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Retrospective Study

Anemia status of infants and young children aged six to thirty-six months in Ma'anshan City: A retrospective study

Wang XM *et al*. Retrospective study on the anemia status

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Abstract

BACKGROUND

Anemia in infants and young children can have long-term effects on cognitive and physical development. In Ma'anshan City, China, there has been growing concern about the prevalence of anemia among children aged 6 to 36 mo. Understanding the factors influencing this condition is crucial for targeted interventions and improving overall child health in the region.

AIM

To analyze the anemia status and influencing factors of infants and young children aged 6 to 36 mo in Ma'anshan City, China. Providing scientific evidence for reducing the incidence of anemia and improving the health level of children in this age group.

METHODS

The study encompassed 37698 infants and young children, aged from 6 to 36 mo, who underwent health examinations at the Ma'anshan Maternal and Child Health Hospital from January 2018 to October 2022 were included in the study. Basic information, physical examination, and hemoglobin detection data were collected. Descriptive analysis was used to analyze the prevalence of anemia in children in the region, and univariate analysis was used to analyze the influencing factors of anemia.

RESULTS

The mean hemoglobin level of infants and young children aged 9 to 36 mo increased with age, and the anemia detection rate decreased with age. The anemia detection rate in rural infants aged 6, 9, and 12 mo was higher than that in urban infants. Although the anemia detection rate was higher in 6-mo-old boys than girls, it was higher in 24-mo-old girls than boys. There were statistically significant differences in the anemia detection rates among 9-mo-old and 12-mo-old infants with different nutritional statuses (emaciation, overweight, obese, and normal). Moreover, there were no

statistically significant differences in anemia detection rates among infants and young children with different nutritional statuses at other ages. Besides, the anemia detection rates in obese infants aged 9 and 12 mo were higher than those in normal and overweight infants, with statistically significant differences. Finally, there were no statistically significant differences in the anemia detection rates between emaciation infants and those with other nutritional statuses.

CONCLUSION

The anemia situation among infants and young children aged 6 to 36 mo in Ma'anshan City, China, is relatively prominent and influenced by various factors. Our result shown that attention should be paid to the anemic infant and young child population, with strengthened education and targeted prevention and dietary guidance to help them establish good living habits, improve nutritional status, and reduce the occurrence of anemia to improve children's health levels.

Key Words: Infants; Children; Anemia; Hemoglobin; Anemia detection rates

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Core Tip: In Ma'anshan City, China, anemia is notably prevalent among infants and young children aged 6 to 36 mo, with its incidence influenced by age, urban-rural differences, gender, and nutritional status. Particularly, rural infants and those with certain nutritional statuses, such as obesity, show higher anemia detection rates. To enhance children's health, it's imperative to focus on this vulnerable group, offering them specialized education, dietary guidance, and preventive measures to foster healthy living habits and better nutritional outcomes.

INTRODUCTION

Anemia is a serious global public health issue, affecting approximately one-third of the world's population[1,2]. Children, particularly those under five years of age, are among the high-risk groups for developing anemia. Statistics from 2011 indicate that nearly 43% of children under five were affected by anemia, translating to an alarming estimate of 273 million children globally grappling with this condition[3]. In China, according to the Outline of China's Food and Nutrition Development by the State Council Office, the prevalence of anemia among 2-3-year-old children is in a plateau phase, gradually decreasing after the age of three and continuing to decline until adolescence, which is consistent with international reports[4]. For infants and young children, anemia has irreversible adverse effects on growth and development[1], and is associated with impaired psychomotor development, cognitive dysfunction, and reduced physical activity[5-8]. It not only affects the growth and development of children, but can also cause varying degrees of damage to their intelligence, personality, and immune function[9].

In recent years, China has prioritized the prevention and control of anemia in children, but the prevalence remains high, and there are significant differences in the detection rates of anemia among children of different ages and regions. Therefore, analyzing regional data on childhood anemia and implementing effective targeted intervention measures are urgently needed. Our study investigates and analyzes the current status and influencing factors of anemia among infants and young children aged 6 to 36 mo in Ma'anshan City, China, providing reference materials for reducing the incidence of anemia and improving the health level of children in this age group in the region and has significant guiding implications.

MATERIALS AND METHODS

Study subjects

The study included a total of 37698 infants and young children aged 6 to 36 mo who received health examinations at the Ma'anshan Maternal and Child Health Hospital between January 2018 and October 2022, with the consent and active cooperation of the children's guardians in the data collection process. Our study subjects included 19669 boys and 18029 girls, with a male to female ratio of 1.09:1. These children underwent health examinations at the Ma'anshan Maternal and Child Health Hospital by month of age, with 29291 6-mo-old infants, 7105 9-mo-old infants, 17374 12-mo-old infants, 14799 24-mo-old children, and 5839 36-mo-old children.

