptive synthesis of studies that investigate anemia in children under 5 years in Western China. Our findings highlight a higher prevalence of childhood anemia in Western China (around 40%) than all of China (12%)[8]. Despite recent efforts to decrease the prevalence of childhood anemia in China, childhood anemia remains a severe public health challenge in Western China that deserves extensive attention (WHO, 2011)[16]. Regional contexts, individual sociodemographic characteristics and feeding behaviors, as well as nutritional program interventions play important roles in the prevalence of childhood anemia in Western China.

We found that childhood anemia is more prevalent in western regions of China than in other regions, which is consistent with previous research[6]. The division of eastern, central, and western regions of China is based on levels of economic development, policy implementation, and geographical locations. The western region is less

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economically developed than the other regions[19], contributing 20.7% of the National Economic GDP (Gross Domestic Product) in 2019, compared to the eastern and central regions' contributions of 51.6% and 27.2%, respectively [19]. Moreover, anemia prevalence varies widely within the western region; for example, the highest reported anemia prevalence was in Qinghai (59% to 75%) while the lowest prevalence was in Sichuan (16% to 37%).

Children belonging to an ethnic minority group showed higher anemia rates than Han children in Western China. The western region is multi-ethnic, and the minority population in Western China accounts for about 71% of the national minority population. Moreover, the geographical area populated by minority groups accounts for about 90% of the total area in the west[20]. Several studies on the prevalence of anemia among children from different ethnic groups in the western region were included in this review, among which relatively more studies focus on the Hui, Tibetan, Miao, and Dai minority groups. Those studies reported that Hui, Tibetan, and Miao children had significantly higher prevalence of anemia than Han children[21-23]. Moreover, 319 of the 592 national poverty-stricken counties in China[24] are located where western minority groups live, thus indicating that the highest poverty rates affect minority populations. Because intergenerational transmission of poverty happens in the typical cycle of poverty-malnutrition-poverty in developing countries[25], researchers and policy makers must be aware of the high prevalence of anemia among children in western minority groups.

In summarizing the results of the studies, the prevalence of anemia is highest among children aged 6-24 months, which is consistent with findings from the WHO[26]. The prevalence of anemia is higher in children who continue exclusive breastfeeding over 6 months, compared to those who have timely supplementation. This may be explained by children's changing nutritional needs at different developmental stages. If caregivers do not add adequate or appropriate complementary food in a timely manner, children aged 6-24 months are at greater risk of anemia[27]. To improve the nutrition and health status and the prevalence of IDA among children aged 6-24 months in poor areas, in October 2012, the Chinese government launched a major primary health care project to prevent malnutrition and anemia[28-30]. The project provides free, iron-rich nutrition packages to caregivers and promotes scientific

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knowledge and proper child feeding skills[18]. In 2013, 187 counties in Western China were covered by this project[31], and between 2012 and 2017, the national anemia rate decreased from 32.9% to 17.6%[32]. These results are illustrated in Figure 3, which shows the prevalence of childhood anemia in the western region has been decreasing year by year.

To our knowledge, this is one of few reviews in recent years that focuses on anemia in children under 5 years in Western China. Our study highlights several limitations of the literature in this field. First, during our database search, we identified fewer relevant studies for Western China compared to the rest of China (228 vs. 3363). It is also worth noting that there is a large research gap in childhood anemia research between different provinces and minority groups within the western region. Second, there were only 2 RCTs among all included studies (2 vs. 58). Most included articles are cross-sectional studies, which do not explore the causality of anemia or propose active and effective measures. When measures were suggested, they tended to be general health advisories without a targeted audience, making them less useful for policy changes and interventions[33 34]. Third, the uneven distribution of study designs and quality of studies contributed to a high heterogeneity of studies. More than 40% of the studies that met our inclusion criteria were excluded due to poor research quality. The quality evaluation scores of articles in Chinese are mostly lower than those of articles in English. The above limitations regarding existing literature led to several limitations of our systematic review. However, one major limitation of this review is the absence of a meta-analysis. We could not perform a meta-analysis due to the large methodological heterogeneity of the included studies. Additionally, we were unable to produce pooled regional or overall prevalence estimates; therefore, only median and quartiles are reported in this review.

Conclusions

This study provides a holistic review of preschool children's anemia research in Western China. The prevalence of anemia in children under 5 years in Western China is still relatively high, despite recent efforts to decrease anemia prevalence. For such a multi-ethnic and poor region, interventions must be tailored to local ethnic and regional characteristics. In light of our findings, more high-quality and prospective

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studies are urgently needed to inform targeted and evidence based preventive strategies to identify causes of the high prevalence of childhood anemia in remote and poor areas, as well as to provide timely public health service to economically disadvantaged populations.

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Contributorship: Huan Zhou formulated the research questions and designed the study; Yefan Du, Huan Zhou, and Ruixue Ye designed the search strategy. Yefan Du, Ying Liao, and Fangqun Leng conducted the search, retrieved publications, screened full text, and assessed the quality of the articles. Yefan Du wrote the draft of the manuscript, with specific sections collaborated by Ying Liao, and Fangqun Leng. Ying Liao and Yefan Du produced all figures and tables. Huan Zhou, Linhua Li, Yuping Mao, and Hein Raat reviewed the manuscript. All authors critically revised the manuscript and agreed to the published version of the manuscript.

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Figure legends

Figure 1 Location of the western region (red parts) in the map of China

Figure 2 Study selection profile

Note: Other resources referred to the studies scrutinized by the reference lists of published review articles, to locate additional relevant publications not identified during the database searches.

Figure 3 Time Trend of Anemia Prevalence in 8 Western Provinces (n=34)

Note: This figure used the time of each study conducted; only when the specific time of the study was not accounted for in the article, the time of publication of the article was chosen instead.

Figure 4 Frequency of studies on influencing factors of anemia in children under 5 years in Western China (n=27).

Note:

1. The darker the color, the more research,
2. "Ying Yang Bao" is a free nutrition package provided by the Chinese government for children aged 6-24 months in the poor rural areas.

