

# Prevalence of iron deficiency anemia in Iranian children under 6 years of age: a systematic review and meta-analysis

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**Background:** Iron deficiency anemia is a prevalent condition among children in developing and developed countries that leads to impaired development, activity intolerance, behavioral changes, irritability, and reduced learning ability. The studies conducted in Iran have reported different prevalence rates for this condition. This systematic review and meta-analysis were aimed at estimating the prevalence of iron deficiency anemia in Iranian children under 6 years of age.

**Methodology:** Persian and English articles published from 2001 to 2018 were collected. The search process was conducted in national and international databases, including SID, MagIran, PubMed, Scopus, and Web of Science, using the following keywords and their combinations: Iron, Iron deficiency, Iron deficiency anemia, Ferritin, Child, Children, and Iran. The data were analyzed using the meta-analysis and random effects model. Heterogeneity was assessed using the  $I^2$  statistic. All analyses were performed using the STATA software, version 12.

**Results:** Analysis of six selected articles with a total sample size of 1,700 showed that the prevalence rates of iron deficiency and iron deficiency anemia in the Iranian children under 6 years of age were 27.7% (95% CI: 11.9–43.5) and 18.2% (95% CI: 14.3–22), respectively. In addition, the prevalence of iron deficiency anemia was higher in boys (17.7% with 95% CI: 5.9–29.5) than in girls (14.4% with 95% CI: 4.5–24.2).

**Conclusion:** About one-fifth of Iranian children under the age of 6 years suffer from iron deficiency anemia. Identification of those at risk of developing this condition with the goal of prevention, diagnosis, and treatment seems to be an important and necessary task.

**Keywords:** anemia, iron deficiency anemia, iron, meta-analysis, Iran, prevalence

## Introduction

Iron deficiency anemia is referred to as a condition in which the number of red blood cells is reduced to less than 4 million per deciliter or when there are less than 10 g of hemoglobin per deciliter resulting from iron deficiency.<sup>1</sup> Iron deficiency anemia is the most prevalent nutritional anemia throughout the world and a public health problem, especially in developing countries. One-third of children under 4 years of age and half of children aged 5–15 years in developing countries have anemia.<sup>2</sup> Analysis of data from 187 countries collected from 1990 to 2010 showed that the highest prevalence of iron deficiency anemia was among 1–4-year-old children. Although the prevalence of iron

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deficiency anemia had a decreasing trend between 1990 and 2010, the lowest decrease was also reported in this age group.<sup>3</sup>

Compared to normal infants, iron-deficient anemic infants have lower mental abilities and are more likely to have delays in the development of their upper limb nerves.<sup>4,5</sup> Despite the increase in breastfeeding rates, improvements in the public health, and development of iron-fortified foods, iron deficiency anemia is still highly prevalent among children.<sup>6</sup>

The following prevalence rates have been found for iron deficiency anemia among children in different countries: 20.9% in Brazil,<sup>7</sup> 48% and 37.9% in Nepal,<sup>8,9</sup> and 33.2% in Pakistan.<sup>10</sup>

Iron deficiency and the resulting anemia are very prevalent among women and children throughout the world, especially in developing countries.<sup>11</sup> Iron deficiency anemia in children is more prevalent in developing countries than in developed ones, with prevalence rates of 39% and 20.1% in children aged 4 years or younger, in developing and developed countries, respectively.<sup>12</sup> According to a report by WHO, 41% of women and 27% of preschoolers suffer from iron deficiency anemia.<sup>13</sup> In a study in Brazil with children under 6 years of age, 37.4% of the children had anemia, with the highest prevalence reported among children under 2 years of age.<sup>14</sup> Considering that iron deficiency anemia increases the risk of having infectious diseases, palpitation, shortness of breath, weakness and reduced physical ability, reduced concentration, and reduced learning ability, it is very important to examine its prevalence among children who are an important social assist in every society.<sup>15</sup>

In Iran, in order to prevent iron deficiency anemia, infants aged 6–24 months are prescribed iron supplements, but there is no screening program to diagnose iron deficiency and the resulting anemia in children under 5 years of age who are in an important stage of their development, therefore needing more iron. Previous studies on the prevalence of iron deficiency anemia among Iranian children have led to discrepant results. According to reports, the prevalence of this condition among Iranian children ranges from 3.8% to 31.5%.<sup>1,16</sup> Given that any planning to prevent or control iron deficiency anemia among the Iranian children requires an accurate estimation of its prevalence, the present study aims to estimate the prevalence of iron deficiency anemia among Iranian children.

