Estimation of iron deficiency anemia in Iranian children and adolescents: a systematic review and meta-analysis

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ABSTRACT

Objectives: Iron deficiency anemia (IDA) is a major health issue in those aged less than 18 years old with high impact on their development. There are several reports from Iran with variable results. Systematic review and met analysis of these data would reveal a more realistic view of the prevalence of iron deficiency (ID).

Methods: We conducted a systematic search of national and international databases from December 1990 to 31 January 2016 for population-based studies providing estimates on the prevalence of IDA in Iran. From the extracted crude prevalence rates, the heterogenic index of the studies was determined using the Cochran’s test ($Q$) and $I^2$. Then, based on the heterogenetic results, a random effects model for estimate pooled prevalence of IDA was used. Meta-regression was applied to determine heterogeneity suspected factors.

Results: The overall prevalence of IDA in Iranian population with age less than 18 years was estimated to be 13.9% (95% CI: 10.8–17.1) and the overall prevalence of ID was 26.9% (95% CI: 19.7–34.1). The prevalence of IDA was 7.9% (95% CI: 4.1–11.7) in males and 8.5% (95% CI: 6.1–10.8) among females aged under than 18 years.

Discussion: Despite the efforts of ministry of health and medical education of Iran in implementing free iron supplements for infants and for girls, the prevalence of ID and resultant anemia is considerable. Further interventions to increase use of supplements when they are provided and special programs for non-covered groups including boys under six are in great need.

KEYWORDS

Iron deficiency; iron deficiency anemia; children; adolescents; meta-analysis; Iran

Introduction

For many years, iron deficiency (ID) and the consequent anemia was one of the most important problems of public health in the world and the most prevalent type of malnutrition among the infants and young children, especially in developing countries [1–3]. Because of relatively high prevalence and its known detrimental effects on neurological development, cognitive function, physical strength, immune system, and social activities of infants and young children, this disease is considered as one of the main health indicators [4,5].

In addition to the known long-term consequences of ID anemia (IDA), some children will experience acute life-threatening clinical events including, palpitation, tachypnea, low blood pressure, dyspnea, and congestive heart failure. The presence of one or more of these findings will prompt admission to inpatient pediatric units [6].

Naturally, there is equilibrium between gaining and consuming iron and ID occurs when this equilibrium becomes negative. Considering special growth conditions, increased iron needs, and inadequate iron absorption from the diet, children gradually consume the iron supply. If these patients are treated with suitable iron supplement at this stage, no anemia would occur [7].

According to the reports of the world health organization, globally more than 3 billion people suffer from anemia [8]. There are several reasons for anemia that ID is a major cause. Indeed IDA is the most prevalent type of anemia and one of the most prevalent human diseases affecting near 20% of world population [9].

In 2014, IDA was considered as one of the most effective factors in the global burden of the disease. Also, it has been reported that preschool children have the highest prevalence of anemia, up to 50% across developing countries [10,11]. The statistics obtained from the developing countries on prevalence of IDA in children under 5 years old indicated the high prevalence of this type of anemia globally, with the range of prevalence between 33.7% and 50% in African continent and 46.5%, in Indonesia as the most horrible situations [12–14].
There are various reports on prevalence of this important disease among Iranian adolescents and children from as low as 9% up to more than 40% [15]. Considering the importance of IDA, especially among children and teenagers as the endangered group, and the wide variance of reported prevalence, there is need for structured review of documents to reach a better understanding of different aspects of this problem in the Iranian society. The purpose of the present study is to make a comprehensive estimation of the prevalence level of anemia among Iranian children and teenagers through systematic review and meta-analysis of qualified data. This would help policymakers to have a more realistic view on the situation and to plan more accurately to reduce burden of this disorder.

**Methods**

**Search strategy**

All the published studies from December 1990 to 31 January 2016 in national and international databases including Scientific Information Database (SID), Iranmedex, Magiran, Irandoc, Medline, Scopus, google scholar, and web of science were searched using the following keywords or their equivalent in Persian: ‘Prevalence’, ‘Frequency’, ‘Percent’, ‘mean’, ‘iron’, ‘deficiency’, ‘adolescent’, ‘children’, ‘child’, ‘iron deficiency’, ‘iron deficiency anemia’, ‘ferritin’, ‘boy’ ‘girl’, ‘Iran’.