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Map of China

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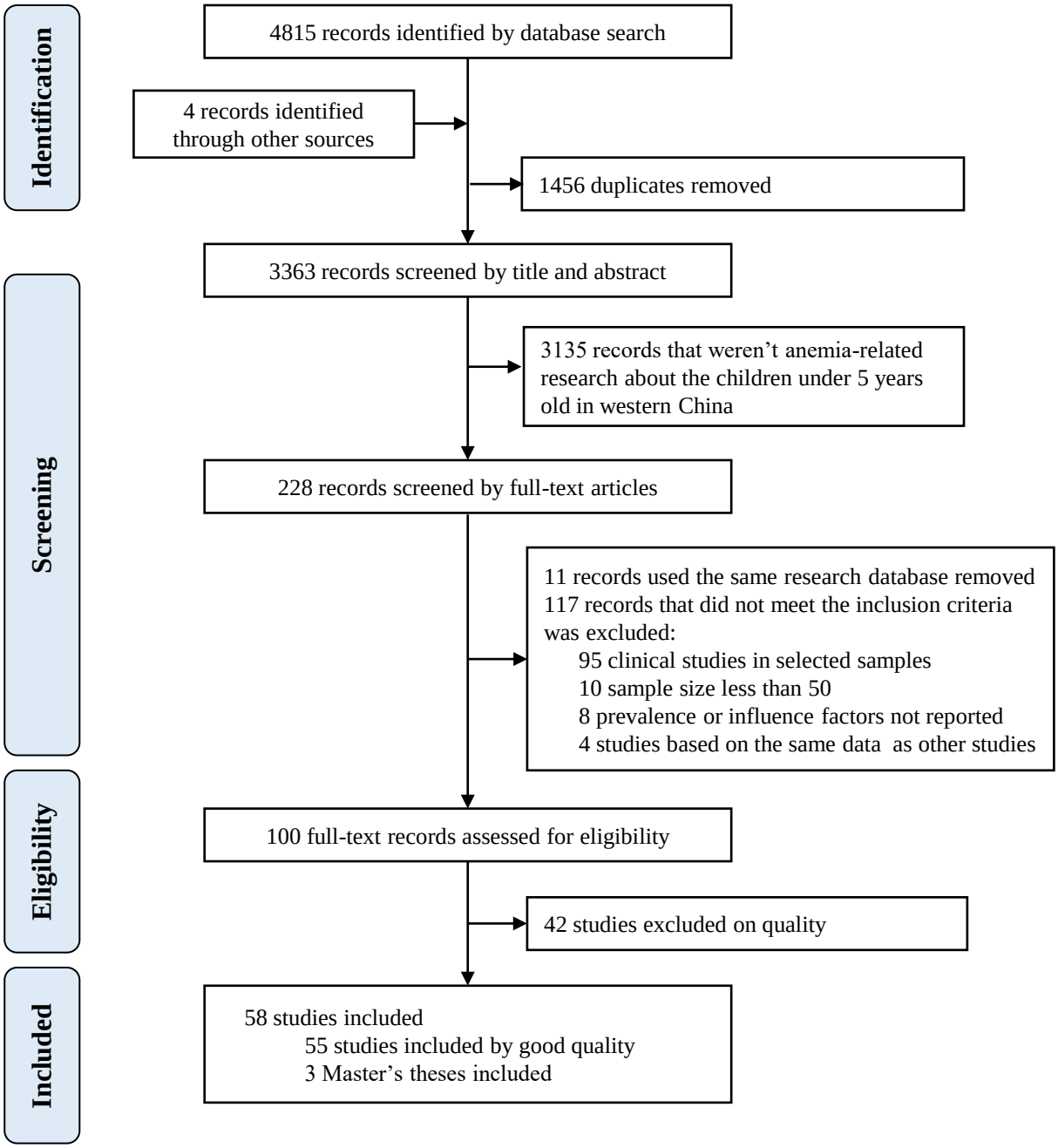
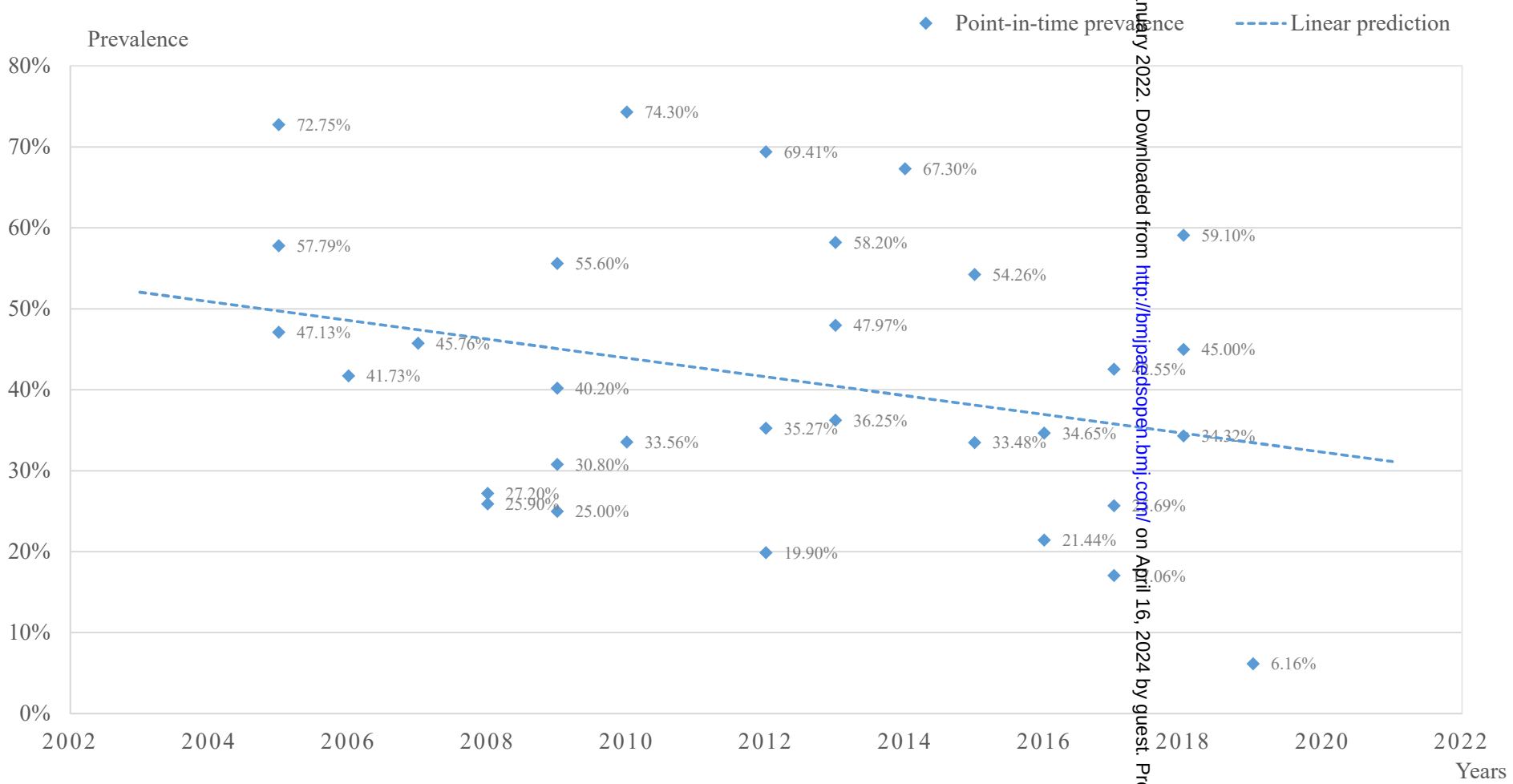

Identification
Screening
Eligibility
Included
4815 records identified by database search
4 records identified through other sources
1456 duplicates removed
3363 records screened by title and abstract
3135 records that weren't anemia-related research about the children under 5 years old in western China
228 records screened by full-text articles
11 records used the same research database removed
117 records that did not meet the inclusion criteria was excluded:
95 clinical studies in selected samples
10 sample size less than 50
8 prevalence or influence factors not reported
4 studies based on the same data as other studies
100 full-text records assessed for eligibility
42 studies excluded on quality
58 studies included
55 studies included by good quality
3 Master's theses included



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Associated Factors	Specific items associated with childhood anemia					
Children characteristics	Age in months (a1, a5, a6, a9-a11, a14, a15, a20, a21, a40, a41, a49, a54, a57, a58)	Ethnic group (a5, a10, a14, a15, a24, a41, a49, a54)	Sex (a21, a43, a45, a54, a57, a58)	Low birth weight (a15, a56)	Premature (a11, a45)	Illness in the past two weeks (a28)
Feeding behaviors	Breastfeeding status (a5, a11, a20, a26, a28, a41, a56)	Duration of continuous breastfeeding (a1, a9, a28, a45)	First time of introducing supplementary food (a9, a15, a28)	Supplementary food diversity (a6, a11, a15, a24, a26, a49, a58)	Frequency of supplementary food addition (a26, a41)	First bite of food after birth (a45)
Maternal characteristics	Education (a1, a41, a43, a45, a56, a57)	Gestational anemia (a10, a15, a54, a58)	Age (a6, a43, a56)	Occupation (a15, a21)	Iron supplementation during pregnancy (a11)	
Family characteristics	Annual household income per capita (a11, a15, a21, a56, a57)	Household environment (a24)	Family size (a54, a56)	Residence area (a15, a54)	Primary caregiver role (a15)	
Nutritional interventions	Ying Yang Bao (a15, a21, a27, a32, a41, a42, a47, a53)	Vitamin and mineral supplementation (a10, a24, a28, a58)	Home use of iron pots and pans (a54)			
Child health Care	Medical Examination (a9, a10)	Vaccination (a10)				
Feeding knowledge	Feeding knowledge (a1, a5)					

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Anemia Prevalence and its Associated Factors in Children under 5 Years in Western China: A Systematic Review

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What is known about the subject?

- Iron deficiency anemia disproportionately affects infants and children in low- and middle-income areas.
- Western China, which covers 72% of China's total area and is home to 27% of the total population, is one of the least economically developed regions in the country.
- In China, 4 of the 5 provinces with the highest rates of childhood anemia are located in Western China.

What this study adds?

- In Western China, the median prevalence of anemia in children under 5 years is 43%, which is much higher than the national average.
- The highest prevalence rates (59.1% to 75.74%) were located in Qinghai province, and the highest levels were reported among children aged 6-24 months.
- Regional contexts, individual sociodemographic characteristics and feeding behaviors, and nutritional program interventions play important roles in the prevalence of childhood anemia in Western China.

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Anemia Prevalence and its Associated Factors in Children under 5 Years in Western China: A Systematic Review

Abstract

Background: Iron deficiency anemia disproportionately affects children in low- and middle-income areas; Western China is a prime example. Given the health risks associated with childhood anemia and the large heterogeneity of published studies on this subject, we conducted a systematic review of the evidence regarding anemia prevalence and associated factors in children under 5 years in Western China.