Inclusion criteria: All 37698 cases were diagnosed as infant and young child anemia by physicians at the Ma'anshan Maternal and Child Health Hospital and had informed consent forms signed by their immediate relatives. Those with severe abnormalities in the functions of the heart, liver, kidney, lung, or other organ systems were excluded from the analysis. This study was approved by the Ethics Committee of the Ma'anshan Maternal and Child Health Hospital.

Research methods

Physical measurement method: Height measurement: A horizontal height measuring instrument was used for children aged 6 to 24 mo, and a vertical height measuring instrument was used for children aged > 24 mo and ≤ 36 mo. The children were required to look straight ahead, with their heels, waist, shoulder blades, and occiput fully in contact with the measuring device, and the distance from the top of their head to the bottom of their feet was recorded.

Weight measurement: A regular electronic scale was used, and the children were required to remove their outer clothes, pants, and socks before measuring.

Nutritional status determination: Height and weight were compared according to the "Chinese Growth Standards for Children Under 7 Years Old WS/T 423-2022". "Emaciation" and "severe emaciation" were combined into emaciation (height/length-for-weight below -2SD), normal (height/length-for-weight above -2SD and < +1SD),

overweight (height/length-for-weight above +1SD and < +2SD), and "obesity" and "severe obesity" were combined into obesity (height/length-for-weight above +2SD).

Specimen collection and laboratory testing: 0.1 mL of peripheral blood was collected for hemoglobin detection, and the hemoglobin detector was a Mindray BC-7500 CRP fully automatic blood analyzer (China Mindray Medical Company).

Anemia determination: Hemoglobin levels were diagnosed according to the World Health Organization (WHO) criteria for childhood anemia: < 110g/L was considered anemia[10].

Quality control

Physicians who carried out physical measurements and examinations were uniformly trained and used hospital-issued standardized physical measurement tools. Measurement standards were unified.

Statistical analysis

Data entry and organization were performed using Excel, and data analysis was conducted using SPSS 21.0. Quantitative data comparisons were made using analysis of variance, while qualitative data comparisons were made using the χ^2 test. A P-value < 0.05 was considered statistically significant.

RESULTS

Mean hemoglobin levels

Mean hemoglobin levels for different age groups: As is shown in Table 1, there were significant differences in the mean hemoglobin levels among the different age groups, and the differences were statistically significant (χ^2 = 2004.658, P < 0.001). From 9 to 36 mo, the mean hemoglobin levels showed an increasing trend with age.

Mean hemoglobin levels for different genders in each age group: As is shown in Table 2, at 12 mo, the mean hemoglobin level for boys was 121.61 ± 10.56 g/L, and for girls it was 121.05 ± 10.06 g/L. The difference in mean hemoglobin levels between boys and girls at 12 mo was statistically significant ($t = 3.583$, $P < 0.001$), while the differences in mean hemoglobin levels between genders in other age groups were not statistically significant.

Anemia detection

Anemia detection rate in different age groups, genders, and regions: As is shown in Table 3, among 6-mo-olds, 3862 cases of anemia were detected, with a detection rate of 13.2%. Among 9-mo-olds, 1389 cases of anemia were detected, with a detection rate of 19.5%. Among 12-mo-olds, 1690 cases of anemia were detected, with a detection rate of 9.7%. Among 24-mo-olds, 372 cases of anemia were detected, with a detection rate of 2.5%. And among 36-mo-olds, 129 cases of anemia were detected, with a detection rate of 2.2%. There were significant differences in the anemia detection rates among different age groups ($\chi^2 = 2366.51$, $P < 0.001$), with the detection rate decreasing as age increased from 9 mo to 36 mo.

As is shown in Table 4, anemia detection rates were higher in rural children aged 6, 9, and 12 mo compared to urban children, and the differences were statistically significant. The detection rate differences between urban and rural areas in other age groups were not statistically significant. The anemia detection rate was higher in 6-mo-old boys than girls, and higher in 24-mo-old girls than boys, with statistically significant differences. In other age groups, the differences in anemia detection rates between genders were not statistically significant.

Anemia detection rates in different nutritional statuses at various ages: As is shown in Table 5, among 9-mo-old and 12-mo-old infants, the anemia detection rates in different nutritional statuses (emaciation, overweight, obese, and normal) showed statistically significant differences. In other age groups, there were no statistically

significant differences in anemia detection rates among infants and young children with different nutritional statuses.

The overall mean values of the four groups of data for 9-mo-old infants showed statistical differences (χ^2 = 16.882, P = 0.001), and the overall mean values of the four groups of data for 12-mo-old infants also showed statistical differences (χ^2 = 15.383, P = 0.002). Both 9-mo-old and 12-mo-old obese infants had higher anemia detection rates than normal-weight and overweight infants, with statistically significant differences. There were no statistically significant differences in anemia detection rates between emaciation infants and infants with other nutritional statuses.