Search was conducted by two independent researchers. Additionally, the lists of references relevant papers were searched to increase sensitivity and select a larger number of studies. The evaluation of the search was randomly conducted by another researcher to be sure that none of the relevant studies was ignored. Further, the paper-based sources including abstract book of hematology and pediatric congresses were searched. The relevant research centers and experts of the field (pediatric hematologist) were contacted to find unpublished studies.

**Study selection**

The full text or the abstract of the papers, documents, and the reports obtained by the advanced search were extracted. After excluding duplicates, irrelevant studies were removed by investigating the title, abstract, and full text of the papers. It is worth to note that in order to prevent the bias caused by republishing (publication transverse and longitudinal biases), the researchers also checked the funding of studies when available to identify these cases.

**Quality assessment**

The quality of studies were assessed using STROBE checklist which includes 12 questions that cover various methodological aspects such as determining the appropriate sample size, sample type, sampling method, study population, the data collection method, definition of variables and method of examining the samples, data collection tools, statistical analysis, purpose of the study, appropriate way of reporting findings and reporting findings based on objectives [16,17]. Studies with minimum score of 8 from 19 were entered in the meta-analysis.

**Inclusion criteria**

All Persian and English studies which had reported the sample size and the prevalence of ID and IDA within the age group of under-18 years old, after the evaluation process and achieving the necessary scores were considered to be eligible to be included in this study.

**Exclusion criteria**

The studies which have not reported the prevalence of ID and IDA, studies without a specified sample size, the abstracts concerning the congresses and seminars with no full texts, case-control studies, interventionist studies, case report studies, the studies reporting the prevalence of anemia among pregnant women, symptomatic patients, and the over-18 age group and studies that did not obtain a minimum score of quality assessment were excluded.

**Data extraction**

Data for each study were extracted based on title of the article, first author’s name, year of the study, sample size, study design, sampling, sample size, total sample size, sample size in terms of gender, language of the article, age range of the studied population, Place of residence (urban/rural), the blood hemoglobin cut-off point, the ferritin cut-off point, the prevalence of ID, the prevalence of anemia, and the prevalence of IDA. Moreover, the data were entered into an Excel spreadsheet.

**Analysis**

The Stata software was used to analyze the data. The standard error of the prevalence of ID and IDA in each study was calculated based on the binomial distribution formula. The heterogetic index between the studies was determined using Cochran’s test (Q) and I². Based on the heterogenic results, the random effect model was used to estimate the overall...
prevalence of ID and IDA in Iran. Moreover, heterogeneity suspected factors were evaluated by meta-regression. The analysis in the age subgroup (aged under 6 years and within 6–18 years) and prevalence based on gender was performed base on gender to determine heterogeneity. The point estimates of the prevalence of IDA and ID in Iran with the confidence interval (CI) of 95% were calculated using forest plots. In the plot, square size represented the weight of each study and side lines show the CI of 95%.

**Results**

In the primary search, 18,279 documents were found about the prevalence of IDA in Iran in national and international databases. By restricting the searching strategy, the number of the relevant papers was decreased to 2053. Moreover, 1082 documents were excluded due to the overlap of electronic data bases. In the next step, the title and abstract of 971 remaining documentaries were further evaluated and irrelevant studies or those who did not meet the inclusion criteria or had the exclusion criteria were omitted. In addition, four papers were added from the references of the articles. With final assessment of the quality of articles and inclusion and exclusion criteria, 27 articles were entered into meta-analysis process (Figure 1).