Methods: We searched for all relevant studies on the prevalence of iron deficiency anemia in children under 5 years in Western China, obtaining research between 1 January 2011 and 30 June 2021, in English and Chinese from Medline, Embase, PubMed, Web of Science, CNKI, WanFang Data, and VIP. Two reviewers independently screened titles and abstracts; three reviewed full texts of relevant articles for data extraction and performed quality assessments. The median prevalence was calculated on unweighted pooling, stratified by region, sex, age, and ethnic group. Associated factors and a linear trend chart were conducted to identify trends and research highlights.

Results: Among the 55 articles included, most were cross-sectional studies (39, 70.91%). The prevalence of anemia in children under 5 years in Western China ranged from 3.69% to 75.74% (median 42.54% [IQR 25.62-52.56]); the highest levels were in Qinghai province: 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]); the highest levels were reported in the subgroup of children aged 6-12 months (median 50.09% [IQR 34.35-59.04]). Regional contexts, individual sociodemographic characteristics and feeding behaviors, and nutritional program interventions were factors associated with anemia prevalence.

Conclusion: The prevalence of anemia in children under 5 years in Western China is concerningly high. For this multi-ethnic and economically underdeveloped region, more high-quality and prospective studies are needed to inform evidence based and targeted preventive strategies to decrease the high prevalence of anemia among young children.

Key Words: Anemia, Iron-Deficiency, Preschool Child, China, Review

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BACKGROUND

Children under the age of 5 years are at a critical stage of physical and intellectual development[1]. However, anemia may disproportionately affect children at this age in low-and middle-income countries (LMICs), causing potentially irreversible effects on cognitive and motor function even after iron supplementation[2-4]. Iron deficiency anemia (IDA) is usually the predominant cause (more than 90%) of early childhood anemia in middle-income and developing countries, such as China[5]. Despite overall improvements to child health made in China over the past 3 decades, the prevalence of anemia among children younger than 5 years in western rural areas is still high[6 7]. According to a national survey, 4 of the 5 provinces with childhood anemia rates higher than the national average are in Western China[8]. If future policies and research do not address the high prevalence of childhood anemia in Western China, such health inequities will continue affecting children living in this region.

Western China includes 12 provinces (including autonomous regions and municipalities), covering about 72% of the country's area; however, only 27.2% of the country's population live in Western China[9 10]. There are 44 ethnic minority groups living in Western China, all with different customs and living habits. Understanding cultural differences between ethnic groups in Western China is crucial for children's health, as public health workers must make informed decisions on prevention efforts for these subgroups. However, most anemia-related studies in Western China have either been conducted in specific areas that do not capture the complete diversity of the region, or have used varied research methodologies. Furthermore, the literature on childhood anemia in Western China is dated, as the most recent reviews on this topic were conducted more than a decade ago[11 12].

Given the health risks associated with childhood anemia and the high heterogeneity of published studies on this topic, the objective of our study is to systematically review the medical literature on the prevalence of anemia among children under 5 years in Western China. We aim to achieve two objectives: first, to understand the overall and sub-regional anemia prevalence in Western China; and second, to identify the factors associated with childhood anemia and the trend of anemia prevalence in this region.

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METHODS

This systematic review was conducted according to PRISMA guidelines[13]. The project protocol was registered with PROSPERO.

Eligibility criteria

Studies were eligible for inclusion only if they stated the prevalence of children under 5 years with IDA in Western China. "Western China" is not a specific administrative division, but the region includes 12 provinces, autonomous regions, and municipalities: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang (Figure 1)[14]. As prevalence data may be sourced from different study designs, we included all relevant cross-sectional studies, randomized controlled trials (RCTs), cohort studies, and published surveillance data. If results based on the same data were presented in more than one publication, results from only one publication were included.

We excluded clinical studies or case reports of children in specific hospitals or communities, and studies with sample sizes less than 50 participants, as the results of these studies are hardly representative of the regional prevalence of anemia. We excluded studies on children in selective samples (premature, low birthweight, birth defects) or with specific types of anemia (aplastic anemia, thalassemia, megaloblastic anemia). Studies with mixed samples that did not present results separately for Western children or studies that assessed iron deficiency anemia with unstandardized diagnostic criteria were also excluded[15 16].

Search strategy

Literature search strategies were developed using medical subject headings (MeSH) and text words related to childhood anemia. The search terms for studies published in English were (anemia OR anaemia OR iron deficiency anemia OR IDA OR nutritional anemia) AND (infants OR children OR preschool) AND (China OR Chinese). The search terms for studies published in Chinese were (贫血 OR 缺铁性贫血 OR 营养性贫血) AND (婴儿 OR 婴幼儿 OR 幼儿 OR 儿童). We searched Medline (Ovid interface, 1948 onwards), Embase, PubMed, Web of Science, CNKI,

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WanFang Data, and VIP. The literature search was limited to studies written in English and Chinese languages, published from 1 January 2011 to 30 June 2021. We carefully examined reference lists of published articles to find other related publications not identified in the database search.

Selection process

EndNote X9 was used to manage search results and delete duplicates. Two researchers (YF and FQ) independently screened the titles and abstracts identified through the search against the inclusion criteria. As the wide range of geographic locations in Western China cannot be defined by search terms, the two researchers screened the full text reports and determined whether studies met the inclusion criteria. Disagreements were resolved by including a third researcher (LY) to make the final decision.

Assessment of methodological quality

We used standardized forms from Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data[17] to determine the methodological quality of included studies. Two researchers (YF and FQ) independently evaluated 9 methodological items of study design, conduct, and analysis for each included study. Each item has four choices: yes, no, unclear or not applicable. One point is assigned to a 'yes' response, and the quality score is the sum of the 9 items, ranging from 0 to 9, with a higher score indicating a lower risk of bias[18]. Researchers then discussed and made a final decision, excluding studies whose scores were less than 6[19].

Data abstraction

A standardized reporting form was used to extract data from each publication (Appendix Table 1). The form included: study ID, first author's name, year of publication, language, study design, year of data collection, place where the study was conducted, sample size, age range of study subjects, prevalence estimates (stratified by sex, age, and ethnic group), and quality score.

Data synthesis

The analysis consisted of four steps: (1) calculation of anemia prevalence estimate in children under 5 years of age per province (distinguishing between urban and rural

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areas if reported), using the median percentage with IQR; (2) stratification of prevalence estimates by sex, age, and ethnic group, separately; (3) collation of factors associated with childhood anemia; and (4) extraction the point estimates of prevalence (with confidential interval) and plotting by year in different provinces of the studies. The prevalence estimates are calculated based on unweighted pooling rather than based on weighted meta-analysis methods. Data were analyzed with Stata version 16.0.

RESULTS

Description of studies

As shown in Figure 2, the search yielded 4815 articles (4811 from the database search, 4 from other sources), excluding 1456 duplicates. After title and abstract screening, 228 remained in the analysis. Next, 117 articles were excluded because they did not meet the inclusion criteria, and another 11 articles were removed due to duplicate data sources. After conducting quality assessments on the remaining 100 articles, 45 were excluded (Appendix Table 2). In total, 55 studies (including 3 Master's theses and 52 reports of original research) met the eligibility criteria and were included in this review.

Most studies were cross sectional studies (n = 39, 70.91%), followed by prospective cohort studies (n =6, 10.91%), surveillance data (n=4, 7.27%), RCTs (n=3, 5.45%), and quasi-experiments (n=3, 5.45%). 28 studies were descriptive and the remaining 27 were analytical (reporting associated factors analyses). The manner of reporting data varied across the studies, and we report data in their original format (Appendix Table 1).

Regional distribution of anemia prevalence in child

Overall, the reported prevalence of childhood anemia in Western China ranged from 3.69% to 75.74% (median 42.54% [IQR 25.62-52.56]) (Table 1). Studies were from 6 western provinces (Gansu: n=7; Sichuan: n=7; Shaanxi: n=8; Guizhou: n=7; Yunnan: n=5; Qinghai: n=5), 5 western autonomous regions (Xinjiang: n=6; Tibet: n=1; Inner Mongolia: n=4; Guangxi: n=3; Ningxia: n=2), and 1 western municipality

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(Chongqing: n=2). Children in Qinghai had the highest anemia prevalence, ranging from 59.10% to 75.74% (median 67.80% [IQR 64.70-72.75]). One study, sampling from all 12 provinces of Western China, found that the anemia prevalence was 49.00%[a54].

