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Prevalence and risk factors of iron deficiency anemia among children; A systematic review

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Abstract

Background:

Iron deficiency anemia refers to a reduction in red blood cells below the normal; it is the most severe form of iron deficiency. Iron deficiency anemia negatively affects children as it affects the brain, central nervous system, and immunological system of children.

Aim:

To assess the prevalence and risk factors of iron deficiency anemia among children by reviewing the previous studies focused on this subject.

Methods:

The scientific databases of PubMed, Google Scholar, Scopus, Elsevier, Science Direct, and Research Gate were explored to search for articles concerned with our subject. The search process was limited to articles published between 2017 and 2023. The search terms used in the search process were "IDA, Prevalence, Risk factors, Determinants, Paediatrics, Children." The inclusion criteria were original English articles conducted on children and reported prevalence and/or risk factors of iron deficiency anemia.

Results:

A total of 2660 articles were obtained, and only ten articles were eligible for the inclusion criteria. The studies included a total number of 12055 children from seven countries. The prevalence range was 7.7% to 71.22%, and the risk factors included gender, anemic mother, stunting, poor dietary diversity, and others.

Conclusion:
A high prevalence of IDA was found among children throughout different countries. The risk factors for IDA were various and differed between the different studies.

**Keywords:** Prevalence, IDA, Risk factors, Children.

**Introduction:**

Anemia is a condition that refers to a level of red blood cell count below the normal threshold that serves as an oxygen carrier to the body. Anemia is a major public health issue globally, especially in developing regions [1]. The causes of anemia are various, and they include nutritional deficiency, especially iron and folic acid, congenital conditions, and parasitic infection. However, iron deficiency is the leading cause of anemia globally [1].

Iron deficiency state ranges from iron deficiency without anemia to iron deficiency anemia (IDA). Iron deficiency without anemia involves two stages, iron deficient erythropoiesis, which refers to the depletion of stored iron and a further reduction in transport iron, whereas iron depletion refers to a reduced amount of stored iron. IDA is the most severe form of iron deficiency [2]. IDA refers to the condition at which the frequency of red blood cells is reduced to less than four million/deciliter or when there is less than 10g of hemoglobin (Hb) per deciliter resulting from iron deficiency [3].
Almost one-third of pediatrics under four years old and fifty percent of children aged 5-15 years in developing countries suffer from anemia [4]. An analysis from 187 countries collected from 1990 to 2010 revealed that children aged 1-4 years old showed the highest prevalence of IDA. Additionally, during this period of time, a reduction in the rate of anemia has been noted; however, the lowest rate of reduction was noted among children aged 1-4 years [5].

Iron is a crucial element for the growth of humans at all stages; therefore, it is necessary for children as it potentially affects children's development. Iron is necessary for the growth and development of the central nervous system, especially during childhood. It is also important for brain growth, monoamine neurotransmitter action, myelination, as well as glial and neuronal energy metabolism [6]. As a result, IDA affects the brain, central nervous system, and immunological system among children under five years [7]. IDA is also associated with long-term poor cognitive and behavioral performance among infants [8]. There are many risk factors for IDA, including low birth weight, low socioeconomic status, low education, living in rural areas, and other factors that vary between different regions [9]. The previous systematic reviews and meta-analyses concerned with IDA prevalence and risk factors among specific children populations or focused on specific countries and included less recent studies [9-11]. Therefore, this systematic review was performed to identify the prevalence and risk factors of IDA, including studies from any country and focusing on more recent studies that were published between 2017 and 2023.

**Method and search strategy:**
Following the PRISMA checklist guidance for systematic review and meta-analysis [12] while writing this systematic review was adopted. Electronic databases and scientific websites were revised to search for articles related to the current subject; these databases included PubMed, Google Scholar, Scopus, Elsevier, Science Direct, and Research Gate. The search process was restricted to a time period between 2017 and 2023. Several keywords were used for searching purposes, including "IDA, Prevalence, Risk factors, Determinants, Paediatrics, Children," which were used in different combinations to obtain all related studies.

**Eligibility criteria:**

All the titles and abstracts produced from this exploration were revised; then, all duplicate titles were excluded. Articles published before 2017 and that appeared coincidentally were also excluded. Articles reported IDA among other populations such as men, women, pregnant, or adolescents were excluded, and only articles focused on the pediatric population were included. The findings were further examined to choose only original research articles focused on IDA among children and reported the prevalence and/or risk factors. Therefore, systematic reviews, meta-analyses, review articles, and letters to the editor were all excluded. All articles from any country were eligible, and only articles in English were defined as articles of relevance.

