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REVIEW ARTICLE

# Trends in iron deficiency anemia research 2010 – 2023: a bibliometric analysis

**Budi Santosa[1], Fitriani Nur Damayanti[2], and Suparman[3]**

[1]Department of Medical/Clinical Laboratory Science, Universitas Muhammadiyah Semarang, Indonesia
[2]Department of Midwifery, Universitas Muhammadiyah Semarang, Indonesia
[3]Department of Mathematics Education, Universitas Ahmad Dahlan, Indonesia

budisantosa@unimus.ac.id

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## ABSTRACT

Anemia is a health disorder marked by a reduction in hemoglobin concentration (Hb), hematocrit (Ht), and erythrocyte count. Iron deficiency anemia is marked by a reduction in hemoglobin synthesis, resulting in the production of hypochromic microcytic erythrocytes. The interest over time in the topic of iron deficiency anemia throughout the world is increasing. Many studies associated with iron deficiency anemia have been conducted by various authors and are increasing from year to year. The aim of the present review was to evaluate the literature on iron deficiency published between 2010 and 2023, with a focus on the trend in number of publications and citations, the trend of the link strength on the topic of iron deficiency anemia, and the low density of articles published from 2010 to 2023, to determine the trend and novelty of the topic of iron deficiency anemia. This review was a systematic study with the stages conforming to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram. The data on scientific publications on the topic of iron deficiency anemia were collected using dimensions.ai from 2010 to 2023. The data were subsequently analyzed with the Vosviewer program. This review resulted in the following findings. First, the number of publications and citations on the topic of iron deficiency anemia increased exponentially from year to year. Second, there were 139 items, 3 clusters, and 5579 links, with a link strength of 18253 for the topic of iron deficiency anemia. Third, the recommended study topics connected with iron deficiency anemia are topics of low density, namely clinician, pathogenesis, and biofortification. The study findings may assist the interested researchers to know the trends and novelties of studies on iron deficiency anemia, and may recommend suggestions for further research.

**Keywords**: Bibliometric analysis, iron deficiency anemia, novelty, trend

## INTRODUCTION

Iron deficiency anemia (IDA) affects more than 1.2 billion persons in the whole world, and iron deficiency without anemia is even more common.(1) Iron deficiency is the most common micronutrient inadequacy that affects almost one-third of the population and is the principal cause of anemia throughout the world.(2) Iron deficiency anemia is the fourth

main cause of life with disability, particularly in women, such that to highlight the prevention and treatment of iron deficiency and IDA is the main goal of public health.[3] Iron deficiency causes weakness, fatigue, difficulty concentrating, and poor academic performance or work productivity because of non-specific symptoms that are considered to result from the reduced oxygen that is sent to the body tissues.[4] The most common clinical manifestation is hypochromic microcytic anemia, and iron deficiency may affect various systems including the central nervous system and the reticuloendothelial system, and has clinical consequences, such as immune disorders, cognitive deficits, reduced capacity for physical activity, and reduced quality of life.[5]

Anemia is a health condition marked by a reduction in hemoglobin concentration (Hb), hematocrit (Ht), and erythrocyte count.[6] Iron deficiency anemia is marked by a reduction in hemoglobin synthesis that results in the production of hypochromic microcytic erythrocytes.[7] Imbalance between intake, absorption, and storage of iron on the one hand and the utilization and loss of iron on the other, ultimately results in IDA.[8] The causes of IDA include reduced intake or absorption of iron, increased requirement for iron in adolescence and pregnancy, bariatric surgery, heavy blood loss during menstruation, chronic blood loss due to gastrointestinal (GI) disorders, polyps, or carcinoma.[9] Impaired absorption of iron may be caused by a reduction in trace elements such as zinc, that is found in the structure of enzymes that coordinate or catalyze the metabolism of iron.[10] The clinical management of patients with IDA needs a comprehensive understanding of the various causes that may result in iron deficiency, including pregnancy, blood loss, renal disease, heavy menstrual bleeding, intestinal inflammatory disorders, bariatric surgery, or extremely rare genetic disorders.[11]

The iron content of the human body is meticulously regulated and is usually maintained at around 40 mg/kg in women and at around 50 mg/kg in men.[12] Because humans cannot regularly secrete excess iron, the iron balance is controlled at the level of iron absorption by duodenal enterocytes, and by the mobilization of iron from the hepatic parenchyma and macrophages.[13] This process is regulated by hepcidin, a small peptide produced in the liver.[14] Hepcidin binds to the cellular iron export protein ferroportin, resulting in internalization of this protein. When the hepcidin concentration increases, iron is retained in enterocytes or macrophages and is not available for the production of erythrocytes.[15] When the hepcidin concentration is reduced, either because of ID or increased erythropoiesis, the iron absorbed by the enterocytes or stored in macrophages is mobilized into the circulation.[16]

The interest over time in the topic of iron deficiency anemia in the whole world has increased, because iron deficiency anemia (IDA) is a widespread public health problem, particularly in low- and middle-income countries.[17] Data on this interest can be searched through Google Trends by typing the key word iron deficiency anemia.[18,19] For example, a search from January 2004 to December 2022 by web-based searching and all categories with resulted in the data presented in Figure 1, that were collected on June 17, 2023.

Interest in the topic of iron deficiency anemia may also be reviewed by country, which is presented in Figure 2. Somalia is the country with the highest interest in the topic of iron deficiency anemia, followed by Zambia.