## Materials and methods

In this systematic review and meta-analysis, the prevalence of iron deficiency anemia among Iranian children

was reviewed based on the articles published from 2001 to 2018 in national and international databases. The articles were collected from the following databases: SID, MagIran, PubMed, Scopus, and Web of Science, using the following keywords and their possible combinations: Iron, Iron deficiency, Iron deficiency anemia, Ferritin, Child, Children, and Iran. The search strategy in the databases was as follows:

("Iron deficiency"[All Fields] OR "Iron deficiency anemia"[All Fields] OR "Ferritin"[All Fields]) AND (("child"[MeSH Terms] OR "child"[All Fields]) OR ("child"[MeSH Terms] OR "child"[All Fields] OR "children"[All Fields])) AND ("Iran"[MeSH Terms] OR "Iran"[All Fields])

## Study selection and data extraction

First, all the articles mentioning the prevalence of iron deficiency anemia among children under 6 years of age were collected. The inclusion criteria were as follows: Observational studies, written in Persian or English, focused on Iranian children under 6 years of age, and access to the article's full text. The titles and abstracts were examined by two independent researchers. Unrelated articles, articles conducted with adults or pregnant women, non-observational studies, studies conducted outside of Iran, review studies, case reports, letters to the editor, and repeated studies were excluded. Most of the studies had reported the prevalence rates of anemia and iron deficiency in addition to the prevalence of iron deficiency anemia; these information were also collected. In order to reduce bias, the search for articles, study selection, qualitative examination, and data extraction were conducted by two independent researchers; disagreements between the two researchers were resolved by the head of the group. In the next step, the characteristics of the articles, including the name of the first author, year of publication, place of publication, sample size, participants' gender, type of the study, and number of participants with anemia, iron deficiency, and iron deficiency anemia were recorded on a data extraction sheet. The methodological quality of the articles was examined using the STROBE checklist that had been used by various studies to examine the methodological quality of observational studies.<sup>17</sup>