26 articles specifically reported anemia prevalence in rural areas, ranging from 3.69% to 72.75% (41.72% [26.88-48.90]). Only 6 articles specifically reported anemia prevalence in urban areas, which ranged from 2.29% to 44.00% (10.50% [6.99-23.12]). 5 studies compared anemia rates between rural and urban areas, among which, 2 studies identified childhood anemia prevalence was significantly higher in rural areas than in urban areas[a2, a8]. However, 2 studies in Xinjiang found the opposite result[a16, a29]. Figure 3 plots the distribution of anemia prevalence in Western China using time-point data extracted from included studies. Overall, the prevalence of childhood anemia in western regions reveals a tendency to decline slowly from 2005 to 2019.

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Table 1 Regional distribution of anemia prevalence among child under 5 years in Western China [i] (n=52[vii])

Western China		n (pooled n)	Total prevalence, %		Range of reported prevalence in child by regional distribution, %	
			Median (IQR)	Range	Rural [n=26]	Urban [n=6]
Province	Qinghai	5 (15430)	67.80% (64.70-72.75)	59.10-75.74% [a21, a26, a46, a48, a51]	59.10-72.75% [a46, a51]	—
	Shaanxi	8 (12518)	46.20% (35.12-49.31)	32.00-54.26% [a6, a15, a23, a25, a32, a36, a45, a47]	32.00-54.26% [a6, a23, a25, a32, a36, a45, a47]	—
	Guizhou	7 (37538)	37.50% (31.24-50.63)	14.90-57.60% [a9, a11, a13, a17, a34, a41, a51]	27.20-53.67% [a11, a13, a41, a51]	—
	Yunnan	5 (49298)	29.55% (14.58-35.20)	13.22-47.15% [a8, a18, a20, a33, a35]	34.58% [a8 iv]	2.29% [a8 iv]
	Gansu	7 (22512)	25.69% (11.70-42.52)	3.69-74.30% [a5, a30, a31, a37, a41, a50ii, a51]	3.69-47.13% [a5, a30, a31, a37, a41, a51]	—
	Sichuan	7 (28385)	17.06% (14.57-37.67)	6.16-51.90% [a1, a2, a4, a14, a41, a49ii, a51]	7.40-51.90% [a1, a2, a4, a41, a51]	4.29-17.06% [a2, a4]
Autonomous regions	Xinjiang	6 (41014)	45.00% (27.49-57.11)	9.81-67.30% [a3, a16, a22, a29, a41, a51]	9.91-57.79% [a3, a16, a22, a29, a41, a51]	9.68-44.00% [a3, a16, a29]
	Inner Mongolia	4 (16554)	29.17% (13.78-42.55)	5.33-45.00% [a27, a38, a41, a51]	16.60-45.00% [a38, a41, a51]	—
	Tibet	1 (540)	—	41.70% [a40 iv]	41.70% [a40 iv]	—
	Ningxia	2 (8758)	—	26.4-44.46% [a12, a51 v]	26.4% [a12 iv]	—
	Guangxi	3 (15515)	—	15.60-45.76% [a41, a42, a51 vi]	15.60-45.76% [a41, a42, a51 vi]	—
Municipality	Chongqing	2 (7417)	—	51.7-53.20% [a19, a51 v]	—	—
One research including all the twelve provinces		1 (2380)	—	49.00% [a54 iv]	49.00% [a54 iv]	—
In total		52 (176462)	42.54% (25.62-52.56)	3.69-75.74% [a1-a6, a8-a23, a25, a26, a28-a38, a40-a55]	41.72% (26.88-48.90); 3.69-72.75% [iii]	10.50% (6.99-23.12); 2.29-44.00% [a2-a4, a8, a16, a28, a29]

Notes: for references see Appendix reference list.

i Anemia is defined by the WHO standard (WHO, 2011)[16] and the Chinese standard (the China Pediatrics Association, 2010)[15] as a hemoglobin (Hb) level is below 145 g/L for children aged 0 to 29 days, below 90 g/L for children aged 1 to 3 months, below 100 g/L for children aged 4 to 6 months, or below 110 g/L for children aged 6 to 59 months is considered anemia.

ii Affected by Wenchuan Earthquake.

iii The references as follows: a1-a3, a5, a6, a8, a11-a13, a16, a23, a25, a29, a30, a32, a36-a38, a40-a42, a45-a47, a51, a54.

iv Reported as point estimate only, as n=1.

v Reported as range only, as n=2.

vi Reported as range only, as n=3.

vii 3 of the total 55 studies are not included in this table because they do not report overall anemia prevalence by province.

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Table 2 Sociodemographic distribution of anemia prevalence among children under 5 years in Western China

	Prevalence	
	Median (IQR)	Range
Age (months) [n (pooled n) = 33 (126486)]		
0~	11.78% (7.90-17.87)	1.70-46.10% [a10, a11, a35, a37, a41, a55]
6~	50.09% (34.35-59.04)	17.71-72.50% [a1, a5, a8, a9, a11-a13, a17-a20, a23-a26, a28, a29, a31, a35, a37, a38, a41, a44, a46, a52, a53, a55]
12~	40.81% (26.07-47.56)	6.73-69.30% [a1, a2, a5, a7-a9, a13, a17-a20, a24, a26, a28, a29, a31, a33-a35, a37, a38, a41, a43, a44, a46, a52, a55]
24~	17.50% (10.95-24.55)	4.65-67.20% [a2, a7-a9, a26, a29, a33, a34, a37, a41, a43, a55]
36~	12.29% (6.25-24.07)	4.00-64.70% [a2, a7-a9, a33, a34, a37, a41, a43]
48~60	12.95% (6.93-18.60)	4.42-64.80% [a2, a7-a9, a33, a34, a37, a41, a43]
Sex [n (pooled n) = 30 (84782)]		
Boys	36.60% (25.68-47.96)	3.47-71.10% [a1-a3, a5, a6, a9, a11-a13, a18-a20, a22, a23, a25, a29-a37, a40-a42, a45, a52, a55]
Girls	31.38% (22.62-45.87)	3.37-62.90% [a1-a3, a5, a6, a9, a11-a13, a18-a20, a22, a23, a25, a29-a37, a40-a42, a45, a52, a55]
Ethnic group [n (pooled n) = 9 (44323)]		
Han	—	6.92-62.70% [a5, a9, a12, a21, a29, a35]
Hui	—	21.71-53.10% [a5, a12, a21, a29]
Tibetan	—	35.42-78.10% [a5, a21]
Miao	—	9.2-60.04% [a9, a13]
Dai	—	23.42-29.55% [a33, a35]
Others*	—	1.08-77.20% [a5, a9, a13, a21, a27, a29, a35]

Note: * Others include Dongxiang, Dong, Shui, Maonan, Tu, Uygur, Kazak, Bulang, Jinuo, Jingpo, Deang, Achang, Dulong, Nu, Pumi, Lisu, Lahu, Hani, Va, Naxi, Molidawa, Oroqen, Ewenki, and Bai minority groups.

Sociodemographic distribution of anemia prevalence in children

Table 2 provides a sociodemographic overview of studies reporting prevalence of anemia in children younger than 5 years in Western China. Most studies reported prevalence of anemia in children aged 6-24 months (n=32). Children aged 6-12 months had a higher prevalence than other age groups (50.09% [34.35-59.04]). The rates of anemia in boys and girls under 5 years were similar, ranging from 3.47% to 71.10% for boys (36.60% [25.68-47.96]) and 3.37% to 62.90% for girls (31.38% [22.62-45.87]).

Associated factors with childhood anemia

Figure 4 displays the 27 articles that conducted analysis on associated factors of childhood anemia, controlling for confounding factors. We grouped associated factors into the 7 categories (reported by descending frequency of studies): children characteristics, feeding behaviors, maternal characteristics, family characteristics, nutritional interventions, child health care, and feeding knowledge.

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Children characteristics, feeding behaviors, and maternal characteristics were the most common associated factors. Regarding children characteristics, 17 articles reported associations between children age and anemia, and most indicated that children younger than 24 months had an increased risk of anemia[a5, a10, a11, a52]. 8 articles reported association between ethnic group and childhood anemia. Specifically, Hui, Miao, and Tibetan children were at higher risk of anemia than Han children[a12, a13, a47]. Regarding feeding behaviors, 7 articles reported effects of breastfeeding on anemia: 2 articles reported a higher prevalence of anemia in children who were exclusively fed formula compared to children who received a mix of formula and breastmilk[a5, a54]; the other 5 articles reported a higher prevalence of anemia in children who were exclusively breastfed after reaching 6 months, compared to children who received mixed breastfeeding after 6 months[a11, a17, a23, a25, a39]. Regarding maternal characteristics, 6 articles reported positive effects of maternal education on reducing childhood anemia. Furthermore, 8 articles reported the effects of Ying Yang Bao (YYB, a nutrition pack)[20] on anemia, all reporting that supplemental feeding with YYB has a significant protective effect on the prevention of childhood anemia.