These data portray a general interest in the topic of iron deficiency anemia. Although IDA has been known for a long time, there are still undisclosed problems and there is still room for perfecting its management.[20]

Bibliometric analysis is a quantitative scientific method of evaluating published articles that may assist researchers to find trends of research development and hotspots in a given scientific field, to provide the development of future studies for

researchers.[21] Bibliometric analysis assists researchers to identify emerging areas and future directions of the study domain with the help of visualization tools.[22] Bibliometric analysis has been used by various authors to evaluate the publications on information theory that are listed in the Scopus database,[22] to evaluate immigration and environmental degradation,[23] and to investigate trends in research on glioma radiotherapy since 2011.[24]

The obtained results are of immense value for academicians, scientific researchers, research institutions, institutions of higher education, and health personnel to constantly develop scientific studies on the theme of iron deficiency anemia and who need historic studies and future data.[25]

There are five types of research metrics for data analysis, namely scientometrics, bibliometrics, cybermetrics, informetrics, and altmetrics.[26] For example, bibliometric analysis is used in research and is more suited to the quantitative analysis of the distribution of research articles, terms, and key words in determining research trends.[27] Bibliometric analysis is regarded as a scientific field that shows a comprehensive map of the structure, evaluation, and measurement of knowledge.[28] In addition, bibliometric analysis is a study method used in library and information science to evaluate research performance.[29] Bibliometric analysis is essential in evaluating the impact of studies, where the studies are ranked on the basis of the citations that they receive.[30]

The aim of the present review was to evaluate the literature on iron deficiency published between 2010 and 2023, with a focus on the trend of the number of publications and citations, the trend of link strength on the topic of iron deficiency anemia, and the low density of publications from 2010 to 2023 for evaluating the trend and novelty of the topic of iron deficiency anemia.