The second step involved manual reviewing of the abstracts to select the relevant studies for revision. The inclusion criteria were studies reported complete and clear data, including the age of children, number of children, study design, and country of the study. Also, articles reported clear findings, including the prevalence of IDA, and/or risk factors were eligible for inclusion. On the other hand, studies that reported overlapped,
incomplete data or overlapped findings were excluded. Also, unavailable full-text articles were excluded. The full description of the search strategy is shown in figure 1.

Data review and analysis:

Stage one in the data review included a preliminary review of abstracts in determining the data of interest. The data required for collection included author and years of publication, study design, country, sample size and age of children, and the items reported prevalence and risk factors. The data was collected using a specially designed excel sheet, and then the
data was revised and transferred to a pre-designed table for summarization.

Results:

This systematic review included ten studies that met the eligible criteria [13-22] (Table 1). Regarding study design, the majority of the studies were cross-sectional [13, 15, 16, 19, 20, 21, 22], whereas regarding the remaining three studies, there was one prospective[14], one was retrospective[17], and one was observational cross-sectional[18]. The included studies were from seven countries; one from Bangladesh [13], two from Indonesia [14, 21], two from Tanzania [15, 20], one from Ethiopia[16], one from United Arab Emirates (UAE) [17], one from Angola[18], and two from Malaysia[19, 22].

The total number of children in the included studies was 12055 children; the smallest sample size was 100 [13, 14], and the largest sample size was 8014[15]. One study was conducted on IDA to report the severity prevalence of IDA[13], another one was conducted on underweight children [21], whereas the remaining studies were conducted on children and infants without specification of the population. There were two studies conducted on school children[19, 22], whereas the remaining studies were conducted on preschool children and infants. The smallest age range was 9-11 months [14], whereas the oldest age range was 8-10 years [19]. There were nine studies reported the prevalence of IDA [14-22], whereas one study reported the prevalence of anemia based on anemia severity[13]. There were two studies reported the prevalence only of IDA without reporting the risk factors[21, 22], and eight studies reported the risk factors [13-20].
Regarding the prevalence of IDA, one study reported the prevalence of IDA severities, and the prevalence was the highest regarding mild IDA (65%), followed by moderate IDA (33%) and severe IDA (2%) [13]. The overall prevalence of IDA among the included studies ranged between 7.7% [22] to 71.22% [17]. There were two studies that additionally reported the prevalence of IDA according to age groups [15, 20]. The highest prevalence of IDA in the two studies was reported in the youngest age groups; the prevalence among those with 6-23 months was 67% [15]; also, the other study reported a prevalence of 50.6% among the youngest age group which included children aged 2-12 months [20].

Regarding the risk factors of IDA, one study reported no correlations between IDA and the investigated risk factors, including nutritional status (P=0.3), maternal education (P=0.2), maternal occupation (P=0.5), maternal parity (P=0.5) and family income (P=0.3) [14]. Another study reported that the protective factor of IDA, where the prevalence of IDA was significantly reduced as the height for age increased (AOR=0.7) [16]. The remaining six studies reported the risk factors of IDA [13, 15, 17, 18, 19, 20]; the risk factors associated with the overall IDA included iron supplementation during pregnancy (67%), poor dietary diversity (59%), low birth weight (67%), early introduction of complementary food before six months (68%) [13], nationality (OR=1.53, P<0.01) [17], body mass index (BMI) (P<0.001), presence of soil-transmitted helminthes (P<0.001), level of knowledge regarding IDA (P<0.001), level of practice (P=0.03), daily iron consumption (P=0.008), household income (P=0.02) [19], drinking milk of cow (AOR=5.6) [20], employed mother (OR=1.2, P=0.01), uneducated (OR=1.46, P=0.001) male gender (OR=1.14, P=0.02) [15] (OR=2, P=0.002) [18], BMI of mother (19-25 Kg/m²) (OR=1.25, P=0.002), anemic mother (OR=1.86, P<0.001), having a baby
at home (OR=1.15, P=0.03), children belong to bigger household (OR=1.15, P=0.02), children fever (OR=1.44, P<0.001) stunting (OR=1.31, P<0.001) [15], age of 6-23 months (OR=7.4, P<0.001), and non-malarian inflammation (OR=2.4, P<0.001) [18].