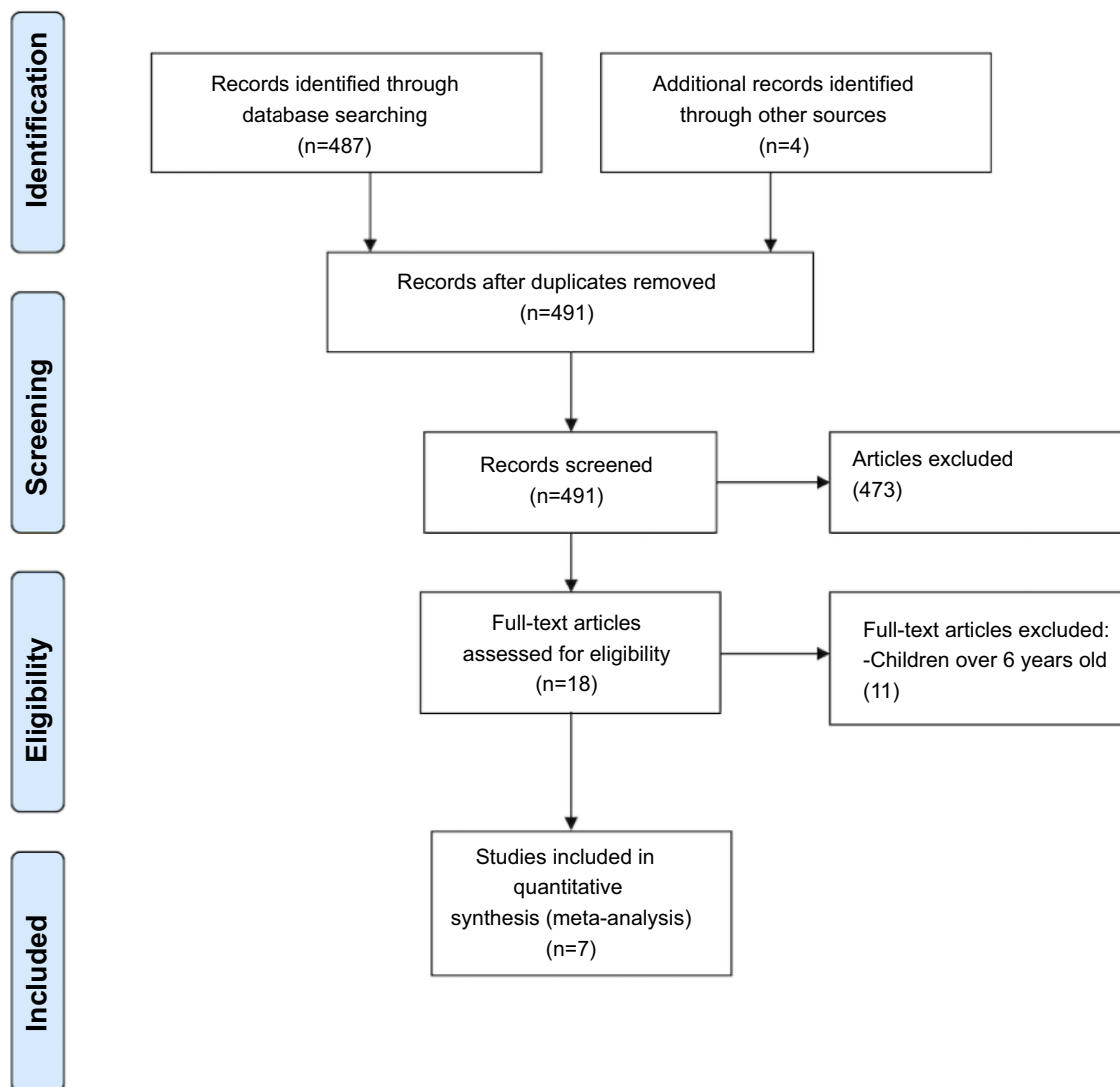
## Statistical analysis

This systematic review and meta-analysis were conducted using the PRISMA statement. The pooled point prevalence and 95% confidence interval for iron deficiency anemia were calculated for each selected study. The binomial distribution

formula was used to assess variance, and the weighted mean was used to combine the prevalence rates in different studies. According to the  $I^2$  statistic, heterogeneity was classified into three categories: 25% indicating low heterogeneity, between 25% and 75% indicating moderate heterogeneity, and over 75% indicating high heterogeneity.<sup>18</sup> According to the degree of heterogeneity between the selected studies based on the  $I^2$  statistic and the Cochran's Q test ( $p < 0.1$ ), the fixed or random effects model was used to estimate the pooled prevalence. The subgroup analysis was used to examine the prevalence of iron deficiency anemia by gender and Iran's region. The univariate meta-regression analysis was used to examine the relationship between the prevalence of iron deficiency anemia with a year of publication and sample size. The analyses were performed using the STATA software, version 12.

## Results

In this systematic review and meta-analysis, all the observational studies on the prevalence of iron deficiency anemia among children under 6 years of age, published from 2001 to 2018 were reviewed based on the PRISMA statement. The process of screening and selecting the articles is presented in Figure 1. In the initial search, a total of 491 articles were found. After examination of the titles and abstracts, 473 unrelated articles were excluded. The remaining 18 articles were examined based on the inclusion criteria, 11 studies that had been conducted with adolescents were excluded, and finally, 7 related articles entered the analysis. In terms of methodological quality, one study had excellent quality<sup>2</sup> and the remaining studies had moderate quality (Figure 1).



**Figure 1** Process of screening and selecting the studies based on the PRISMA statement.

The total sample size was 1,700. The prevalence of iron deficiency anemia had been reported in five studies. In addition, sample size by gender had been reported in six studies: 822 boys and 708 girls (Table 1).

According to the results, the prevalence of iron deficiency was 27.7% (95% CI: 11.9–43.5), and the prevalence of iron deficiency anemia was 18.2% (95% CI: 14.3–22) among the Iranian children under 6 years of age (Figure 2).

According to the results by gender, the prevalence of iron deficiency anemia was higher in boys (17.7% with 95% CI: 5.9–29.5) than in girls (14.4% with 95% CI: 4.5–24.2) (Figure 3).

According to the meta-regression analysis, there was no significant relationship between the prevalence of iron deficiency anemia and year of publication ( $p=0.929$ ) and sample size ( $p=0.063$ ).