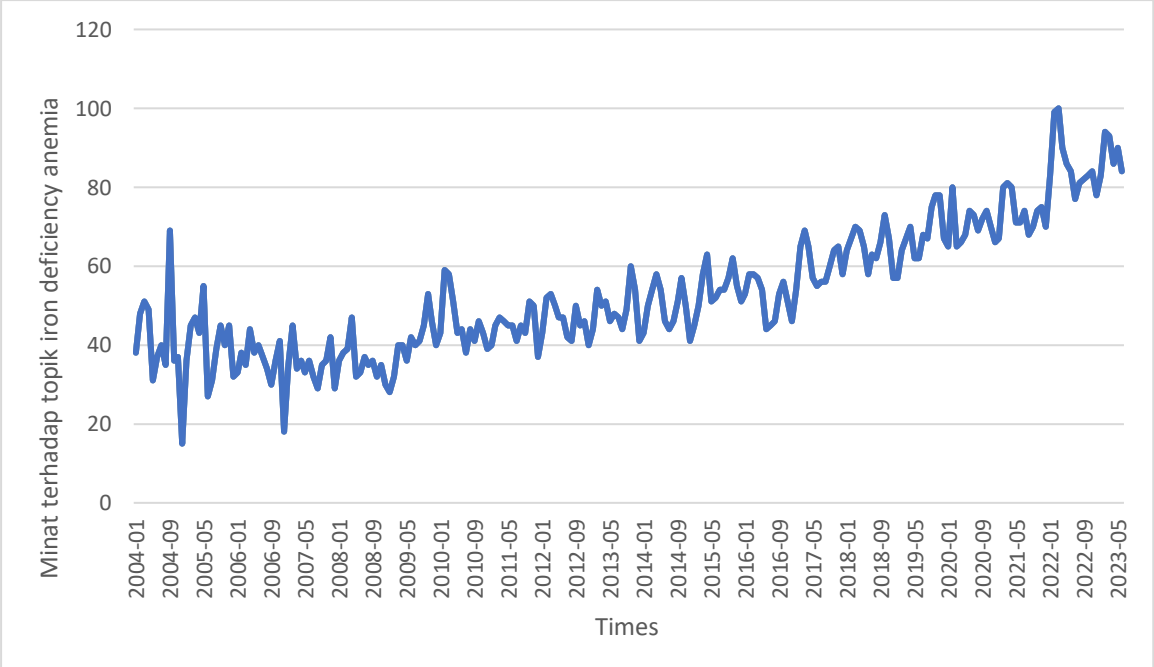


**Figure 1**. Interest over time in the topic of iron deficiency anemia (Data source: Google Trends)

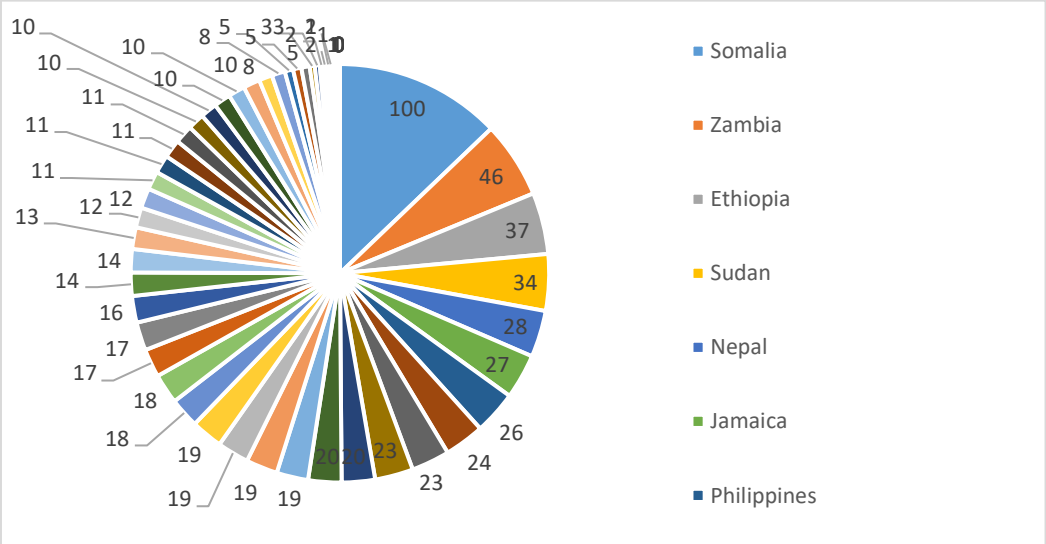


**Figure 2**. Histogram of interest in iron deficiency anemia, by country (Data source: Google Trends)

## METHODS

This bibliometric analysis was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.[31]

### Data collection

The data used in this study were based on online searches through https://app.dimensions.ai/. The data were collected on June 17, 2023. The stages in PRISMA comprise identification, screening, and included, such as shown in Figure 3. Stage 1 (identification) detected 17,879 records from dimensions.ai, by considering, for each main search term of iron deficiency anemia, "document type article and proceeding" and "all data published in the data range from 2010 to 2022". In stage 2 (screening), the option "article title, abstract" was chosen in the field of each search term, such that 9,572 records were output. In stage 3 (included), the final sample produced 8,307 accessible articles.

### Data analysis

Data were analyzed by means of VOSviewer, which is a computer program for constructing and viewing bibliometric maps.[32] For "type of data" was selected "create a map based on text data". In this study, the data analysis was from the point of view of co-occurrence and co-authors.

The procedure for the analysis of co-occurrence was as follows. For "data source" was selected "read data from references manager files". For "choose fields" was selected "fields from which terms will be extracted are title and abstract fields". For "counting method" was selected "full counting". For "threshold" was selected "minimum number of occurrences of a term is 10". For "choose number of terms" was selected 139.

The procedure for analysis of co-authors was as follows. For "choose type of data" was selected "create a map based on bibliographic data". For "choose data source" was selected "read data from reference manager file". For "supported file type" was selected "ris". For "choose type of analysis and counting method" was selected "type of analysis is co-authorship" and for "counting method" was selected "full counting". For "choose threshold" was selected "maximum number of documents of an author = 0". Of the 1345 authors, 84 met the threshold. For "choose …of author" was selected "For each of the 84 authors, the total strength of the co-authorship links with other authors will be calculated". The authors with the highest total link strength will be selected.