All of the 27 studies fed into the meta-analysis process were cross-sectional either descriptive or analytic. The sampling methods were as follow: 10 cluster random sampling, 12 random systematic sampling, one simple random, three multi-step sampling with random classification and one convenience sampling. The residence place of the population studied was urban in 24 studies, urban–rural in two studies, and rural in one study. The regions of the studies were: one study in Khuzestan province, one in East Azerbaijan province, one in Kermanshah province, two in Kerman province, four in Southern Khorasan province, one in Northern Khorasan province, three in Fars province, one in Qazvin province, one in Qom province, one in Gilan province, one in Mazandaran

![Figure 1. Literature search and review flowchart for selection of primary studies.](image-url)
province, two in independent region of Kashan, one in Lorestan province, two in Semnan province, two in capital Tehran, one in Kohgiloyeh and Boyer-Ahmad province, one in Yazd province, and one in Sistan and Baluchestan province.

These studies included 11,493 Iranians with age under 18 years. The Hemoglobin cut-off point was 10.5 g/dl in two studies, below 11 g/dl six studies, below 11.5 g/dl three studies, below 12 g/dl 14 studies, and below 13 g/dl one study. The hemoglobin cut-off point has not been mentioned in one study. The ferritin cut-off point was below 10 mg/l in one study, and below 15 mg/l in three studies, below 12 mg/l in 13 studies, below 13 mg/l in one study, and below 15 mg/l in three studies. The ferritin cut-off point was not mentioned in six studies (Table 1).

The prevalence of IDA in the age group of under than 6 years which was reported in 11 studies varied from 6% to 63.5%. By combining the results of these eight studies, the prevalence of IDA among children under 6 years old in Iran with the CI of 95% was estimated to be 26.6% (95% CI: 16.2–36.9). The prevalence of ID in the age group of 6–18 years was reported in 11 studies and varied from 6% to 60.7%. The overall estimate of the prevalence of ID in this age group was 27.1% (95% CI: 17.1–37.2).

There was no significant difference between the two age groups regarding to the prevalence of ID. The overall prevalence of ID in Iranians aged 18 years old or less with the CI of 95% was estimated to be 26.9% (95% CI: 19.7–34.1) (Figure 3).

The prevalence of IDA among boys was reported in seven studies and varied between 2.4% and 37.8%. The prevalence of IDA among girls has been reported in 15 studies and varied from 1.7% to 21.4%. The overall prevalence of IDA among boys was 11.3% (95% CI: 6.3–16.2) [age under 6 years 19.5% (95% CI: 3.1–35.9) and age 6–18 years 6.7% (95% CI: 2.6–10.7)] and it was 8.6% (95% CI: 6.2–10.9) among the girls [age under 6 years 13.9% (95% CI: 1.3–26.5) and age 6–18 years 6.7% (95% CI: 10.8–17.1) (Figure 2).

The overall prevalence of IDA among those aged under than 18 years in Iran was estimated to be 13.9% (95% CI: 10.8–17.1) (Figure 2).

The prevalence of ID based on ferritin level in the age group under 6 years old was reported in eight studies and varied from 8.6% to 63.5%. By combining the results of these eight studies, the overall prevalence of IDA among children under 6 years old in Iran with the CI of 95% was estimated to be 26.6% (95% CI: 16.2–36.9). The prevalence of IDA among boys was reported in seven studies and varied between 2.4% and 37.8%. The prevalence of IDA among girls has been reported in 15 studies and varied from 1.7% to 21.4%. The overall prevalence of IDA among boys was 11.3% (95% CI: 6.3–16.2) [age under 6 years 19.5% (95% CI: 3.1–35.9) and age 6–18 years 6.7% (95% CI: 2.6–10.7)] and it was 8.6% (95% CI: 6.2–10.9) among the girls [age under 6 years 13.9% (95% CI: 1.3–26.5) and age 6–18