Two studies [15, 18] reported risk factors of IDA based on age groups. The risk factors associated with IDA for 6-23 months were employed mother (OR=1.43, P=0.003) [15], male child (OR=1.46, P=0.001) [15], (OR=2.1, P=0.001)[18], children considered small size at birth (OR=1.77, P=0.002), anemic mother (OR=2.28, P<0.001) [15], continued breastfeeding (OR=1.9, P=0.01), and non-malarian inflammation (OR=2.2, P<0.001) [18]. The risk factors for Ida among 24-59 months children included uneducated mothers (OR=1.54, P<0.001), anemic mothers (OR=1.77, P<0.001), babies delivered at home (OR=1.27, P<0.001) children fever (OR=1.61, P<0.001) and stunting (OR=1.46, P<0.001) [15]. The risk factors associated with children aged 24-36 months were moderate to severe stunting (OR=2.6, P=0.03), malarian inflammation (OR=18.2, P<0.001), and non-malaria inflammation (OR=4, P=0.007) [18].

**Table 1: Summary of the data collected**
<table>
<thead>
<tr>
<th>Author and Publication year</th>
<th>Study design</th>
<th>Country</th>
<th>Sample size and Age of participants</th>
<th>Items reported</th>
<th>Prevalence and risk factors</th>
</tr>
</thead>
</table>
| Shahin et al. 2022 [13]     | Cross-sectional   | Bangladesh    | N=100 children with IDA, Age= under five years | Risk factors, Prevalence of anemia severity | *Mean Hb=8.1g/dl  
*65% had mild anemia, 33% had moderate, and 2% had severe anemia  
*The main risk factors were iron supplementation during pregnancy (67%), low (poor) dietary diversity score (59%), low birth weight (67%), and early introduction of complementary foods before 6 months (68%) |
| Ringoringo 2022 [14]        | Prospective       | Indonesia     | N=100 healthy infants, Age=9-11 months | Risk factors, Prevalence                | *The prevalence of IDA was 32%  
*There was no correlation between the prevalence of IDA and nutritional status (P=0.3), maternal education (P=0.2), maternal occupation (P=0.5), maternal parity (P=0.5), or family income (P=0.3) |
| Msaki et al, 2022 [15]      | Cross-sectional household survey | Tanzania | N=8014 children, Age=6-59 months (under five years) | Risk factors, Prevalence                | *IDA was defined at Hb<11g/dL  
*The prevalence of IDA among children aged 6-23 months=67%, 24-59 months=49%, and 6-59 months=59%.  
*The risk factors of IDA for children with 6-23 months included employed mother (OR=1.43, P=0.003), male child (OR=1.46, P=0.001), the child considered small size at birth by mothers(OR=1.77, P=0.002), anemic mother (OR=2.28, P<0.001).  
*The risk factors for IDA for children with 24-59 months included an uneducated mother |
*The risk factors associated with IDA for children with 6-59 months included employed mother (OR=1.2, P=0.01), uneducated mother (OR=1.46, P=0.001), male child (OR=1.14, P=0.02), BMI of mother of 19-25Kg/m² (OR=1.25, P=0.002), anemic mother (OR=1.86, P<0.001), having a baby at home (OR=1.15, P=0.03), children belong to bigger households (OR=1.15, P=0.02), child fever (OR=1.44, P<0.001), and stunting (OR=1.31, P<0.001).