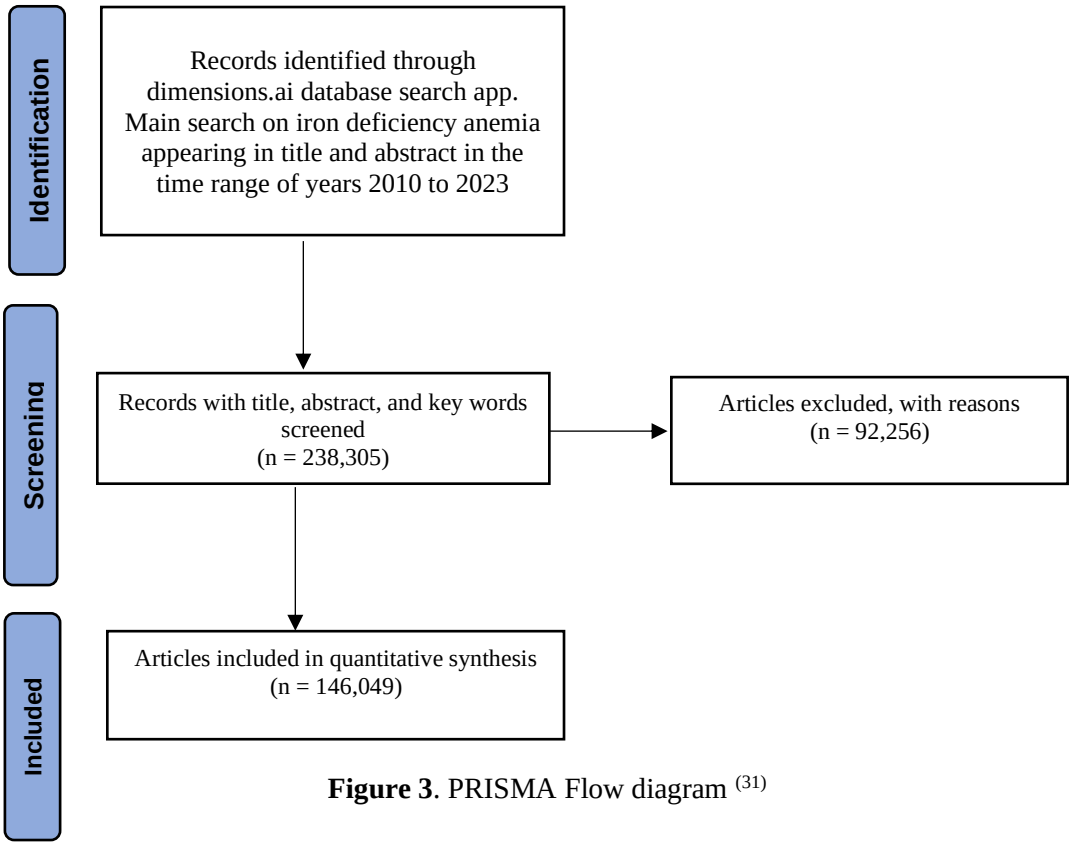


**Figure 3**. PRISMA Flow diagram [31]

## RESULTS

### Analysis of number of publications

The search from 2010 to 2023 produced published scientific articles. The annual numbers of publications on iron deficiency anemia from 2010 to 2022 are presented in Figure 4. The highest increase of 12,013 occurred in 2021, whereas the lowest increase of 880 occurred in 2010.

### Analysis of citations

The annual numbers of citations on iron deficiency anemia from 2010 to 2022 are presented in Figure 5. The highest increase of 51,106 occurred in 2022, whereas the lowest increase of 375 occurred in 2010.

### Analysis of networks

The network visualization map of 139 terms is presented in Figure 6. The selected number of terms was 139. Two items that are connected by a line signify that these two occur together in one title and abstract. On the contrary, two items that are not connected by a line signify that these two do not occur together in one title and abstract. In Figure 5, there were 139 items, 3 clusters, 5579 links, and a link strength of 18,253.

### Analysis of overlays

Overlay visualization is presented in Figure 7. VOSviewer also makes available overlay visualization maps, the one for 139 terms is presented in Figure 7.

Overlay visualization gives an analysis based on the key word iron deficiency anemia from 2010 to 2022 to observe the trend of titles of research studies associated with midwifery policy. Based on the overlay visualization map in Figure 7, the yellow nodes imply that the key word is “interest in current studies”. For example, the current research trend in iron deficiency anemia focused on guideline, heart failure, and reproductive age.