DISCUSSION

Anemia is one of the most severe global public health problems in the 21st century. Alarmingly, children have consistently been the population with the highest prevalence of anemia worldwide[11]. Specifically, the prevalence of anemia in children aged 6-59 mo is as high as 40% or more[3], and infants aged 6-24 mo are also at high risk for anemia[12]. Furthermore, anemia has varying degrees of impact on children's immune function, growth and development, motor and cognitive function development, among other aspects[13-16]. Recent literature also suggests that there is a positive correlation between anemia and autism spectrum disorder, attention deficit hyperactivity disorder, and learning disabilities[17].

The WHO has proposed a public health classification standard for anemia prevalence in populations: a detection rate of ≥ 40% is considered a severe public health issue; rates between 20.0% and 39.9% signify a moderate public health concern; rates ranging from 5.0% to 19.9% indicate a mild public health concern; a rate of ≤ 4.9% falls within the normal prevalence range[10]. Our study conducted from 2018 to 2022, included a total of 37,698 infants and toddlers aged 6 to 36 mo, revealing the anemia detection rate and average hemoglobin levels for infants and toddlers aged 6 to 36 mo in the Ma'anshan region from 2018 to 2022. During this period, anemia in infants aged 6 to 12 mo in the area was considered a mild public health issue (anemia detection rate at 13.2% for 6-mo-

olds, 19.5% for 9-mo-olds, and 9.7% for 12-m-olds), higher than the anemia prevalence rates found in the Baiyun District of Guangzhou (8.07%), Xicheng District of Beijing (5.99%), and Baoshan District of Shanghai (8.83%) for infants and toddlers aged 6 to 24 mo, as retrieved from the CNKI (National Knowledge Infrastructure). Notably, these prevalence rates are markedly lower than those observed in Huaihua City, Hunan Province (29.73%), the Inner Mongolia Autonomous Region (33.28%), and Gansu Province (25.69%). For the age group of 24 to 36 mo, anemia levels were comfortably within the standard range, with detection rates of 2.5% at 24 mo and 2.2% at 36 mo. These figures are also below those of neighboring cities in Anhui Province, such as Wuhu City (3.19%) and Hefei City (3.84%).

Hemoglobin is a protein in red blood cells responsible for carrying oxygen from the lungs to various parts of the body and transporting carbon dioxide back to the lungs for exhalation[18]. Hemoglobin content is an important indicator of the body's oxygen transport capacity[19]. Our findings indicated that as children age from 9 to 36 mo, their average hemoglobin levels tend to rise. This trend could be attributed to the fluctuations in hormone levels and growth factors inherent to child development. Specifically, erythropoietin - a hormone instrumental in fostering the production and maturation of red blood cells - might experience variations in its secretion levels as children grow, subsequently influencing hemoglobin concentrations[20,21]. The period from 9 to 36 mo is when children experience the fastest growth, tripling their size at birth[22], indicating an increased need for iron[23,24]. Our results also found that there is a statistically significant difference in the average hemoglobin levels between 12-mo-old boys and girls, which may be due to differences in growth rates. It has been found that in many families, girls are given less food than boys, overlooking the fact that girls develop nearly two years earlier than boys. Nutritional deficiencies are also a major cause of significant differences in hemoglobin levels between 12-mo-old boys and girls[25]. The lack of significant gender differences in hemoglobin levels at other ages may be related to the gradual development of the brain and the improvement of girls' active eating abilities.

Furthermore, our research identified that within the Ma'anshan region, the peak anemia detection rate was observed in infants aged 6 to 9 mo, reaching a significant 19.5%. Beyond this age bracket, specifically from 9 to 36 mo, there's a discernible decline in the anemia detection rate. For infants between 6 to 12 mo, anemia remains categorized as a mild public health concern. Delving into the CNKI database, we discerned that in a multi-center Chinese study examining the prevalence and temporal trends of anemia in infants and toddlers aged 6 to 23 mo, the highest prevalence of anemia was pinpointed in the 6 to 11 mo age group, with a subsequent decline as age advanced. This pattern aligns with findings from studies undertaken in seven Chinese cities, two towns, and Shanghai. Analogous trends have been documented in numerous other countries as well[26,27]. The period from 6 to 9 mo is critical for introducing complementary foods, and the high prevalence of anemia may be related to improper or unsuccessful addition of complementary foods, failure to timely supplement iron-fortified foods and red meat, infants' maladaptation to complementary foods, and the inability of dairy foods to meet growth and development needs, or due to religious or economic reasons[28,29]. It is necessary to strengthen nutrition education and guidance for infants, especially those aged 6 to 9 mo, to reduce the incidence of anemia.