### Table 1. Characteristics of primary studies included to a meta-analysis.

| ID | First author | Publication year | Resident area | Age group | Sample size | Cut-off | Prevalence | Prevalence of IDA |
|----|--------------|------------------|---------------|-----------|-------------|---------|------------|------------------|
| 1  | Khorashady Zade and Armat [18] | 2011 | Urban | <6 | 181 | 111 | 70 | 10.5 | <10 | – | 31.5 | 37.8 | 21.4 |
| 2  | Ramzi et al. [19] | 2011 | Urban | 6–18 | 363 | – | 363 | <12 | <12 | 8.5 | 1.7 | – | 1.7 |
| 3  | Heidarnia et al. [20] | 1999 | Urban | <6 | 320 | – | – | <11 | 10 | 22.5 | 7.2 | – | – |
| 4  | Shahbani et al. [21] | 2004 | Urban | <6 | 449 | 239 | 210 | 11 | 10 | 5.4 | 3.8 | – | – |
| 5  | Fesharakiniya et al. [22] | 2006 | Urban | 6–18 | 450 | 123 | 219 | <12 | <12 | 24 | 1.8 | – | – |
| 6  | Kadivar et al. [23] | 2003 | Urban | <6 | 541 | 289 | 252 | <12 | <12 | – | – | – | – |
| 7  | Namakin et al. [24] | 2009 | Urban | <6 | 300 | 165 | 135 | 11.5 | – | 28.3 | 10.3 | 12.0 | 8.2 |
| 8  | Pooraram et al. [25] | 2013 | Both | 6–18 | 336 | – | 336 | <12 | <12 | 10.7 | 4.4 | 4 | 4 |
| 9  | Torabizadeh et al. [26] | 2007 | Urban | 6–18 | 881 | – | 881 | <11.5 | <12 | 38 | 2.5 | – | – |
| 10 | Haghbin et al. [27] | 2000 | Urban | 6–18 | 260 | – | – | <12 | <12 | 6 | 4.5 | – | – |
| 11 | Prandavar and Sobhanian [28] | 2001 | Urban | <6 | 380 | 212 | 168 | <11 | <12 | 18.7 | 1.8 | 17.9 | 18.4 |
| 12 | Honarpisheh and Khalifeya Soltani [29] | 1999 | Urban | <6 | 335 | 179 | 156 | 10.5 | <12 | 43.5 | 5.7 | – | – |
| 13 | Abasiyan and Nourian [30] | 1999 | Both | 6–18 | 520 | – | 520 | <12 | – | – | 5 | – | 5.2 |
| 14 | Motlagh and Mardani [31] | 2000 | Both | <6 | 1128 | – | – | <11 | <12 | – | – | – | – |
| 15 | Taghizadeh et al. [32] | 2000 | Urban | 6–18 | 350 | – | 350 | <12 | <10 | 36.6 | 15.4 | – | 15.4 |
| 16 | Pourghasem et al. [33] | 2000 | Urban | 6–18 | 652 | 312 | 340 | <11.5 | <15 | 60.7 | 11.5 | 10.3 | 13 |
| 17 | Khorashady Zade and Armat [18] | 2013 | Urban | 6–18 | 325 | 165 | 160 | <12 | <15 | – | 8.36 | 2.42 | 14.37 |
| 18 | Monajemzadeh and Zarkesh [35] | 2009 | Urban | <6 | 126 | 61 | 65 | <11 | <12 | 31.7 | 26.2 | – | – |
| 19 | Latifzadeh and Kazemi [36] | 1999 | Urban | <6 | 417 | – | – | <12 | <13.5 | 13.9 | 0.2 | – | – |
| 20 | Saei et al. [37] | 1998 | Urban | 6–18 | 325 | – | 325 | <12 | <12 | 27.7 | 11.4 | – | 11.4 |
| 21 | Nejad Amir et al. [38] | 2002 | Urban | 6–18 | 799 | 333 | 466 | <12 | <12 | 34.5 | 7.6 | 3.6 | 10.5 |
| 22 | Mahyar et al. [39] | 2001 | Rural | <6 | 170 | – | – | – | – | 63.5 | 24.7 | – | – |
| 23 | Khazaei et al. [40] | 2007 | Urban | 6–18 | 450 | 260 | 220 | <12 | <12 | 24 | 1.8 | – | – |
| 24 | Abadini et al. [41] | 2010 | Urban | 6–18 | 554 | – | – | <13 | – | – | – | – | – |
| 25 | Fakhre-Movahedi [42] | 2004 | Urban | 6–18 | 402 | 402 | 12 | <15 | – | 4.5 | – | 4.5 |
| 26 | Fesharakiniya et al. [22] | 2013 | Urban | <6 | 143 | 75 | 68 | <11 | <12 | 12.36 | 16.8 | – | – |
| 27 | Akramipour et al. [43] | 2008 | Urban | 6–18 | 336 | – | 336 | <12 | <20 | – | – | 13.1 | 13.1 |
### Figure 2. Prevalence of IDA in primary studies included to a meta-analysis and overall assessment by age group less than 6 years and 18–6 years old.

