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MINI – REVIEW

Prevalence of anemia among coronavirus disease 2019 patients in Ethiopia: A meta-analysis

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Abstract

Coronavirus disease 2019 (COVID-19) is caused by the severe acute respiratory syndrome coronavirus 2, impacting various systems in the human body, including the hematological and reticuloendothelial systems, which can alter blood production. Consequently, severe anemia-associated complications could occur in COVID-19 patients. At present, there is a lack of pooled prevalence data on anemia among COVID-19 patients in Ethiopia. This systematic review and meta-analysis aimed to determine the overall prevalence of anemia in this population. Following PRISMA guidelines, we conducted a literature search across PubMed/MEDLINE, Cochrane Library, Google Scholar, HINARI, and the Ethiopian Journal of Health Development for articles published before 2024. Additional manual searches were performed to identify relevant studies. Study selection, data extraction, and quality assessment were conducted independently by the authors. The I^2 test statistics were used to assess heterogeneity among studies, and the overall prevalence was calculated using a random-effect restricted maximum likelihood model. Out of 860 studies obtained, 11 articles were included in the meta-analysis. The pooled prevalence of anemia among COVID-19 patients in Ethiopia was found to be 22.81% (95% CI [confidence interval]: 14.76 – 30.85%). Specifically, the prevalence of anemia in Addis Ababa and Amhara was 27.13% (95% CI: 14.59 – 39.66%) and 22.50% (95% CI: 11.04 – 33.96%), respectively. This study indicates that anemia is a moderate public health problem among COVID-19 patients in Ethiopia. Consequently, it is imperative to implement preventative interventions and management strategies for anemia in this population.

Keywords: Prevalence; Anemia; Coronavirus disease 2019; Severe acute respiratory syndrome coronavirus 2; Ethiopia

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1. Introduction

Coronavirus disease 2019 (COVID-19) is a viral infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). As of now, COVID-19 has resulted in 6 million deaths worldwide. The global economic burden of COVID-19 was estimated to be between US $77 billion and US $2.7 trillion in 2019. It was first discovered in Wuhan, Hubei province, China, following the initial cases of this respiratory viral illness. The World Health Organization (WHO) declared COVID-19 a global pandemic on March 11, 2020.[1,2]

COVID-19 infection begins as a respiratory tract infection but is considered a systemic disease that significantly causes inflammation, platelet activation, hypercoagulability, endothelial dysfunction, constriction of blood vessels, stasis, hypoxia, muscle immobilization, and hematopoietic system over time, leading to various hematological complications.[3,4] Anemia is now recognized as an independent prognostic risk factor for COVID-19, and hemoglobin levels can be used in laboratory diagnosis for risk stratification in patient care.[5] In addition, COVID-19 patients without anemia are less likely to have one or more comorbidities compared to those with severe COVID-19 illness who do have anemia.[6]

Anemia is a significant worldwide public health issue that impacts both developed and developing countries. As of 2021, the global prevalence of anemia was estimated at 1.92 billion (24.3%) across all age groups.[7] COVID-19 patients exhibit a higher prevalence of anemia compared to control groups.[8] Among patients with laboratory-confirmed COVID-19, the global prevalence of anemia was reported to be 61%.[8] In Ethiopia, COVID-19 has caused 7574 deaths,[9] yet there is limited data on the prevalence of anemia among COVID-19 patients in the country. Therefore, this review aims to assess the national prevalence of anemia among COVID-19 patients in Ethiopia.

2. Methods

2.1. Search strategy

This review was conducted following the preferred reporting items for systematic review and meta-analysis guidelines.[10] A literature search was performed on international scientific research databases such as Google Scholar, PubMed/MEDLINE, Cochrane Library, and the Ethiopian Journal of Health Development for studies published before 2024. The reference lists of published articles were also searched to identify relevant unpublished studies. The search utilized a combination of keywords and medical subject headings terms, including "Anemia" or "Hemoglobin," or "Hematocrit," "Hematological profile," or Hematologic abnormality," and "COVID-19," or SARS-CoV-2," or "Coronavirus 2019," or "Severe acute respiratory syndrome coronavirus 2," and "Ethiopia." This systematic review and meta-analysis have been registered with PROSPERO under the number CRD42024508873.