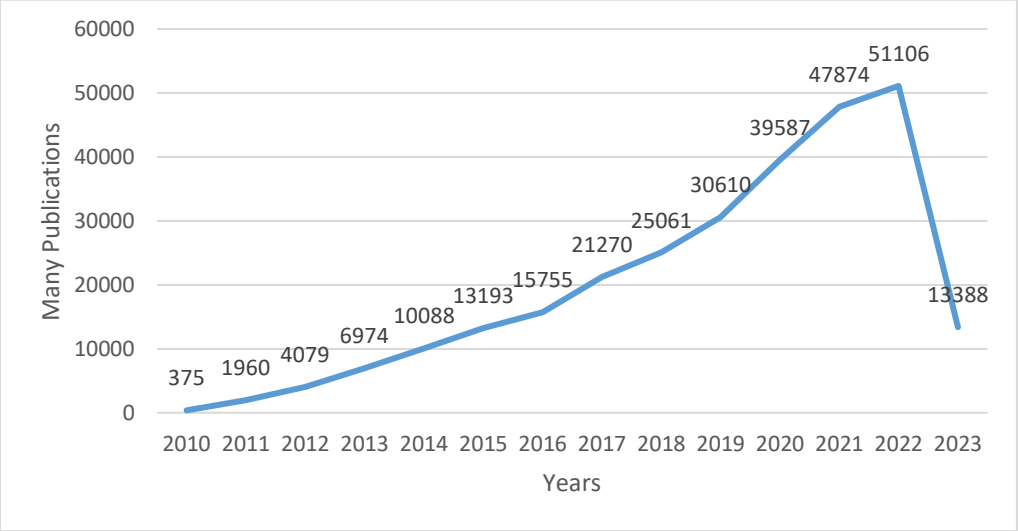


**Figure 4**. Number of publications on iron deficiency anemia from 2010 to 2023 (Source: https://app.dimensions.ai/)

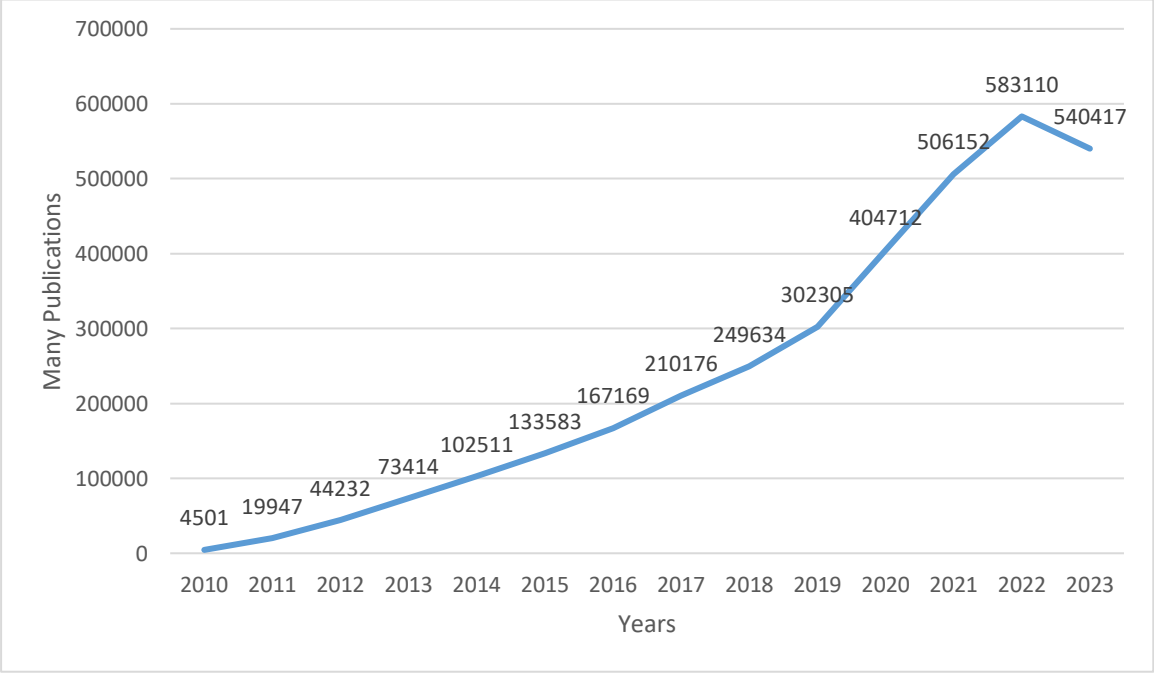


**Figure 5.** Number of citations for topic of iron deficiency anemia from 2010 to 2023 (Source: https://app.dimensions.ai/)