DISCUSSION

In this review, we report a descriptive synthesis of studies that investigate anemia in children under 5 years in Western China. Our findings highlight a higher prevalence of childhood anemia in Western China (around 43%) than all of China (12%)[8]. Despite recent efforts to decrease the prevalence of childhood anemia in China, childhood anemia remains a severe public health challenge in Western China that deserves extensive attention (WHO, 2011)[16]. Regional contexts, individual sociodemographic characteristics and feeding behaviors, as well as nutritional program interventions play important roles in the prevalence of childhood anemia in Western China.

We found that childhood anemia is more prevalent in western regions of China than in other regions, which is consistent with previous research[6]. The division of eastern, central, and western regions of China is based on levels of economic development,

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policy implementation, and geographical locations. The western region is less economically developed than the other regions[21], contributing 20.7% of the National Economic GDP (Gross Domestic Product) in 2019, compared to the eastern and central regions' contributions of 51.6% and 27.2%, respectively[21]. Moreover, anemia prevalence varies widely within the western region; for example, the highest reported anemia prevalence was in Qinghai while the lowest prevalence was in Sichuan.

Children belonging to an ethnic minority group showed higher anemia rates than Han children in Western China. The western region is multi-ethnic, and the minority population in Western China accounts for about 71% of the national minority population. Moreover, the geographical area populated by minority groups accounts for about 90% of the total area in the west[22]. Several studies on the prevalence of anemia among children from different ethnic groups in the western region were included in this review, among which relatively more studies focus on the Hui, Tibetan, Miao, and Dai minority groups. Those studies reported that Hui, Tibetan, and Miao children had significantly higher prevalence of anemia than Han children[23-25]. Moreover, 319 of the 592 national poverty-stricken counties in China[26] are located where western minority groups live, thus indicating that the highest poverty rates affect minority populations. Because intergenerational transmission of poverty happens in the typical cycle of poverty-malnutrition-poverty in developing countries[27], researchers and policy makers must be aware of the high prevalence of anemia among children in western minority groups.

In summarizing the results of the studies, the prevalence of anemia is highest among children aged 6-24 months, which is consistent with findings from the WHO[28]. The prevalence of anemia is higher in children who continue exclusive breastfeeding over 6 months, compared to those who have timely supplementation. This may be explained by children's changing nutritional needs at different developmental stages. If caregivers do not add adequate or appropriate complementary food in a timely manner, children aged 6-24 months are at greater risk of anemia[29]. To improve the nutrition and health status and the prevalence of IDA among children aged 6-24 months in poor areas, in October 2012, the Chinese government launched a major primary health care project to prevent malnutrition and anemia[30-32]. The project provides free, iron-rich nutrition packages to caregivers and promotes scientific

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knowledge and proper child feeding skills[20]. In 2013, 187 counties in Western China were covered by this project[33], and between 2012 and 2017, the national anemia rate decreased from 32.9% to 17.6%[34]. These results are illustrated in Figure 3, which shows the tendency that prevalence of childhood anemia in the western region has been decreasing by year.

To our knowledge, this is one of few reviews in recent years that focuses on anemia in children under 5 years in Western China. Our study highlights several limitations of the literature in this field. First, during our database search, we identified fewer relevant studies for Western China compared to the rest of China (228 vs. 3363). It is also worth noting that there is a large research gap in childhood anemia research between different provinces and minority groups within the western region. Second, there were only 2 RCTs among all included studies (2 vs. 55). Most included articles are cross-sectional studies, which do not explore the causality of anemia or propose active and effective measures. When measures were suggested, they tended to be general health advisories without a targeted audience, making them less useful for policy changes and interventions[35 36]. Third, the uneven distribution of study designs and quality of studies contributed to a high heterogeneity of studies. More than 40% of the studies that met our inclusion criteria were excluded due to poor research quality. The quality evaluation scores of articles in Chinese are mostly lower than those of articles in English. The above limitations regarding existing literature led to several limitations of our systematic review. However, one major limitation of this review is the absence of a meta-analysis. We could not perform a meta-analysis due to the large methodological heterogeneity of the included studies. Additionally, we were unable to produce pooled regional or overall prevalence estimates; therefore, only median and quartiles are reported in this review.

Conclusions

This study provides a holistic review of preschool children's anemia research in Western China. The prevalence of anemia in children under 5 years in Western China is still relatively high, despite recent efforts to decrease anemia prevalence. For such a multi-ethnic and poor region, interventions must be tailored to local ethnic and regional characteristics. In light of our findings, more high-quality and prospective

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studies are urgently needed to inform targeted and evidence based preventive strategies to identify causes of the high prevalence of childhood anemia in remote and poor areas, as well as to provide timely public health service to economically disadvantaged populations.

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Contributorship: Huan Zhou formulated the research questions and designed the study; Yefan Du, Huan Zhou, and Ruixue Ye designed the search strategy. Yefan Du, Ying Liao, and Fangqun Leng conducted the search, retrieved publications, screened full text, and assessed the quality of the articles. Yefan Du wrote the draft of the manuscript, with specific sections collaborated by Ying Liao, and Fangqun Leng. Ying Liao and Yefan Du produced all figures and tables. Huan Zhou, Linhua Li, Yuping Mao, and Hein Raat reviewed the manuscript. All authors critically revised the manuscript and agreed to the published version of the manuscript.

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Figure legends

Figure 1 Location of the western region (red parts) in the map of China

Figure 2 Study selection profile

Note: Other resources referred to the studies scrutinized by the reference lists of published review articles, to locate additional relevant publications not identified during the database searches.

Figure 3 Point Estimates of Prevalence by Year in 9 Western Provinces (n=34)

Note: This figure used the time of each study conducted; only when the specific time of the study was not accounted for in the article, the time of publication of the article was chosen instead.

Figure 4 Frequency of studies on influencing factors of anemia in children under 5 years in Western China (n=27).

Note:

1. The darker the color, the more research,
2. "Ying Yang Bao" is a free nutrition package provided by the Chinese government for children aged 6-24 months in the poor rural areas.