2.2. Selection criteria and exclusion criteria

All types of population-based studies conducted in Ethiopia that reported the prevalence of anemia among COVID-19 patients in the country and were published in peer-reviewed journals until 2024 were included in this review. The study population consisted of Ethiopian COVID-19 patients. Studies that only reported results as mean, median, and interquartile range were excluded, as well as studies based on secondary data and poster representation such as review articles, conference abstracts, case reports, and editorials.

2.3. Data extraction and quality assessment

The systematic review process involved importing articles to Endnote 20, screening titles and abstracts, and appraising full texts. Discrepancies were resolved through discussion and consensus. Data were summarized in an Excel spreadsheet, and study quality was assessed using JBI critical appraisal tools. Key study characteristics, such as the first author's name, publication year, study year, setting, sample size, and the number of COVID-19 patients with anemia, were extracted. Descriptive statistics were employed for data analysis, with any discrepancies resolved through author discussion. The results were presented in tables and figures for a clear presentation. This review aims to provide a comprehensive summary of anemia prevalence in COVID-19 patients and may guide future research and clinical practice.

2.4. Outcome of interest

The primary outcome of interest is the pooled prevalence of anemia, defined by the WHO as a hemoglobin value of <12 g/dL for females and <13 g/dL for males.[11]

2.5. Statistical analysis and synthesis

Overall, the study methodology involved presenting results in percentages with 95% confidence intervals (CI), using narrative synthesis for included studies. A summary table was created to outline the characteristics of the studies, and a meta-analysis was conducted using a random-effects restricted maximum likelihood (REML) model in STATA version 17. Heterogeneity among studies was assessed using I^2 statistics, and publication bias was qualitatively analyzed through Funnel plots, Begg's, and Egger's tests. Subgroup analyses were also conducted to identify potential sources of heterogeneity.

3. Results

3.1. Identified studies

The literature search retrieved a total of 860 articles. Of these, 10 were excluded due to duplication. From the remaining 850 articles, 847 were excluded because they did not relate to the aim of this meta-analysis and did not meet eligibility criteria. Consequently, 11 articles were included in this meta-analysis (Figure 1).

3.2. Description of included studies

The studies included in the meta-analysis varied in their design and location, with most of them conducted in Addis Ababa and three in the Amhara region. The studies were published between 2020 and 2024 and consisted of a mix of retrospective and prospective cohort studies, as well as cross-sectional studies. In total, 3136 COVID-19 patients were included in the meta-analysis (Table 1).

3.3. Risk of bias and heterogeneity

According to the JBI critical appraisal tools, each study was evaluated for risk of bias and quality using 10 different criteria. These criteria included case definition, method of data collection, non-response bias, representation, sampling, reliability and validity of study tools, prevalence period, numerator and denominator, random selection, and data collection methods. The risk of bias assessment revealed that six studies had low risk, two studies had moderate risk, and three studies had a high risk of bias. Furthermore, the included studies displayed high heterogeneity based on the I^2 test (97.77%), which necessitated the use of a random-effects model (Table S1).

However, we employed a funnel plot to assess publication bias, which did not reveal any clear bias. The *P*-values from Egger's regression and Begg's test were 0.007 and 0.086, respectively, indicating a lack of publication bias. In addition, the funnel plot showed no signs of publishing bias or asymmetry (Figure 2). To reduce heterogeneity, subgroup analysis was conducted based on the study region (Figure S1).