Moreover, the anemia detection rate for 6-mo-old boys was higher than that for girls, while at 24 mo, girls had a higher rate than boys, with statistically significant differences. However, there were no statistically significant differences in anemia detection rates between different genders at other ages.

In contrast to data from CNKI, our findings diverge from studies on childhood anemia reported in regions like Beijing, Henan, and Shanghai, as well as from the most recent benchmarks set by the Chinese health system. It's imperative to highlight that the rate of anemia detection might be influenced by regional disparities. Specifically, unique risk factors associated with left-behind children play a role. For instance, a diminished family income can result in reduced nutritional intake. Additionally, the underdeveloped chewing and digestive capabilities of young children limit the variety

of foods they can effectively digest. This leads to a restricted intake of essential micronutrients, potentially culminating in anemia[30-33].

In the Ma'anshan region, the anemia detection rate for infants and toddlers aged 6 to 36 mo was highest in rural populations at 24.0% and urban populations at 14.2%, both peaking in 9-mo-old infants. This may be related to the improper or unsuccessful addition of complementary foods at this age, as well as urban-rural economic and cultural differences. According to data from the 2013 China National Nutrition and Health Survey, the prevalence of anemia among children under 5 years old in China was 11.6%, with 10.6% in urban areas and 12.4% in rural areas. While these figures are still relatively high, they are lower compared to the prevalence of childhood anemia in some other rural areas of China, such as Jiangxi (53.9%) and Qinghai (59.1%), suggesting that the infant and child healthcare efforts in the Ma'anshan region have been effective. However, this study suggests that there are differences in anemia detection rates between urban and rural infants aged 6 to 12 mo in the Ma'anshan region, which may be related to the educational level of the primary caregivers who directly influence children's nutritional intake[34]. Both excessive and insufficient intake can cause various health problems in children. It is still necessary to evaluate intervention measures in infant populations, especially in vulnerable rural groups, to strengthen education and guidance, and for the government to implement more targeted policies to reduce the prevalence of anemia.

In 9-mo-old and 12-mo-old infants, the anemia detection rates for different nutritional statuses (emaciation, overweight, obese, and normal) showed statistically significant differences, while there were no statistically significant differences in anemia detection rates for infants and toddlers with different nutritional statuses at other age groups. Both obese 9-mo-old and 12-mo-old infants had higher anemia detection rates than normal and overweight infants, with statistically significant differences. There were no statistically significant differences in anemia detection rates between emaciation infants and infants with other nutritional statuses[35,36]. This suggests that the nutritional status of infants and toddlers is related to the occurrence of anemia, emphasizing the need to

strengthen education and guidance on feeding and nutrition among the parents of infants, in order to reduce the prevalence of anemia and improve their growth status.

CONCLUSION

Our research indicates a significant correlation between nutritional status and anemia. Nutritional status plays an important role in the production of hemoglobin and the function of red blood cells[37], thus directly affecting the occurrence and development of anemia. Nutrients in food, such as iron[38], are essential elements for the synthesis of hemoglobin. Iron deficiency is the most common cause of anemia. Folate and vitamin B_{12} are crucial for the production and maturation of red blood cells[39]. Deficiencies in these nutrients can lead to macrocytic anemia, characterized by increased red blood cell volume and decreased cell count. In addition, vitamin B_6 plays an auxiliary role in the synthesis of hemoglobin. Long-term vitamin B_6 deficiency may affect hemoglobin production and consequently cause anemia[40]. Furthermore, protein is the main component of hemoglobin and participates in the production of red blood cells. Long-term insufficient protein intake may lead to anemia. Other trace elements, such as copper, also play a role in red blood cell production and hemoglobin synthesis[41].

Preserving optimal nutritional health and securing sufficient intake of vital nutrients are fundamental in both preventing and addressing anemia. For those diagnosed with anemia, specific nutritional interventions, including the administration of iron supplements, folate, and vitamin B_{12}, have proven effective in ameliorating the condition. This study analyzes the anemia status and influencing factors of infants and toddlers aged 6 to 36 mo in Ma'anshan City, Anhui Province, providing a scientific basis for reducing the prevalence of anemia and improving child health. However, this study, as a retrospective analysis, did not conduct a detailed questionnaire survey, and the analysis of influencing factors is insufficient. Moreover, the age range of 0 to 24 mo is a critical period for neurobehavioral development, vulnerable to the influence of risk factors such as anemia, which can persist throughout the lifespan. The anemia status of 6 to 12-mo-old infants in this region still poses a mild public health problem, reminding

us to pay further attention to infant anemia, regularly screen for anemia and conduct neurobehavioral assessments in infants and toddlers, detect anemia and neurobehavioral development deviations as early as possible, provide timely and effective prevention, treatment, and early intervention, and ensure the healthy growth of children. The cognitive, motor, and learning capacities of children identified with anemia in this research warrant further exploration in future studies.

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