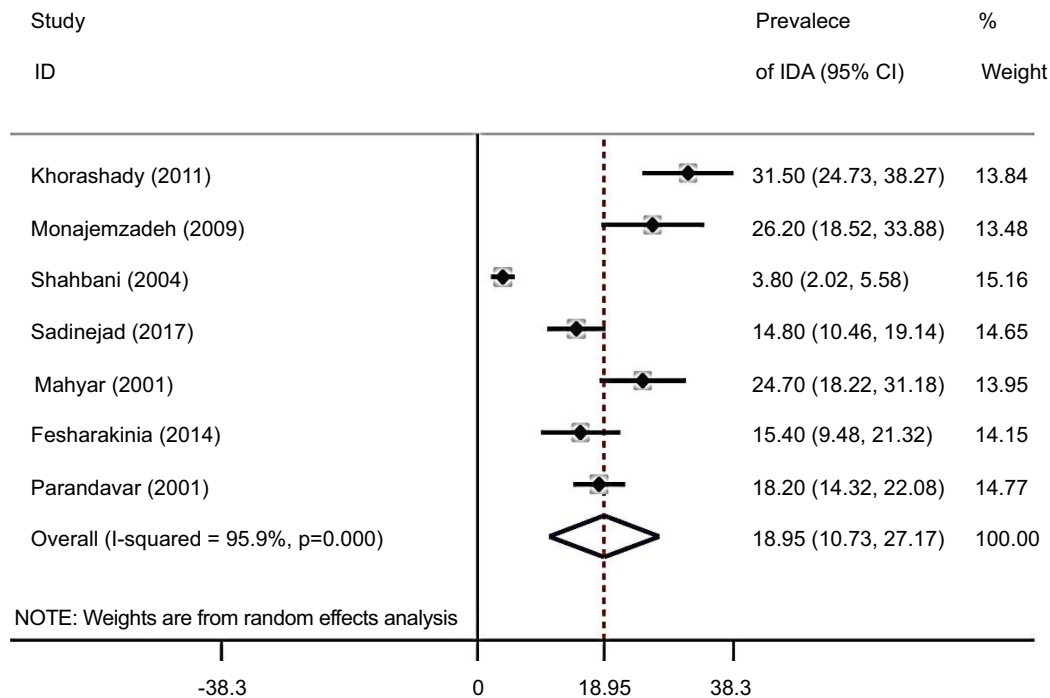
### Discussion

In the present systematic review and meta-analysis, the pooled prevalence of iron deficiency anemia among children under 6 years of age was examined for the first time in Iran. According to the study results, iron deficiency anemia had a prevalence rate of 18.2% (95% CI: 14.3–22). In other words, about one-fifth of Iranian

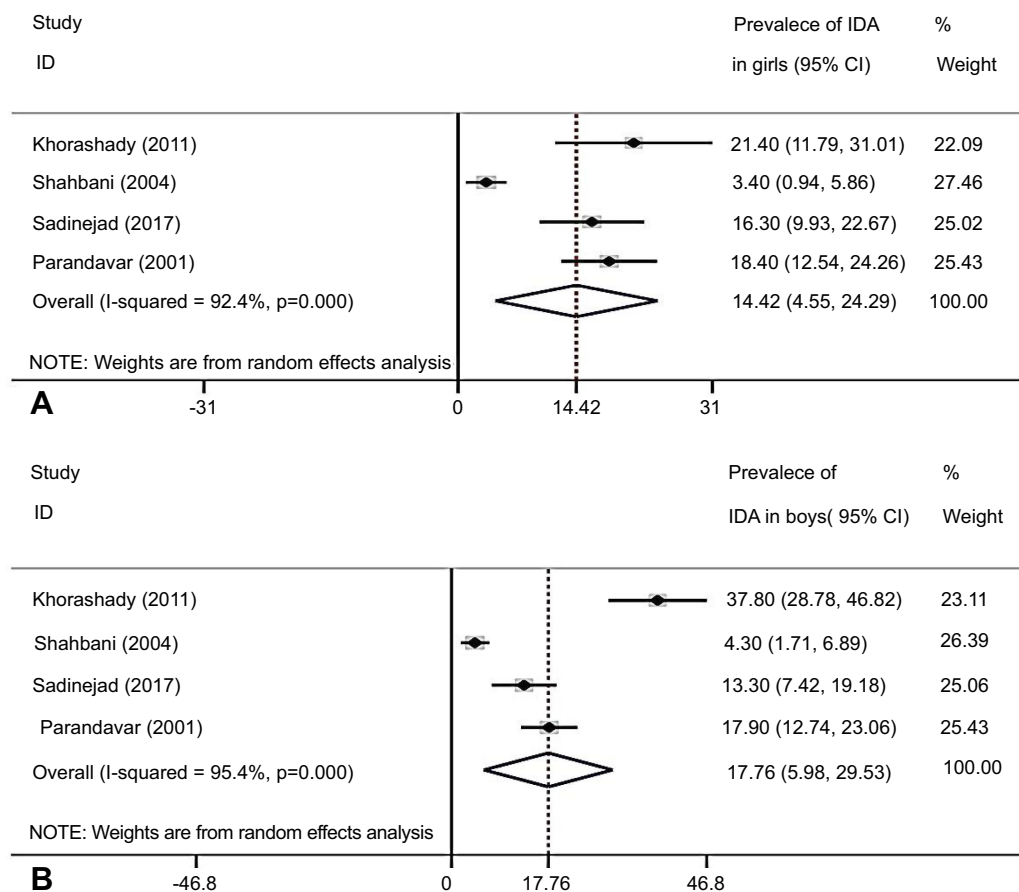
**Table 1** Characteristics of the selected studies