3.4. Prevalence of anemia

The prevalence of anemia in Ethiopia varies significantly, ranging from 4.08% among 318 COVID-19 patients in

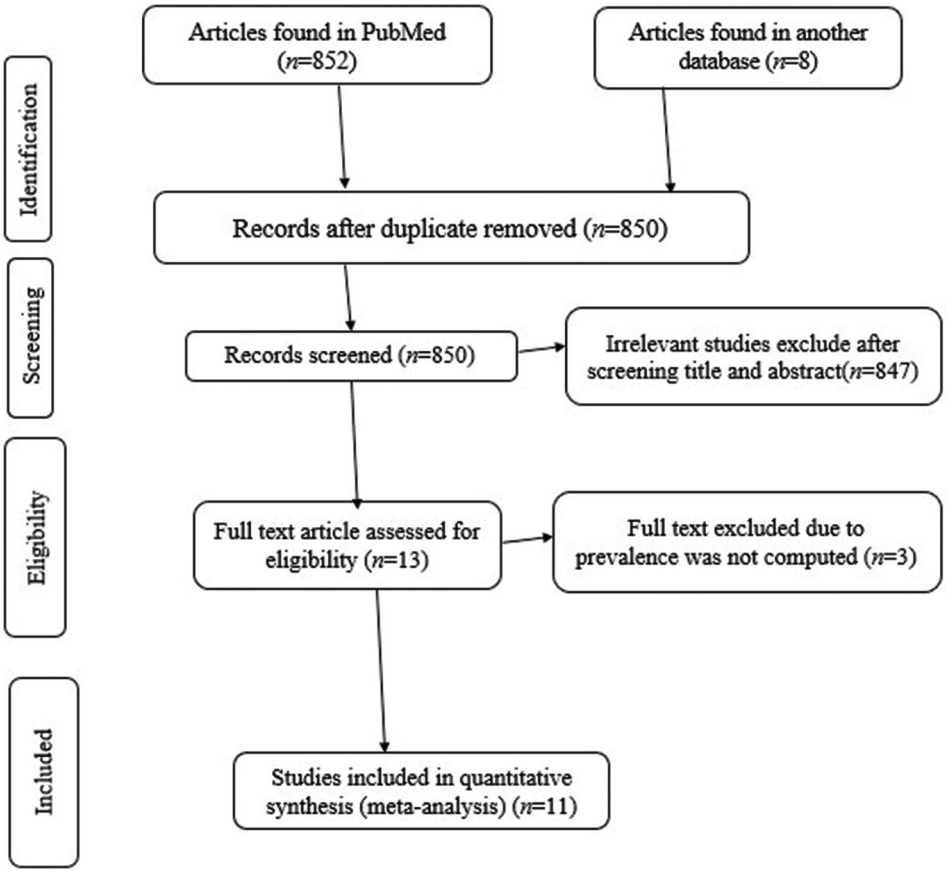

Figure 1. The flow chart illustrates the selection process of studies for the systematic review and meta-analysis on the prevalence of anemia among coronavirus disease 2019 patients in Ethiopia

Table 1. Characteristics of the included studies in systematic review and meta-analysis

References	Study year	Study design	Sample size	Study area	Cases	Prevalence (%)
12	2020	Prospective cohort	136	Amhara	18	13.24
13	2020	Prospective cross-sectional	334	Addis Ababa	83	24.9
14	2022	Retrospective cross-sectional	253	Amhara	85	33.6
15	2021	Comparative cross-sectional	319	Addis Ababa	135	42.3
16	2022	Retrospective cohort	126	Addis Ababa	47	37.3
17	2021	Retrospective cross-sectional	240	Addis Ababa	37	14.42
18	2021	Prospective cohort	40	Addis Ababa	17	42.5
19	2020	Retrospective cohort	429	Addis Ababa	23	5.36
20	2022	Retrospective cohort	318	Oromia	13	4.08
21	2021	Retrospective cohort	452	Amhara	94	20.79
22	2022	Multicenter retrospective cohort	489	Amhara, Oromia, and Addis Ababa	94	19.22