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Design</th>
<th>Country</th>
<th>Sample Size</th>
<th>Age</th>
<th>Risk factors</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orsango et al, 2021 [16]</td>
<td>Cross-sectional</td>
<td>Ethiopia</td>
<td>N=331</td>
<td>Age=2-5 years</td>
<td>-Employed mother (OR=1.2, P=0.01), uneducated mother (OR=1.46, P=0.001), BMI of mother of 19-25Kg/m² (OR=1.25, P=0.002)</td>
<td>*IDA was defined at both hemoglobin level &lt;11g/dl and low ferritin concentration</td>
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<td></td>
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<td></td>
<td>*The prevalence of IDA was 25% *The prevalence of IDA significantly reduced as the height for age increased (AOR=0.7)</td>
</tr>
<tr>
<td>Faysal et al, 2020 [17]</td>
<td>Retrospective</td>
<td>United Arab Emirates</td>
<td>N=1595</td>
<td>Age=1-5 years</td>
<td>-Nationality (OR=1.53, P&lt;0.01), where Emirati children were 54% less likely to have IDA compared to non-Emirati children</td>
<td>*The prevalence of IDA was 71.22% *The risk factor of IDA was nationality (OR=1.53, P&lt;0.01)</td>
</tr>
<tr>
<td>Fancony et al, 2020 [18]</td>
<td>Observational cross-sectional</td>
<td>Angola</td>
<td>N=948</td>
<td>Age=6-36 months</td>
<td></td>
<td>*The prevalence of IDA was 19.4% *Regression model regarding the population showed that IDA was associated with the age</td>
</tr>
</tbody>
</table>
*The risk factors of IDA among children with age 6-23 months were male gender (OR=2, P=0.002), continued breastfeeding (OR=1.9, P=0.01), and non-malarian inflammation (OR=2.2, P<0.001).

*The risk factors of IDA among children with 24-36 months were moderate to severe stunting (OR=2.6, P=0.03), malarian inflammation (OR=18.2, P<0.001), and non-malarian inflammation (OR=4, P=0.007)

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Type</th>
<th>Country</th>
<th>Sample Description</th>
<th>Risk factors and Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roslie et al 2019 [19]</td>
<td>Cross-sectional</td>
<td>Malaysia</td>
<td>-N=261 schoolchildren</td>
<td>*The prevalence of IDA was 13.79%</td>
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<td></td>
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<td></td>
<td>-Age=8-10 years</td>
<td>*The factors associated with IDA were BMI (P&lt;0.001), presence of soil-transmitted helminths (P&lt;0.001), level of knowledge regarding IDA (P&lt;0.001), level of practice (P=0.03), daily iron consumption (P=0.008), and household income (P=0.02)</td>
</tr>
<tr>
<td>Kessy et al 2019 [20]</td>
<td>Cross-sectional</td>
<td>Tanzania</td>
<td>-N=303 children under five years</td>
<td>*The prevalence of IDA was 28.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Age=2-59 months (under five years)</td>
<td>*Regarding age groups, the prevalence of IDA was 50.6% among those with 2-12 months, 40% among 13-23 months, and 9.4% among 24-59 months</td>
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<td></td>
<td>*Drinking the milk of a cow was associated with an increased risk of IDA (AOR=5.6)</td>
</tr>
<tr>
<td>Ahmad et al 2018 [21]</td>
<td>Cross-sectional</td>
<td>Indonesia</td>
<td>-N=154 underweight children</td>
<td>*The prevalence of IDA was 19.7%</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Location</td>
<td>Sample Description</td>
<td>Prevalence</td>
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</tr>
<tr>
<td>Halib et al 2017</td>
<td>Cross-sectional</td>
<td>Malaysia</td>
<td>-N=249 primary school children</td>
<td>-Prevalence</td>
</tr>
</tbody>
</table>

IDA; Iron deficiency anemia, Hb; Hemoglobin,
Discussion:

IDA in children may be underdiagnosed as most children don't undergo blood tests if there is no reasonable clinical event or reason [23]. However, IDA has adverse consequences on the development of children and can increase the risk of infectious diseases, reduced concentration and learning ability, weakness, and reduced physical ability [24]. Therefore, it is necessary to identify the prevalence and risk factors of IDA among children to understand the range of the problem and try to put solutions for it.

In the current analysis, the prevalence of IDA among children ranged between 7.7% and 71.22%. This high rate of prevalence isn't surprising, as previous studies from different countries reported a high prevalence of IDA, including Pakistan (33.2%)[25] and Nepal (37.9% and 48%)[26,27]. It was reported that the prevalence of IDA is more prevalent among children of developing countries compared to those from developed countries among those aged four years and younger[28]. However, all studies included in our analysis coincidentally were from developing countries, and none were from developed countries. According to the world health organization (WHO), 27% of preschool children suffer from IDA [29]. In our analysis, the prevalence of IDA among preschool children exceeded the proportion reported by the WHO in four studies[14, 15, 17, 20].