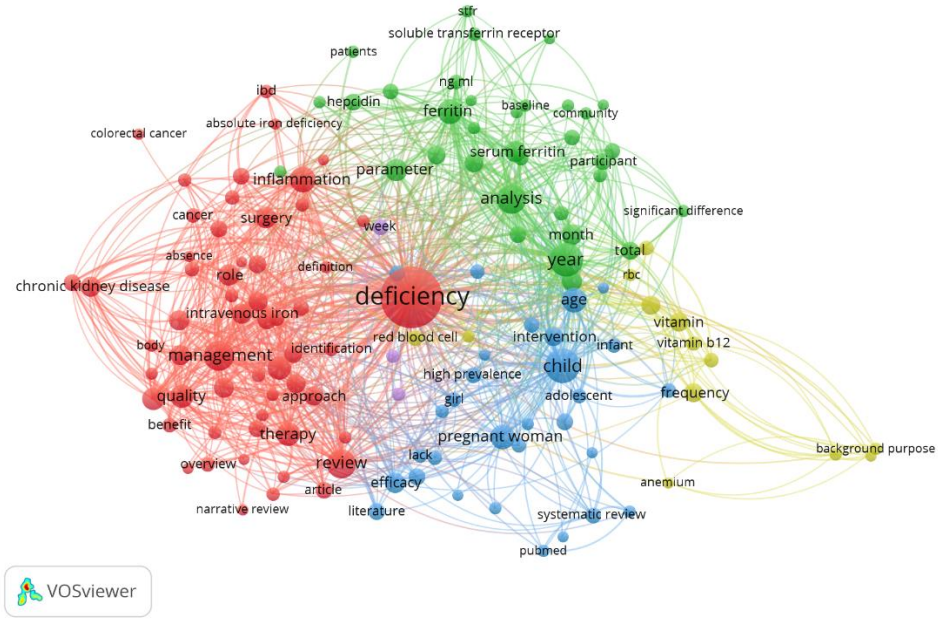


**Figure 6**. Network visualization (Source: VOSviewer)

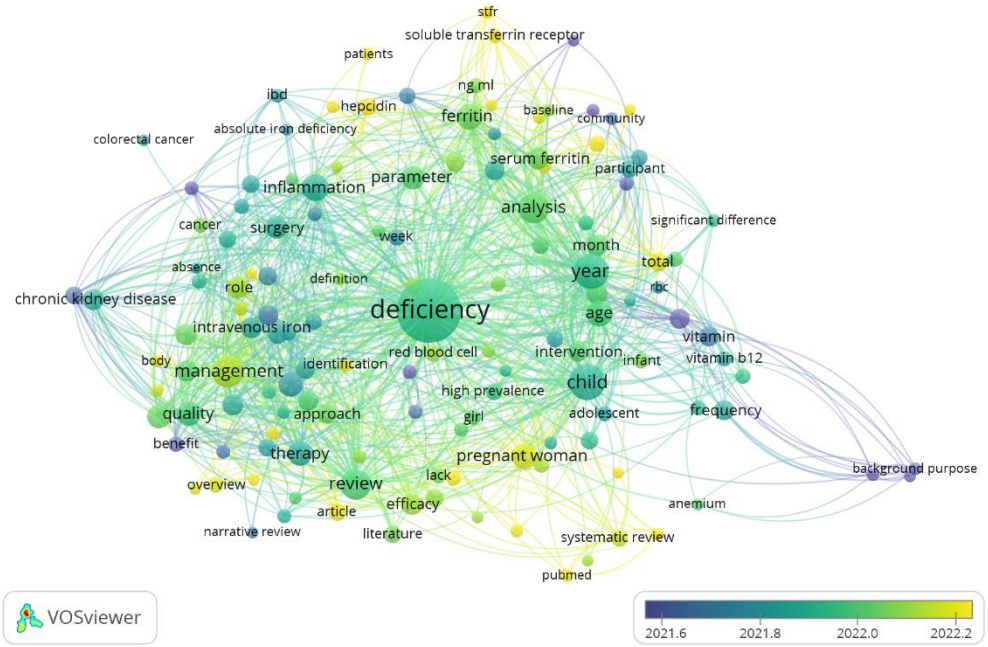


**Figure 7.** Overlay visualization (Source: VOSviewer)

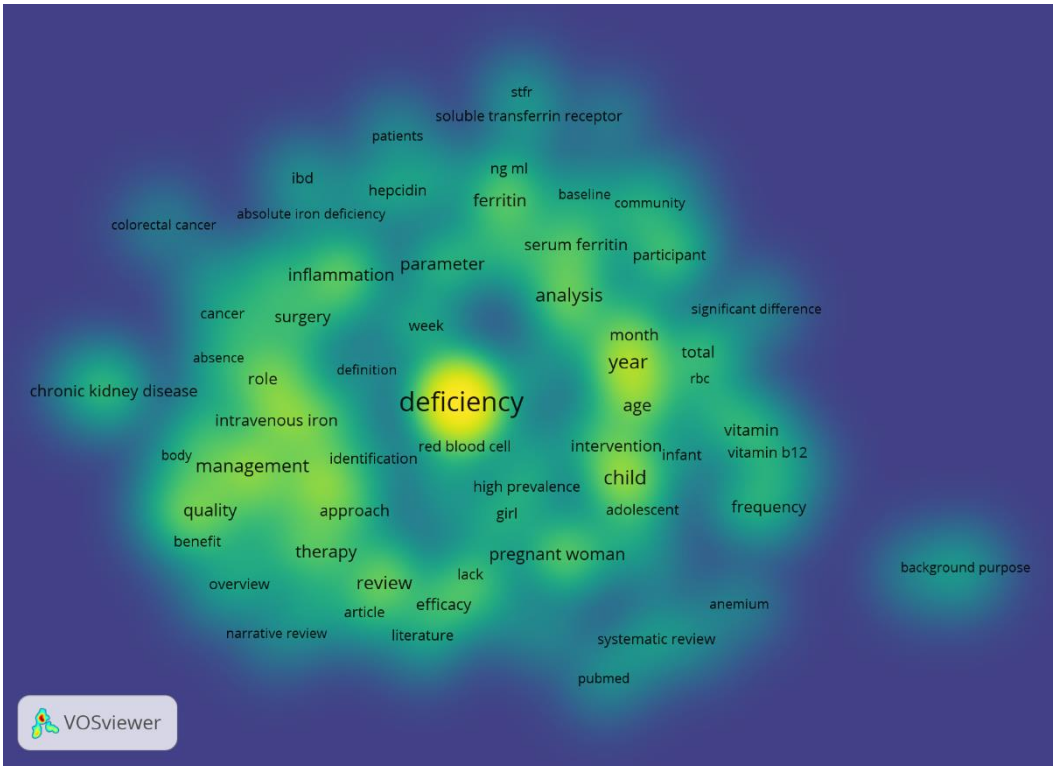


**Figure 8.** Density visualization (Source: VOSviewer)

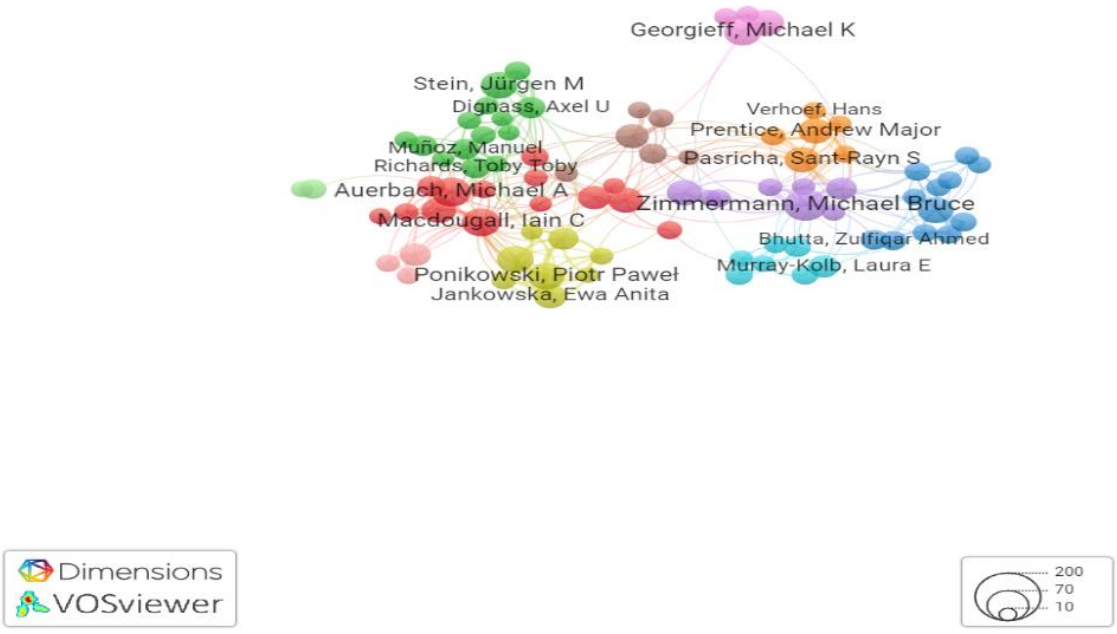


**Figure 9**. Network visualization for co-authors (Source: VOSviewer)

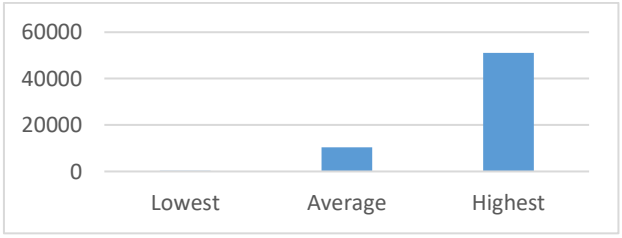


**Figure 10**. Histogram of lowest, average, and highest increase in number of citations for topic of iron deficiency anemia