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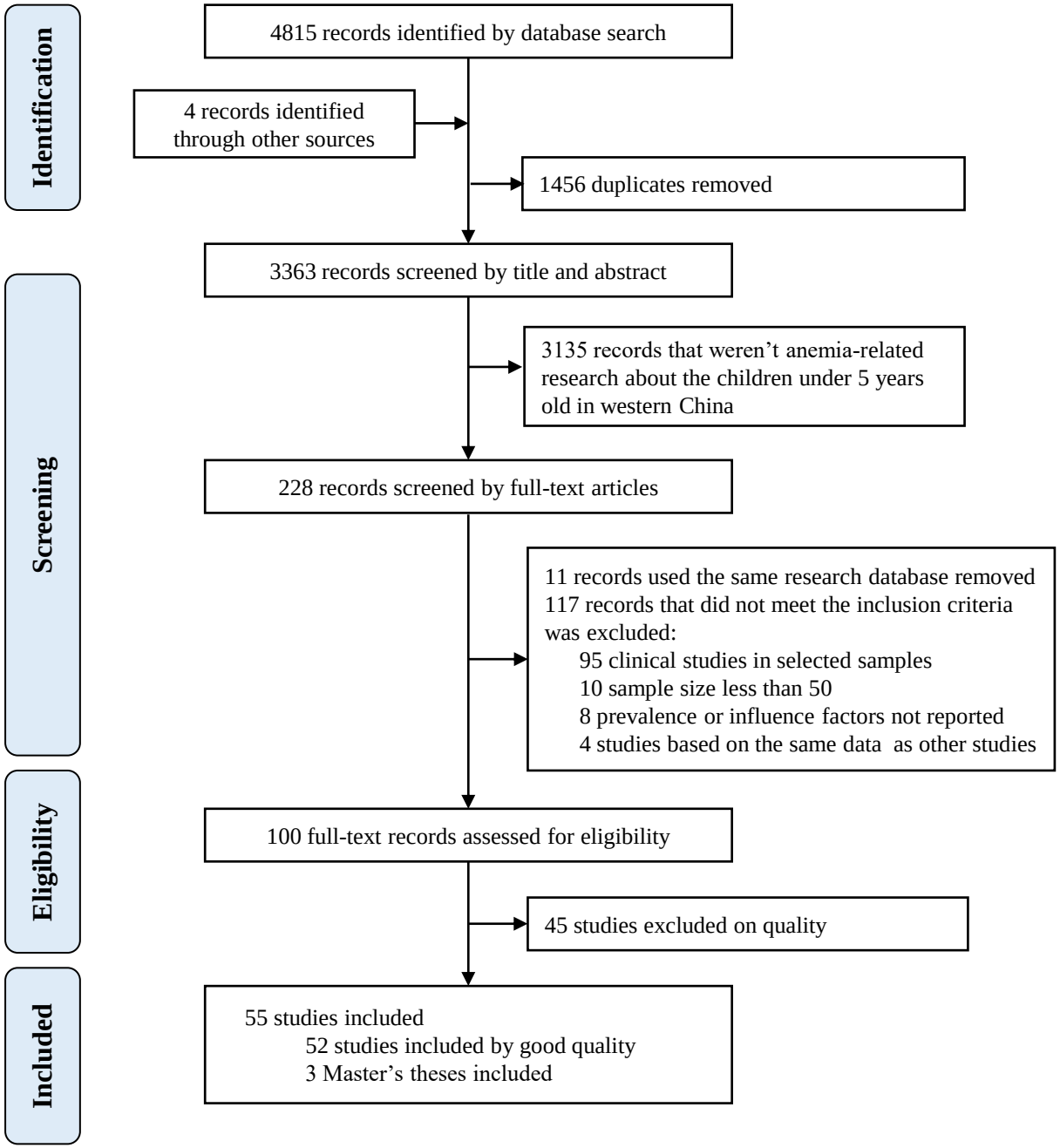
Identification
Screening
Eligibility
Included
4815 records identified by database search
4 records identified through other sources
1456 duplicates removed
3363 records screened by title and abstract
3135 records that weren't anemia-related research about the children under 5 years old in western China
228 records screened by full-text articles
11 records used the same research database removed
117 records that did not meet the inclusion criteria was excluded:
95 clinical studies in selected samples
10 sample size less than 50
8 prevalence or influence factors not reported
4 studies based on the same data as other studies
100 full-text records assessed for eligibility
45 studies excluded on quality
55 studies included
52 studies included by good quality
3 Master's theses included

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Associated Factors	Specific items associated with childhood anemia					
Children characteristics	Age in months (a1, a5, a6, a9-a11, a12, a13, a17, a18, a37, a38, a46, a51, a54, a55)	Ethnic group (a5, a10, a12, a13, a21, a38, a46, a51)	Sex (a18, a40, a42, a51, a54, a55)	Low birth weight (a13, a53)	Premature (a11, a42)	Illness in the past two weeks (a25)
Feeding behaviors	Breastfeeding status (a5, a11, a17, a23, a25, a38, a53)	Duration of continuous breastfeeding (a1, a9, a25, a42)	First time of introducing supplementary food (a9, a13, a25)	Supplementary food diversity (a6, a11, a13, a21, a23, a46, a55)	Frequency of supplementary food addition (a23, a38)	First bite of food after birth (a42)
Maternal characteristics	Education (a1, a38, a40, a42, a53, a54)	Gestational anemia (a10, a13, a51, a55)	Age (a6, a40, a53)	Occupation (a13, a18)	Iron supplementation during pregnancy (a11)	
Family characteristics	Annual household income per capita (a11, a13, a18, a53, a54)	Household environment (a21)	Family size (a51, a53)	Residence area (a13, a51)	Primary caregiver role (a13)	
Nutritional interventions	Ying Yang Bao (a13, a18, a24, a30, a38, a39, a44, a50)	Vitamin and mineral supplementation (a17, a21, a25, a55)	Home use of iron pots and pans (a51)			
Child health care	Medical Examination (a9, a10)	Vaccination (a10)				
Feeding knowledge	Feeding knowledge (a1, a5)					

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Appendix Table 1: Data extraction for anemia studies of children under 5 years in Western China

ID (1)	Reference (2)	Language (3)	Study design (4)	Year of data collection (5)	Place in which the study was conducted (6)	Age range (months) (7)	Sample size (8)	Prevalence estimates (9)	Quality score # (10)
a1	Xiao SY et al, 2021	Chinese	cross sectional study	2018.04-2018.07	Liangshan Prefecture, Sichuan Province	6-24	1244	51.90%	7
a2	Luo M et al, 2021	Chinese	cross sectional study	2019	Chengdu, Zigong, Panzhihua, Deyang, Luzhou, Leshan, Neijiang, Yibin, Guang'an, Suining, Guangyuan, Aba, Ganzi and Liangshan Prefecture, Sichuan Province	0-59	7534	6.16%	6
a3	Gao Y et al, 2020	Chinese	cross sectional study	2018.03-2018.05	Xinjiang Autonomous Region	6-24	3837	45.00%	7
a4	Xu W et al, 2020	Chinese	cross sectional study	2017.05-2019.07	Mianyang Prefecture, Sichuan Province	0-36	1090	17.06%	6
a5	Li FY et al, 2019	Chinese	cross sectional study	2017.08	Gansu Province	6-24	3188	25.69%	8
a6	Nie JC et al, 2019	Chinese	cohort study	2013-2016	Shaanxi Province	4-42	4722	44.40%	7
a7	Yue L et al, 2019	Chinese	cross sectional study	2018.09-2018.10	Gannan Prefecture, Gansu Province	0-60	1327	—†	7
a8	Zhu XX et al, 2019	Chinese	surveillance	2012-2018	Yunnan Province	0-59	35225	14.58%	7
a9	Zheng YY et al, 2019	Chinese	surveillance	2013.09-2013.12	Guizhou Province	6-59	853	14.90%	8
a10	Sun C et al, 2019	Chinese	cross sectional study	2014.10-2014.11	Liangshan Prefecture, Sichuan Province and Gannan Prefecture, Gansu Province	2-24	1065	52.68%	7
a11	Chen Y et al, 2019	Chinese	cohort study	2017.08-2018.08	Zunyi Prefecture, Guizhou Province	0-11	672	37.50%	8
a12	Li XQ et al, 2018	Chinese	cross sectional study	—	Ningxia Autonomous Region	6-24	2047	26. 40%	8
a13	Yu CY et al, 2018	Chinese	cross sectional study	2017.02-2018.01	Qiannan Prefecture, Guizhou Province	6-23	19498	47.59%	8
a14	Li ZC, 2018	Chinese	cross sectional study	2018.01-2018.12	Panzhihua Prefecture, Sichuan Province	0-36	1500	16.73%	6
a15	Shang GMJ, 2018	Chinese	cross sectional study	2013.04-2013.10	Shangluo, Ankang, Hanzhong Prefecture, Shaanxi Province	6-10	650	50.61%	-

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ID (1)	Reference (2)	Language (3)	Study design (4)	Year of data collection (5)	Place in which the study was conducted (6)	Age range (months) (7)	Sample size (8)	Prevalence estimates (9)	Quality score [#] (10)
a16	Liu GM et al, 2018	Chinese	surveillance	2012-2016	Korla and Shanshan County, Xinjiang Autonomous Region	0-59	19394	9.81%	7
a17	Zhan CX et al, 2017	Chinese	cross sectional study	2013.07-2013.09	Guizhou Province	6-23	779	57.60%	7
a18	Chen LQ et al, 2017	Chinese	cross sectional study	2014.10-2014.11	Jianchuan, Yiliang, Mojiang and Lushui County, Yunnan Province	6-23	1226	47.15%	7
a19	Jiang QJ et al, 2017	Chinese	cross sectional study	2013.07	Chongqing Municipality	6-24	706	51.70%	7
a20	Tang YB et al, 2016	Chinese	cross sectional study	2012.12	Lanping and Heqing County, Yunnan Province	6-23	642	35.20%	6
a21	Zhang YF et al, 2016	Chinese	cross sectional study	2012.08	Huzhu, Minhe and Guinan County, Qinghai Province	6-23	4394	67.80%	6
a22	Eysa ZRH et al, 2016	Chinese	cross sectional study	2014.06-2015.06	Altay Prefecture, Xinjiang Autonomous Region	0-36	793	67.30%	7
a23	Luo RF et al, 2016	Chinese	cross sectional study	2013.04-2013.10	Shaanxi Province	6-12	1770	48.87%	8
a24	Jiang QJ et al, 2016	Chinese	cohort study	2013.07-2014.07	Chongqing Municipality	6-24	706	—†	7
a25	Sun L et al, 2015	Chinese	cross sectional study	—	Shaanxi Province	6-11	951	54.26%	8
a26	Xu YY et al, 2015	Chinese	cross sectional study	2012.07	Yushu, Chenduo, Zhiduo, Nangqian, Zaduo and Qumalai County, Qinghai Province	6-35	978	64.70%	6
a27	Hong M et al, 2015	Chinese	cross sectional study	2014	Hulunbuir Prefecture, Inner Mongolia Autonomous Region	3-59	338	5.33%	7
a28	Yang MZ et al, 2014	Chinese	cross sectional study	2011.03-2011.07	Yunnan, Guizhou, and Sichuan Province	6-24	3410	22.40%	7
a29	Tang SW et al, 2014	Chinese	cross sectional study	2012.09-2012.11	Urumqi and Urumqi County, Xinjiang Autonomous Region	6-36	2138	29.98%	8
a30	Chen R et al, 2014	Chinese	randomized controlled trial	2009-2010	Gansu Province	0-60	1218	3.69%	6
a31	Dong CX et al, 2013	Chinese	cross sectional study	—	Yuzhong and Yongjing County, Gansu Province	6-23	837	58.20%	7
a32	Yuan YY et al, 2013	Chinese	cross sectional study	—	Shaanxi Province	0-18	336	35.12%	6