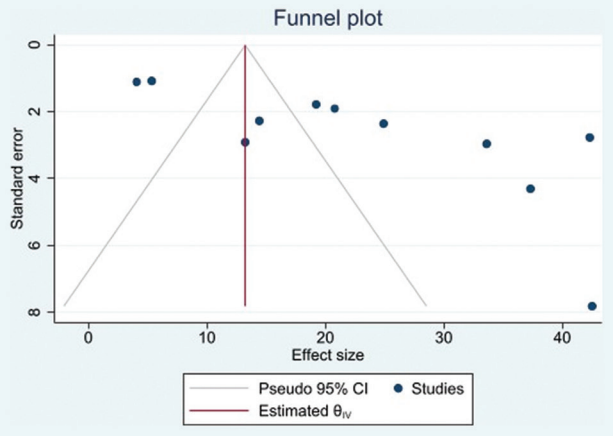

Figure 2. Analysis of publication bias for the studies on the prevalence of anemia among coronavirus disease 2019 patients in Ethiopia
Abbreviation: CI: Confidence interval.

Oromia to 42.5% among 40 COVID-19 patients in Addis Ababa. A meta-analysis of eight studies using the random-effects REML model found the overall prevalence of anemia among COVID-19 patients in Ethiopia to be 22.81% (95% CI: 14.76 – 30.85%) (Figure 3).

We conducted a subgroup analysis by stratifying the data based on region. The prevalence of anemia among COVID-19 patients in Addis Ababa and Amhara was found to be 27.13% (95% CI: 14.59 – 39.66%) and 22.50% (95% CI: 11.04 – 33.96%), respectively (Figure S2).

3.5. Meta-regression

Meta-regression was performed to identify the sources of heterogeneity between the studies. In this systematic review and meta-analysis, meta-regression was performed by study design, study area, and study period to evaluate whether these variables are sources of heterogeneity between the studies. Thus, the study design and study area were found to be a source of heterogeneity in which the *P*-value was below 0.05 (Table 2).

Table 2. Meta-regression of selected variables affecting the prevalence of anemia among COVID-19 patients in Ethiopia: systematic review and meta-analysis

Source of heterogenicity	Coefficients	Standard error	*P*-value
Study period	23.42	609.38	0.970
Study design	23.87	4.33	0.000
Study area	23.57	4.18	0.000

3.6. Sensitivity analysis

Sensitivity analysis was used to determine whether individual studies had an impact on the pooled effect size. As demonstrated, no single study significantly influenced the total estimate of anemia among COVID-19-infected patients. After removing one study at a time, all effect sizes ranged from 14.76% to 30.75%, and the pooled effect size remained within the CI of the total estimate. This shows that our results were not driven by any single study (Figure 4).

4. Discussion

The prevalence of anemia ranged from 5.63% to 42.5%. The highest prevalence of anemia was reported in Addis Ababa, Ethiopia, in 2021.[18] The lowest prevalence was also reported in Addis Ababa, Ethiopia, in 2020.[19] In this study, we aimed to estimate the overall prevalence of anemia among COVID-19 patients in Ethiopia by reviewing available studies. The overall prevalence of anemia was found to be 22.81% (95% CI: 14.76 – 30.85%), which is in line with a similar study conducted in Kenya where the prevalence was 25%.[23] According to the WHO's classification, anemia