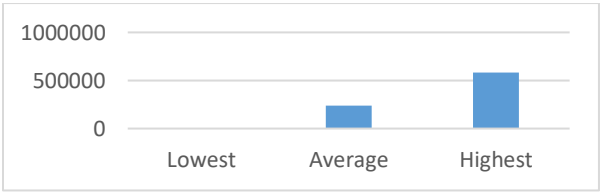


**Figure 11**. Histogram of lowest, average, and highest increase in number of citations for topic of iron deficiency anemia

**Analysis of densities**

Density visualization of the 139 terms is presented in Figure 8. Figure 8 shows density visualization of a large number of items found on several items, such as woman, risk, and child. Several items with yellow-colored nodes signify that these items have been used as a topic in previous journal publications. Therefore, the suggested research topics associated with iron deficiency anemia are those with a density visualization in the low category such as clinician, pathogenesis, and biofortification.

## DISCUSSION

The iron balance is essential for all cell life. The homeostatic mechanism for iron evolved to avoid excess iron and the formation of hazardous reactive oxygen species by reutilizing the iron in the body and limiting iron absorption from the environment. The unavoidable other side of the coin is the ease of developing iron deficiency.[26] Anemia is a health condition marked by a reduction in hemoglobin concentration (Hb), hematocrit (Ht), and erythrocyte count.[6] Anemia is one of the many consequences of iron deficiency, and clinical and functional disorders may occur without anemia.[33] Anemia is the clearest sign of iron deficiency, and iron deficiency anemia is frequently considered to be identical with iron deficiency. Iron deficiency is the reduction in total body iron, particularly the iron stored in macrophages and hepatocytes. The largest amount of iron is consumed for hemoglobin synthesis (Hb) to produce 200 billion erythrocytes daily.[1] Iron deficiency is a more general condition that frequently precedes the appearance of anemia or shows deficits in organs/tissues in addition to that seen in erythropoiesis, such as skeletal and cardiac muscle, the latter being extremely dependent on iron for the production of myoglobin and energy for maintaining mechanical contraction.[1]

Iron deficiency is one of the main contributors of the global disease load, and particularly attacks children, premenopausal women, and individuals in low- and middle-income countries.[33] Iron deficiency (ID) and iron deficiency anemia (IDA) produce a gigantic disease load in the whole world. If the intake of iron is insufficient to meet the needs or to compensate for physiological or pathological losses, the iron store in the body

is depleted. Absolute ID occurs when the iron store is insufficient to meet the needs of the individual, and generally occurs in young children (under 5 years of age) and premenopausal women (particularly pregnant women). In patients with inflammation, the reduction of iron from the plasma results in erythropoiesis of iron deficiency and anemia, although the iron store in the body is adequate (functional iron deficiency). This process commonly occurs in patients with complex medical or surgical disorders, in persons residing in areas with a high prevalence of infection, and in patients receiving erythropoiesis-stimulating agents.[34]

The present review showed that from 2010 to 2022, the lowest number of publications on iron deficiency anemia occurred in 2010 and the highest in 2020 with an average of 1325 (Figure 9). The number of publications increased exponentially from year to year.

The lowest increase in the number of citations on iron deficiency anemia occurred in 2010 and the highest in 2022 with an average of 20610 (Figure 11). The number of citations also rose exponentially from year to year. The most-cited article had the title of '2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC' [35] with 10,000 citations, followed by the article titled 'Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017'[36] with 7,700 citations.

For type of data was chosen 'create a map based on text data' to create a term co-occurrence map based on text data. For data source was chosen 'read data from references manager files' because the supported file type was ris. For threshold was chosen 'minimum number of occurrences of a term is 10'. This resulted in 231 meets of the threshold of the 9,302 terms. For each of the 231 terms, a relevance score was to be calculated. Based on this score, the most relevant terms were to be selected. The default choice was to select the 60% most relevant terms.

Figure 6 shows that among the 137 items there are 5 clusters, namely cluster 1 (57 items), cluster 2 (34 items), cluster 3 (30 items), cluster 4 (13 items), and cluster 5 (3 items). These clusters are shown in more detail in Table 1.

Figure 7 shows the trend of entered key words, such as guideline, heart failure, reproductive age, outcome, and regulation.

Finally, the contribution to these topics were focused on the associated iron deficiency anemia, with 5 highest foci of iron deficiency anemia, namely the epidemiological and biochemical aspects, the clinical evaluation and etiology of iron deficiency anemia, and the bioavailability of dietary iron.[37]

The various sub-periods in which scientific activities on this topic developed in 2010-2022 represent an abundant collection of key words. In the titles, abstracts, and key words of the articles in the sample, VOSviewer identified different key words, allowing for the validation of the width of the study axis in research activities.