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ID (1)	Reference (2)	Language (3)	Study design (4)	Year of data collection (5)	Place in which the study was conducted (6)	Age range (months) (7)	Sample size (8)	Prevalence estimates (9)	Quality score # (10)
a33	Yao LQ et al, 2013	Chinese	cross sectional study	—	Xishuangbanna, Yuxi and Dehong Prefecture, Yunnan Province	0-59	2355	29.55%	7
a34	Zhao SH et al, 2013	Chinese	cross sectional study	—	Danzhai, Huishui and Longli County, Guizhou Province	0-59	884	35.27%	6
a35	Yao LQ et al, 2013	Chinese	cross sectional study	2009.06-2011.09	Yunnan Province	0-59	9850	13.22%	8
a36	Sun LH et al, 2012	Chinese	cross sectional study	2010	Pucheng, Chunhua, Yuyang, Jia and Xixiang County, Shaanxi Province	0-60	1951	32.00%	7
a37	Zhao WL et al, 2012	Chinese	cross sectional study	2009.08-2009.09	Longxi and Kangle County, Gansu Province	0-59	1398	11.70%	8
a38	Ma YY, 2012	Chinese	randomized controlled trial	2009.04-2009.08	Moridawa Banner, Oroqen Banner, Arong Banner and Zhalantun, Inner Mongolia Autonomous Region	6-24	1364	45.00%	-
a39	Zhao WL et al, 2012	Chinese	randomized controlled trial	—	Longxi and Kangle County, Gansu Province	0-59	1212	—†	8
a40	Kang YY et al, 2012	Chinese	cross sectional study	2010.07-2010.08	Lhasa Prefecture, Tibet Autonomous Region	0-35	540	41.70%	8
a41	Zhang JG et al, 2011	Chinese	cross sectional study	2009	Sichuan, Gansu and Guizhou Province, Inner Mongolia, Guangxi and Xinjiang Autonomous Region	0-59	8141	24.10%	8
a42	Li ML, 2011	Chinese	cross sectional study	2008.10	Guangxi Autonomous Region	0-24	663	25.90%	-
a43	Zhao XF et al, 2011	Chinese	cross sectional study	2009.04	Pengzhou County, Sichuan Province, Kang County, Gansu Province, Ningqiang County, Shaanxi Province	0-59	466	31.07%	6
a44	Huo JS et al, 2015	English	cohort study	2010.05-2011.11	Sichuan, Shaanxi and Gansu Provinces	6-23	4590	52.80%	9
a45	Yang WF et al, 2012	English	cross sectional study	2010.03-2010.10	Shaanxi Province	0-18	336	35.12%	8
a46	Huang YW et al, 2019	English	cross sectional study	2018.07	Huzhu County, Qinghai Province	6-23	754	59.10%	9
a47	Luo RF et al, 2017	English	quasi-experiment	2013.04-2015.04	Shaanxi Province	6-11	1802	48.00%	9
a48	Zhang YF et al, 2016	English	quasi-experiment	2012.08-2014.08	Huzhu and Guinan County in Qinghai Province	6-23	2593	75.74%	8
a49	Yang F et al, 2015	English	cohort study	2009.06	Shifang Prefecture, Sichuan Province	0-59	2165	12.40%	8

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ID (1)	Reference (2)	Language (3)	Study design (4)	Year of data collection (5)	Place in which the study was conducted (6)	Age range (months) (7)	Sample size (8)	Prevalence estimates (9)	Quality score # (10)
a50	Dong CX et al, 2013	English	quasi-experiment	2010.05-2011.10	Kang County, Gansu Province	6-24	1019	74.30%	6
a51	Gao WL et al, 2013	English	cross sectional study	2005.06-2005.08	Xinjiang, Qinghai, Ningxia, Sichuan, Guangxi, Guizhou, Gansu Province, Inner Mongolia Autonomous Region, and Chongqing Municipality	6-35	6711	52.47%	7
a52	Sun J et al, 2013	English	cross sectional study	2010.04-2010.05	Sichuan, Shaanxi and Gansu Provinces	6-23	1254	52.20%	6
a53	Wang L et al, 2019	English	cohort study	2013-2017	The Qinba Mountain Area of China	6-12	1170	51.00%	7
a54	Wang L et al, 2018	English	surveillance	2016-2017	Xinjiang, Tibet, Qinghai, Ningxia, Yunnan, Sichuan, Guangxi, Guizhou, Gansu and Shaanxi Province, Inner Mongolia Autonomous Region, and Chongqing Municipality	6-30	2380	49.00%	7
a55	Wang J et al, 2015	English	cross sectional study	2010.08-2010.09	Zheng'an County, Guizhou Province, Wuding County, Yunnan Province and Zhen'an County, Shaanxi Province	12-35	1379	25.60%	7

Notes: * Master's degree thesis. † Total anemia prevalence was not reported.

One point is assigned to a 'yes' response, and the quality score ranges from 0 to 9, with a higher score indicating a lower risk of bias.

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Appendix Table 2: Methodological quality assessments using Joanna Briggs Institute Critical Appraisal Checklist for Studies Reporting Prevalence Data forms

ID	Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Score#
a1	Xiao SY et al, 2021	Y	Y	N	Y	Y	Y	Y	Y	U	7
a2	Luo M et al, 2021	Y	Y	N	Y	Y	Y	N	Y	U	6
a3	Gao Y et al, 2020	Y	Y	N	Y	Y	Y	Y	Y	U	7
a4	Xu W et al, 2020	Y	N	N	Y	Y	Y	Y	Y	U	6
a5	Li FY et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a6	Nie JC et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	U	7
a7	Yue L et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	U	7
a8	Zhu XX et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	U	7
a9	Zheng YY et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a10	Sun C et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	U	7
a11	Chen Y et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a12	Li XQ et al, 2018	Y	Y	Y	Y	Y	Y	U	Y	Y	8
a13	Yu CY et al, 2018	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a14	Li ZC, 2018	Y	Y	N	Y	Y	N	Y	Y	U	6
a15	Shang GMJ, 2018*	-	-	-	-	-	-	-	-	-	-
a16	Liu GM et al, 2018	Y	Y	N	Y	Y	Y	Y	Y	U	7
a17	Zhan CX et al, 2017	Y	Y	N	Y	Y	Y	Y	Y	U	7
a18	Chen LQ et al, 2017	Y	Y	N	Y	Y	Y	Y	Y	U	7
a19	Jiang QJ et al, 2017	Y	Y	N	Y	Y	Y	Y	Y	U	7
a20	Tang YB et al, 2016	Y	Y	N	N	Y	Y	Y	Y	U	6
a21	Zhang YF et al, 2016	Y	Y	N	N	Y	Y	Y	Y	U	6
a22	Eysa ZRH et al, 2016	Y	Y	N	Y	Y	Y	Y	Y	U	7
a23	Luo RF et al, 2016	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a24	Jiang QJ et al, 2016	Y	N	N	Y	Y	Y	Y	Y	Y	7
a25	Sun L et al, 2015	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a26	Xu YY et al, 2015	Y	Y	N	Y	Y	Y	N	Y	N	6
a27	Hong M et al, 2015	Y	Y	N	Y	Y	Y	Y	Y	U	7
a28	Yang MZ et al, 2014	Y	Y	N	Y	Y	Y	N	Y	Y	7
a29	Tang SW et al, 2014	Y	Y	Y	Y	Y	Y	N	Y	Y	8
a30	Chen R et al, 2014	Y	Y	N	Y	Y	N	Y	Y	U	6
a31	Dong CX et al, 2013	Y	Y	N	Y	Y	Y	Y	Y	U	7
a32	Yuan YY et al, 2013	Y	Y	N	Y	Y	Y	N	Y	U	6
a33	Yao LQ et al, 2013	Y	Y	Y	N	Y	Y	Y	Y	U	7
a34	Zhao SH et al, 2013	Y	Y	N	N	Y	Y	Y	Y	U	6
a35	Yao LQ et al, 2013	Y	Y	Y	Y	Y	Y	Y	Y	U	8
a36	Sun LH et al, 2012	Y	Y	N	Y	Y	Y	Y	Y	U	7
a37	Zhao WL et al, 2012	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a38	Ma YY, 2012*	-	-	-	-	-	-	-	-	-	-