| Study ID | ES (95% CI) | % | Weight |
|----------|-------------|---|--------|
| <6       |             |   |        |
| kharashadizadeh (2011) | 31.50 (24.73, 38.27) | 3.28 |        |
| heydarnia (1999) | 7.20 (4.37, 10.03) | 3.77 |        |
| shabani (2004) | 3.80 (2.03, 5.57) | 3.85 |        |
| kavir (2003) | 19.70 (16.35, 23.05) | 3.73 |        |
| parandavar (2001) | 18.20 (14.32, 22.08) | 3.67 |        |
| honaripshieh (1999) | 27.30 (25.00, 29.60) | 3.50 |        |
| mottagh (2000) | 26.50 (23.92, 29.08) | 3.79 |        |
| Monajemzadeh (2009) | 26.20 (18.52, 33.88) | 3.14 |        |
| latifzadeh (1999) | 0.20 (0.23, 0.83) | 3.89 |        |
| mahyar (2001) | 24.70 (19.22, 31.18) | 3.33 |        |
| fesharaki (2013) | 16.80 (10.87, 22.93) | 3.38 |        |
| Subtotal (I-squared = 99.2%, p = 0.000) | 20.91 (12.96, 28.86) | 39.34 |        |

6-18

| Study ID | ES (95% CI) | % | Weight |
|----------|-------------|---|--------|
| Ramzi (2011) | 1.70 (0.37, 3.03) | 3.87 |        |
| kiniya (2006) | 1.60 (0.57, 3.03) | 3.87 |        |
| namkin (2003) | 4.70 (6.66, 13.74) | 3.72 |        |
| pooraram (2004) | 4.40 (2.21, 5.69) | 3.82 |        |
| torabizadeh (2005) | 2.50 (1.47, 3.53) | 3.88 |        |
| haghi (2000) | 4.50 (1.98, 7.02) | 3.80 |        |
| abesiyani (1999) | 5.20 (3.29, 7.11) | 3.84 |        |
| taghi (2000) | 15.40 (11.62, 19.18) | 3.68 |        |
| pourhaseem (2000) | 11.90 (9.05, 13.95) | 3.80 |        |
| koronyan (2014) | 6.36 (5.53, 7.17) | 3.76 |        |
| saeb (1998) | 11.40 (7.54, 14.86) | 3.72 |        |
| nejad amir (2002) | 7.60 (5.76, 9.44) | 3.84 |        |
| khazae (2007) | 1.80 (0.57, 3.03) | 3.87 |        |
| abedini (2010) | 53.60 (49.40, 57.75) | 3.64 |        |
| movahedi (2004) | 4.50 (2.47, 6.53) | 3.80 |        |
| Akrami (2006) | 13.10 (4.98, 19.64) | 3.70 |        |
| Subtotal (I-squared = 96.0%, p = 0.000) | 9.60 (6.24, 12.96) | 60.68 |        |
| Overall (I-squared = 98.7%, p = 0.000) | 13.95 (10.86, 17.04) | 100.00 |        |

### Figure 3. Prevalence of ID in primary studies included to a meta-analysis and overall assessment by age group younger than 6 years and 18–6 years old.