Figure 8 shows the researchers, institutions, countries, and journals, with the highest number of articles or citation frequency originating from developed countries. The tendency for the increased growth in publications on the topic of iron deficiency anemia shows the importance of the topic of iron deficiency anemia that has attracted international interest and has attained epidemic proportions in developing countries.[38] Iron is a vital micronutrient that is needed for growth and development in all phases of human life.[39] Iron is needed in hematopoiesis (formation of blood), namely hemoglobin (Hb) synthesis.[40] Iron deficiency anemia may be investigated from many perspectives,[41] with the main contribution from the developing countries, where the

disease has its causes and effects.[42] Dietary, oral, and IV iron has been found effective in combating anemia.[43] Dietary iron can be safe-guarded as protection of the right to health.[44]

Several recommended research topics associated with iron deficiency anemia are the topics of clinician, pathogenesis, and biofortification. These 3 topics have high chances for inclusion in research associated with iron deficiency anemia, because this research has found its path, and many topics have been considered. [45] Analysis of the chances in research topics may provide several outlooks for researchers and practicing educators to identify the important directions of research.[46] Through content analysis it was found that researchers pay attention to these topics. [47]

The scope of research is extremely wide, and involves much content research, resulting in unfocused research. The research methods used may consist of qualitative, quantitative, and mixed research.[48]

The present review will assist the reader to understand the dynamics of developing trends on the research topics from the research results. This will assist researchers by speedily identifying hot spots and foci of research problems, counseling them to find the most influential or relevant references, researchers, and institutions for cooperation.[49] Analysis of the results will assist researchers to find the main journal contributions, and to direct and promote further research developments and achievements in scientific research institutions.[50]

Table 1 Clusters for topic of iron deficiency anemia (Source: Vosviewer)

| Cluster | Number of items | Cluster member item |
|---|---|---|
| 1 | 57 | Absence, absolute iron deficiency, administration, approach, article, benefit, blood loss, blood transfusion body, cancer, chonic disease, chronic kidney disease, ckd, clinical practice, clinician, colorectal cancer, common cause, correction, deficiency, definition, erythropoiesis, evaluation, fatigue, ferric carboxymaltose, functional iron deficiency, haemoglobin, heart failure, heavy menstrual bleeding, ibd, identification, inflammation, inflammatory bowel disease, interaction, iron absorption, iron homeostasis, **iron therapy**, iv iron, length, life, limitation, management, mechanism, morbidity, narrative study, oral iron, oral iron therapy, overview, patient blood management, quality, recommendation, study, role, sur gery, therapy, transfusion. |
| 2 | 34 | Analysis, bariatric surgery, baseline, biomarker, community, control, correlation, cross sectional study, ferritin, ferritin level, g l, hemoglobin level, hepcidin, ip i, iron metabolism, marker, manage, month, ng ml, obesity, parameter, participant, patients, point, present study, questionnaire, serum iron, significant difference, soluble transferrin receptor, stfr, total, tsat, year. |
| 3 | 30 | Adolescent, adolescent girl, age, child, children, difference, effectiveness, efficacy, first trimester, girl, high prevalence, infant, intervention, issue, lack, literature, low birth weight, meta analysis, micronutrient deficiency, middle income country, mother, person, pregnant woman, pubmed, randomized controlled, reproductive age, safety, systematic study, third trimester, world health organization. |
| 4 | 13 | Anemia, background purpose, frequency, hematinic deficiency, hemoglobin concentration, hyperhomocysteinemia, mcv, mean corpuscular volume, rbc, red blood cell, subject, vitamin, vitamin b12 |
| 5 | 3 | Case report, severe iron deficiency, week. |

Although this review has contributed in giving an outlook on the development of publications on iron deficiency anemia from 2010 to 2022 through app.dimension.ai, this study has its limitations. The app.dimension.ai database is periodically updated with new publications. Therefore, the bibliometric analysis of iron deficiency anemia may be reviewed again in the next few years. In addition, this bibliometric analysis only extracted data on scientific articles from the app.dimension.ai database. Further studies should add other databases for a wider understanding of iron deficiency anemia.

## CONCLUSIONS

This review was a bibliometric analysis of the medical literature on iron deficiency anemia published over the last 14 years. The numerous publications on the topic of iron deficiency anemia have an upward trend, the number of citations on the topic of iron deficiency anemia is increasing. The connection of the topic of iron deficiency anemia with several other topics may be analyzed with the VOSviewer program, namely on network visualization, overlay visualization, and density visualization.

### Conflict of interest

The authors declare that this study did not have any conflicts of interest.

### Acknowledgments

The authors thank the developers of the following software programs VOSvierwer, Publish or Perish, https://app.dimensions.ai/, https://trends.google.co.id/, and Mendeley. These software programs facilitated the authors in the search and analysis of data related to scientific articles.

### Author Contributions

BS conceived the presented idea, developed the theories. FND did the calculations, verified the analytical method. S reaserched the topic of iron deficiency anemia and supervised the research findings. All authors discussed the results and contributed to the final manuscript.

### Funding

None.

### Data availability statement

The data used in this study were accessed through https://app.dimensions.ai/, https://trends.google.co.id/, and VOSvierwer**.**

### Declaration of Use of AI in Scientific Writing

Nothing to declare

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