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ID	Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Score#
a39	Zhao WL et al, 2012	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a40	Kang YY et al, 2012	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a41	Zhang JG et al, 2011	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a42	Li ML, 2011*	-	-	-	-	-	-	-	-	-	-
a43	Zhao XF et al, 2011	Y	Y	N	Y	Y	N	Y	Y	U	6
a44	Huo JS et al, 2015	Y	Y	Y	Y	Y	Y	Y	Y	Y	9
a45	Yang WF et al, 2012	Y	Y	Y	Y	Y	Y	N	Y	Y	8
a46	Huang YW et al, 2019	Y	Y	Y	Y	Y	Y	Y	Y	Y	9
a47	Luo RF et al, 2017	Y	Y	Y	Y	Y	Y	Y	Y	Y	9
a48	Zhang YF et al, 2016	Y	N	Y	Y	Y	Y	Y	Y	Y	8
a49	Yang F et al, 2015	Y	Y	N	Y	Y	Y	Y	Y	Y	8
a50	Dong CX et al, 2013	Y	Y	N	Y	Y	Y	N	Y	N	6
a51	Gao WL et al, 2013	Y	Y	N	Y	Y	Y	U	Y	Y	7
a52	Sun J et al, 2013	Y	Y	N	Y	Y	Y	N	Y	N	6
a53	Wang L et al, 2019	Y	Y	N	Y	Y	Y	Y	Y	N	7
a54	Wang L et al, 2018	Y	Y	N	Y	Y	Y	Y	Y	U	7
a55	Wang J et al, 2015	Y	Y	N	Y	Y	Y	Y	Y	U	7
56	Liu HX et al, 2019	N	N	N	Y	Y	Y	Y	Y	U	5
57	Dai SJ, 2019	N	N	N	Y	Y	Y	Y	Y	U	5
58	Wang XR et al, 2017	Y	Y	N	Y	Y	Y	N	N	U	5
59	Chen R et al, 2013	Y	Y	N	Y	Y	N	N	Y	U	5
60	Zhang RF et al, 2018	Y	Y	N	Y	Y	Y	U	N	U	5
61	Cui JS et al, 2018	Y	Y	N	Y	Y	Y	U	N	U	5
62	Zhu F et al, 2017	Y	N	N	Y	Y	Y	U	Y	U	5
63	Li X et al, 2017	N	Y	N	U	U	Y	Y	Y	Y	5
64	Xu YQ et al, 2011	N	Y	N	Y	Y	Y	N	Y	U	5
65	Wei P et al, 2016	Y	N	N	Y	Y	Y	U	Y	U	5
66	Gi LPL et al, 2015	Y	Y	N	Y	Y	N	U	Y	U	5
67	Shen QL et al, 2019	N	N	N	Y	Y	Y	U	Y	U	4
68	Zhao B et al, 2019	Y	N	N	Y	Y	Y	N	N	U	4
69	Jing S et al, 2016	N	U	N	Y	Y	Y	U	Y	U	4
70	Wu XH et al, 2016	N	N	N	Y	Y	Y	U	Y	U	4
71	Lu ZH et al, 2015	N	N	U	Y	Y	Y	U	Y	U	4
72	Guan LL et al, 2014	U	U	N	Y	Y	Y	U	Y	U	4
73	Yang YY et al, 2014	N	Y	N	N	Y	Y	U	Y	U	4
74	Ma JF et al, 2014	N	N	N	Y	Y	Y	U	Y	U	4
75	Sun J et al, 2014	N	N	N	Y	Y	Y	U	Y	U	4
76	Ma Y et al, 2014	N	N	N	Y	Y	Y	U	Y	U	4
77	He M et al, 2013	N	N	N	Y	Y	N	Y	Y	U	4
78	Hong M et al, 2012	Y	N	N	Y	Y	N	Y	N	U	4

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ID	Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Score[#]
79	Xu DF et al, 2011	N	N	N	Y	Y	Y	N	Y	U	4
80	Yao SY et al, 2020	Y	U	U	Y	U	N	N	Y	U	3
81	Lin G et al, 2019	N	N	N	Y	Y	Y	N	N	U	3
82	Du XJ et al, 2017	N	N	N	Y	Y	Y	U	N	U	3
83	Yang XD et al, 2017	N	N	N	Y	Y	Y	U	N	U	3
84	Zhang YY et al, 2016	N	N	N	N	Y	Y	U	Y	U	3
85	Luo GQ et al, 2016	Y	U	Y	N	U	Y	U	U	U	3
86	Dong YL et al, 2016	Y	N	N	Y	U	U	U	Y	U	3
87	Li YZ et al, 2015	U	U	U	N	Y	Y	U	Y	U	3
88	Gu LMR et al, 2014	U	U	U	Y	Y	N	U	Y	U	3
89	Lie LZ et al, 2014	Y	N	N	Y	U	N	U	Y	U	3
90	Cui CX et al, 2013	Y	Y	N	N	U	Y	N	N	U	3
91	Huang CX et al, 2012	Y	N	N	Y	N	N	N	Y	U	3
92	Qiu YL et al, 2012	N	N	N	N	Y	Y	U	Y	U	3
93	Su XQ et al, 2011	N	N	N	Y	Y	Y	N	N	U	3
94	Yin MH et al, 2012	N	N	N	N	Y	Y	N	N	U	2
95	Yu WT et al, 2012	Y	N	N	N	N	N	Y	N	U	2
96	Dong YL et al, 2014	Y	N	N	N	Y	N	N	N	U	2
97	Du WW et al, 2011	N	N	N	Y	N	N	N	Y	U	2
98	Wei XX et al, 2011	N	N	N	N	N	Y	N	Y	U	2
99	Wan R et al, 2011	Y	U	N	N	U	N	Y	N	U	2
100	Zhou Q et al, 2017	N	N	N	Y	Y	N	N	U	U	2

Notes: * Master's degree thesis.

[#] Each item has four choices: yes (Y), no (N), unclear (U) or not applicable (-). One point is assigned to a 'yes' response, and the quality score is the sum of the 9 items, ranging from 0 to 9, with a higher score indicating a lower risk of bias.

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JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data

Reviewer_____Date_____.

Author_____Year_____Record Number_____.

	Yes	No	Unclear	Not applicable
1. Was the sample frame appropriate to address the target population?	?	?	?	?
2. Were study participants sampled in an appropriate way?	?	?	?	?
3. Was the sample size adequate?	?	?	?	?
4. Were the study subjects and the setting described in detail?	?	?	?	?
5. Was the data analysis conducted with sufficient coverage of the identified sample?	?	?	?	?
6. Were valid methods used for the identification of the iron deficiency anemia (with a general diagnostic criteria)?	?	?	?	?
7. Was the condition measured in a standard, reliable way for all participants?	?	?	?	?
8. Was there appropriate statistical analysis?	?	?	?	?
9. Was the response rate adequate, and if not, was the low response rate managed appropriately (>15% as sufficient)?	?	?	?	?

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Medline search term - Ovid interface

1. exp Anemia/
2. anaemia.mp.
3. exp Anemia, Iron-Deficiency/
4. IDA.mp.
5. nutritional anemia.mp.
6. 1 or 2 or 3 or 4 or 5
7. exp Infant/
8. exp Child/
9. exp Child, Preschool/
10. 7 or 8 or 9
11. exp China/
12. Chinese.mp.
13. 11 or 12
14. 6 and 10 and 13
15. limit 14 to yr = ”2011-2021”

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