Regarding the risk factors of IDA, it was reported that poor housing, low education, living in rural areas, drinking the milk of cows frequently, poor sanitation, joblessness, and poor health conditions were associated with anemia for all ages [7]. In the current analysis, we found a variety of risk factors for IDA. This may return to the fact that the risk factors may
be varied based on the region of the study. We found that drinking the milk of cows carried a high risk for IDA development (AOR=5.6). Also, unemployed and uneducated mothers were associated with IDA. However, one study in our analysis reported that maternal education and occupation had no association with IDA among children [14]. The lack of iron intake from daily consumed food can increase the chances of anemia [1]. In our analysis, we found that poor dietary diversity, low birth weight, and the presence of soil-transmitted helminths were risk factors for IDA. This can be explained by the fact that children consuming poor dietary diversity lack essential elements that should be obtained from food, and the presence of parasites affect the nutritional status of the patient.

A systematic review identified IDA among Iranian children less than six years a total of six articles were included with a sample size of 1700 and included studies published between 2001 to 2018. The prevalence of IDA among such populations was 18.2%, and the prevalence was higher among males (17.7%) compared to females (14.4%) [10]. Our analysis included a larger number of studies around the world with a larger sample size and more recent articles. The overall prevalence ranged between 7.7% and 71.22%. It should be noted that none of the included studies was from developed countries; the highest prevalence (71.22%) was recorded from UAE[17], whereas the lowest prevalence was reported from Malaysia [22]. Also, it should be noted that studies in our analysis included children with age up to ten years.

A systematic review and meta-analysis by Gedfie et al. conducted on children less than five years reported a global pooled prevalence of IDA of 16.4%, and the risk factors for IDA were age less than two years and living in a large family size, whereas anemic mother and low birth weight
were factors associated with iron deficiency [9]. In our analysis, we didn't estimate the pooled prevalence; however, only one study reported a prevalence (7.7%) less than [22] reported in the previous systematic review and meta-analysis [9]. Therefore, the prevalence in our analysis is much higher; this may be attributed to the fact that the included studies were from developing countries. Additionally, we found various risk factors for IDA, and we found that the factors reported in the previous systematic review and meta-analysis [9] that were associated with iron deficiency were associated with IDA in our analysis. A systematic review and meta-analysis from Brazil included 57 studies that showed that the pooled prevalence in Brazil among children aged less than five years was 40.2% [11].

**Conclusion:**

There was a high prevalence of IDA among children at preschool age and those at school age till ten years. There were various risk factors for IDA; however, these risk factors varied between different studies as well as different age groups of children. The variation in risk factors may reflect that the risk factors varied based on the region of the study.

**Limitations, strengths, and recommendations:**

The limitations of this review include the inclusion of studies from developing countries; therefore, we couldn't confirm if the prevalence of IDA is higher in developing countries compared to developed ones or not. However, the inclusion of these studies from developing countries was a coincidence as we included the studies that met the inclusion criteria and such studies met the set inclusion criteria. Also, we didn't estimate the pooled prevalence; however, the prevalence was higher than that reported by the WHO in many studies. Additionally, we couldn't determine the
major risk factors as the studies included in our analysis reported various and different risk factors, and this may reflect the impact of region on risk factors such as the presence of some diseases in some regions, such as malaria infection and the lack of such diseases in other regions. Also, we didn’t discuss risk factors deeply, as the previous studies and systematic reviews focused on the prevalence, not the risk factors. The strengths of this systematic review are the inclusion of more recent studies compared to the previous systematic analysis and the inclusion of children until ten years, unlike previous studies that focused on children at definite ages. Also, we identified the prevalence of IDA from different countries, unlike the previous analysis that focused on specific nations. We recommend further studies to investigate the risk factors of IDA among children with the investigation of specific risk factors that can be investigated through all the studies to determine the major risk factors and determine if the risk factors are affected by the region of the study.

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25- Habib MA, Black K, Soofi SB, et al. Prevalence and predictors of iron deficiency anaemia in children under five years of age in Pakistan, a


Records identified from: Databases (n=2660)

Records removed before screening:
  Duplicate records removed (n=690)
  Records marked as ineligible by automation tools (n=920)
  Records removed for other reasons (n=889)

Records screened (n=161)

Records excluded (n=61)

Reports sought for retrieval (n=10)

Reports not retrieved (n=9)

Reports assessed for eligibility (n=101)

Reports excluded:
  Incomplete data (n=5)
  Overlapped data (n=5)
  Non-original articles (n=51)
  Non-English articles (n=30)

Studies included in review (n=10)