| Study ID | ES (95% CI) | % | Weight |
|----------|-------------|---|--------|
| <6       |             |   |        |
| heydarnia (1999) | 22.50 (17.92, 27.08) | 5.26 |        |
| shabani (2004) | 8.60 (6.01, 11.19) | 5.34 |        |
| parandavar (2001) | 18.70 (14.78, 22.62) | 5.29 |        |
| honaripshieh (1999) | 43.50 (38.19, 48.81) | 5.22 |        |
| Monajemzadeh (2009) | 31.70 (23.58, 39.82) | 5.03 |        |
| latifzadeh (1999) | 13.90 (10.58, 17.22) | 5.32 |        |
| mahyar (2001) | 63.50 (58.26, 70.74) | 5.10 |        |
| fesharaki (2013) | 12.36 (9.67, 17.75) | 5.22 |        |
| Subtotal (I-squared = 97.8%, p = 0.000) | 26.59 (16.20, 36.97) | 41.78 |        |

6-18

| Study ID | ES (95% CI) | % | Weight |
|----------|-------------|---|--------|
| Ramzi (2011) | 8.50 (6.63, 11.37) | 5.33 |        |
| kiniya (2006) | 24.00 (20.05, 27.95) | 5.29 |        |
| namkin (2009) | 28.30 (23.20, 33.40) | 5.24 |        |
| pooraram (2004) | 10.70 (7.39, 14.01) | 5.32 |        |
| torabizadeh (2005) | 35.00 (34.70, 41.31) | 5.32 |        |
| haghi (2000) | 6.00 (3.11, 8.89) | 5.33 |        |
| taghi (2000) | 38.00 (31.55, 41.65) | 5.24 |        |
| pourhaseem (2000) | 60.70 (58.95, 64.45) | 5.30 |        |
| saeb (1998) | 27.70 (22.83, 32.57) | 5.25 |        |
| nejad amir (2002) | 34.50 (31.20, 37.80) | 5.32 |        |
| khazae (2007) | 24.00 (20.05, 27.95) | 5.29 |        |
| Subtotal (I-squared = 98.8%, p = 0.000) | 27.15 (17.13, 37.17) | 58.22 |        |
| Overall (I-squared = 98.5%, p = 0.000) | 26.93 (19.72, 34.14) | 100.00 |        |

NOTE: Weights are from random effects analysis.
Figure 4. Prevalence of IDA in primary studies included to a meta-analysis and overall assessment in boys by age group younger than 6 years and 6–18 years old.

Figure 5. Prevalence of IDA in primary studies included to a meta-analysis and overall assessment in girls by age group younger than 6 years and 6–18 years old.
years 7.9% (95% CI: 5.4–10.3)). It is worth mentioning that, among studies that reported prevalence of ID among boys, the results of study conducted by Khorashehy zade et al. in compared with other studies was located in outliers’ points. After this study limited, the prevalence of IDA was estimated in total boys 7.9% (95% CI: 4.1–11.7) [age under 6 years 10.9% (95% CI: 2.4–24.2), and age 6–18 years 6.7% (95% CI: 2.6–10.7)], and it was 8.5% (95% CI: 6.1–10.8) among the girls [age under 6 years 10.6% (95% CI: 4.04–25.3) and age 6–18 years 8.3% (95% CI: 5.8–10.8) (Figures 4 and 5).

To examine the factors associated with heterogeneity, the variables such as the publication year, hemoglobin cut-off point, and ferritin cut-off point were entered to the meta-regression analysis. None of these factors had significant impact on heterogeneity (Table 2).

### Discussion

There have been wide variations on reported prevalence of IDA in Iranian children and adolescents. The largest survey on the prevalence of anemia in children 2–12 years old in the Islamic Republic of Iran was reported by Sayyari et al. In their study, the researchers reported a 15% prevalence rate for anemia in Iranian children [44]. Safavi et al. had reported the prevalence of anemia and ID in 11 different geographical regions in 2001 to be 21.5% and 42.7%, respectively. The highest prevalence was in South of Kerman, south of Khorasan, Sistan and Baluchestan with average of 44%. The lowest levels of prevalence were 9% in central Isfahan, Yazd, Kohgiloyeh and Boyer-Ahmad provinces [15]. In the present study, we tried to estimate the pooled prevalence of IDA and ID, among the Iranian children and adolescents under 18 years based on the data obtained from the qualifies primary studies. According to the results of the present study, the overall prevalence of the IDA and ID, among the population aged 18 years or less in Iran was estimated to be 13.9% and 26.9%, respectively. It is worth mentioning that this study addition to that covered all geographic regions of Iran and could be considered a realistic view of the whole nation, this is the first study to examine the prevalence of IDA among children and adolescents by using a systematic review and meta-analysis approach.