Reference	Year	Sample size			Place	ID (%)	IDA (%)		
		Total	Male	Female			Total	Male	Female
Sadinejad <sup>19</sup>	2017	257	128	129	Isfahan	–	14.8%	13.3%	16.3%
Fesharakinia <sup>20</sup>	2014	143	75	68	Birjand	12.3	15.4%	–	–
Khorashady <sup>1</sup>	2011	181	111	70	Bojnourd	–	31.5%	37.8%	21.4%
Monajemzadeh <sup>21</sup>	2009	126	61	65	Ahwaz	37.1%	26.2%	–	–
Shahbani <sup>16</sup>	2004	443	235	208	Yazd	8.6%	3.8%	4.3%	3.4%
Prandavar <sup>22</sup>	2001	380	212	168	Jahrom	18.7%	18.2%	17.9%	18.4%
Mahyar <sup>23</sup>	2001	170	–	–	Qazvin	63.5%	24.7%	–	–

**Abbreviations:** ID, Iron deficiency; IDA, Iron Deficiency Anemia.



**Figure 2** Overall prevalence of iron deficiency anemia among Iranian children under 6 years of age. The 95% confidence interval for each study is shown in the form of horizontal lines around the central mean, the midpoint of the dotted line represents the mean of the overall score, and the lozenge shape shows the confidence interval of the prevalence of the disorder.



**Figure 3** Prevalence of iron deficiency anemia in the Iranian girls (**A**) and boys (**B**) under 6 years of age. The 95% confidence interval for each study is shown in the form of horizontal lines around the central mean, the midpoint of the dotted line represents the mean of the overall score, and the lozenge shape shows the confidence interval of the prevalence of the disorder.

children under 6 years of age had iron deficiency anemia; this is consistent with the prevalence of this condition among Brazilian children (20.9%).<sup>7</sup> Much higher than that found in our study, a study conducted in Ghana with children under 5 years of age, reported a prevalence of 78.4% for iron deficiency anemia (24).<sup>24</sup> In addition, the prevalence of this condition among Iranian children was lower than that among Nepalese and Pakistani children.<sup>8,10</sup> A global examination by WHO with children aged 6–59 months found the prevalence of iron deficiency anemia to be 42.6%.<sup>25</sup> In addition, in a 2001 report by WHO, a prevalence of 30% was reported for this condition among children aged 1–4 years in developing countries.<sup>12</sup> The higher prevalence rates of iron deficiency anemia in developing countries can be attributed to low iron absorption in the early years of life in which children's development is very fast, lifestyle, geographical factors, socioeconomic status, and children's nutrition.

The results by gender showed that the prevalence of iron deficiency anemia was higher in boys than in girls. This finding is in line with those of Sirdah et al (2014) (26).<sup>26</sup> It is also consistent with the results of a meta-analysis in Ghana showing that iron deficiency was higher in boys than in girls.<sup>24</sup> Lozzof et al (2006) also found a higher prevalence of this condition in boys than in girls.<sup>27</sup> However, in contrary to our findings, a study conducted in India found the higher prevalence of this condition in girls than in boys.<sup>28</sup> However, the study finding that the prevalence of iron deficiency anemia was higher in boys than in girls may be explained by the fact that boys gain more weight in the first year of life.<sup>27</sup>

According to the WHO's reports, the prevalence of iron deficiency among children aged 6–59 months is 62.3% in Africa, 22.3% in North America, and 53.8% in Southeast Asia.<sup>25</sup> These are higher than the prevalence rate we found among Iranian children. Iron deficiency anemia in children, especially in infants, can lead to changes in their

development, especially in their nervous system that may be irreversible despite receiving appropriate treatments.<sup>29,30</sup>

## Conclusion

According to the study results, although the prevalence of iron deficiency anemia among Iranian children is lower than in many other countries, it is still high relative to the developed countries, therefore appropriate measures are needed to be taken to control this problem in Iran.

In overall, the findings showed that about one-fifth of Iranian children under 6 years of age suffer from iron deficiency anemia. Considering the negative consequences of this condition in this age group, it seems important to identify those at risk for developing it and provide them with the necessary treatments.

## Disclosure

The authors report no conflicts of interest in this work.

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