The reported figure for ID in children and adolescents in developing countries varies between 25% and 35% in most series [45] while the prevalence is between 5% and 8% in industrial countries [46]. The results of the present study reveal that the percentage of IDA among Iranian children appears to be in a better condition with respect to other developing countries including Indonesia (46.5%) [47], Africa (50%) [48], Guatemala (30–60%) [49], and Turkey (19.6%) [50]. Although in the absence of a standard frameworks for diagnosis of IDA and ID comparison between studies might not be appropriate [44]. It should be emphasized that despite reported lower prevalence of IDA in Iranian children and adolescents compared to other developing countries, the situation is still alarming [23].

The prevalence of IDA and ID was significantly higher in the age group of under 6 years compared with the age group between 6 and 18 years in our meta-analysis. In a study from Brazil, it was demonstrated that there is a relationship between the age and the IDA and younger children are more susceptible to IDA [51]. The report form world health organization also indicates the highest prevalence of anemia is among the children in their preschool age up to 47.7% [52]. The need for Iron is high in this age period but their intake specially with this pandemics of junk foods is low [53]. It is also postulated that in the age group of under 6 years, iron absorption from the diet is lower compared to the 6–18 years age group [54]. Hence the priority of interventions should be in this group as there is both higher prevalence and higher impact on further development of the children and their future life [24].

Based on the reports of the studies in Iran, the most important causes of the ID among children are the factors associated with nutritional problems and low consumption of nutritional iron sources [55].

In comparison between boys and girls Nichlas et al. reported a higher prevalence of IDA in boys [56]. Boys may suffer from a more severe ID than girls at the beginning of life due to higher calorie consumption [57]. As the children grow up, the high prevalence of IDA among the girls is expected due to environmental factors, nutritional pattern as well as the occurrence of puberty and menstruation.

Our study revealed also that the overall prevalence of IDA among girls was slightly higher than in boys (8.5% vs. 7.9%). Also analysis in age groups revealed that between the age group 6–18 years girls had a higher prevalence of IDA than boys (8.3% vs. 6.7%). But this between age group under 6 years in boys had a few higher than girls (10.9% vs. 10.7%). This results may be expected thereby the effect of menstruation [55]. In recent years, the implementations of free iron supplementation in female secondary schools and high schools have decreased the gap between boys and girls in age group 6–18 years [19].

This systemic review and meta-analysis to our best knowledge is the first report of national prevalence of IDA in Iranian children and adolescents. The strength

### Table 2. Factors associated with the prevalence of IDA heterogeneity by using univariate Meta-Regression model.

| Variables            | B     | p-value |
|----------------------|-------|---------|
| Publication year     | 0.4   | 0.507   |
| Cut-off point ferritin| −1.6  | 0.445   |
| Cut-off point Hb     | −6.3  | 0.228   |
of this study is use of qualified studies with coverage of the most regions of Iran. But lack of standard definition of anemia and ID and variable cut offs used in these studies is a point of weakness.

In conclusion, despite the efforts of ministry of health and medical education of Iran in implementing free iron supplements for infants less than 2 years and for females in age range of 12–18, the prevalence of ID and resultant anemia is considerable. Further interventions to increase use of supplements when they are provided and special programs for non-covered groups including boys under 6 are in great need.

Disclosure statement
No potential conflict of interest was reported by the authors.

Funding
This work was supported by the Torbat Heydariyeh University of Medical Sciences, Torbat Heydariyeh, Iran under Grant number A-10–1304-4.

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