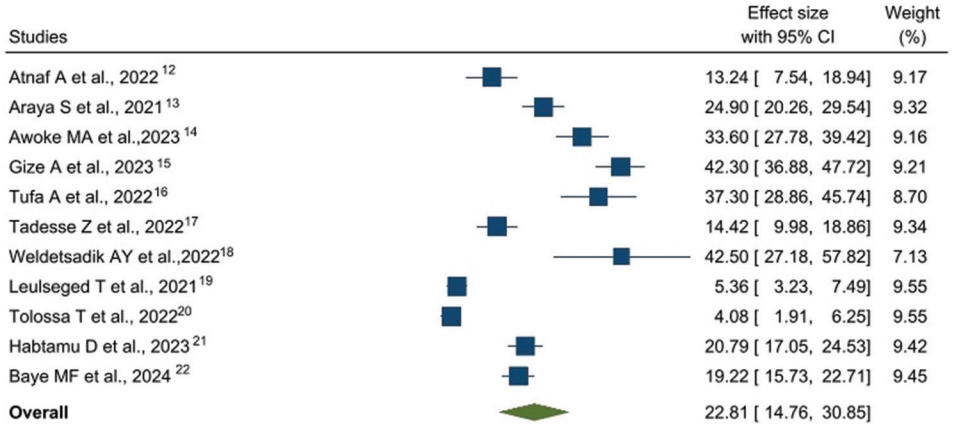

Figure 3. Forest plot of ten studies on the prevalence of anemia among coronavirus disease 2019 patients in Ethiopia
Abbreviation: CI: Confidence interval.

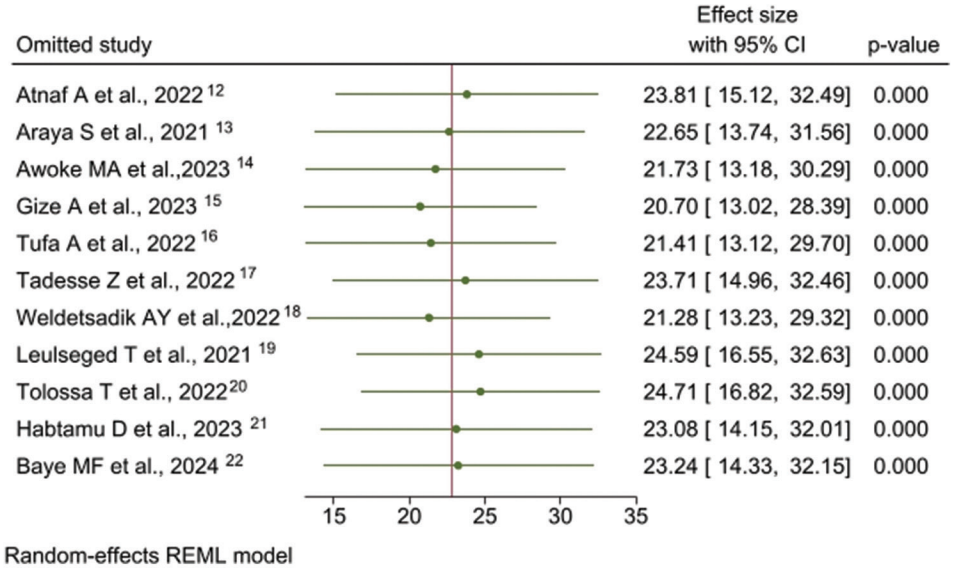

Figure 4. Leave-one-out meta-analysis to see the influence of the single study on the pooled effect size
Abbreviations: CI: Confidence interval; REML: Restricted maximum likelihood.

is considered mild, moderate, or severe when its prevalence exceeds 5%, 20%, or 40%, respectively.[24]

A scientific explanation for anemia among COVID-19 patients is that SARS-CoV-2 directly infects erythroid precursor cells, impairs hemoglobin homeostasis, and worsens the severity of COVID-19. This leads to impaired porphyrin metabolism and changes in the expression of key enzymes involved in iron and hemoglobin metabolism. Furthermore, SARS-CoV-2 inhibits heme metabolism and induces hemoglobin denaturation during erythrocyte development.[25] SARS-CoV-2 interacts with protoporphyrin IX through spike protein 1, causing the dissociation of iron from porphyrin. The interaction between the beta chains of hemoglobin, open reading frame 8, and the surface glycoproteins of the virus leads to a decline in hemoglobin levels during SARS-CoV-2 infection.[26,27] Another contributing factor to anemia during SARS-CoV-2 infection is the presence of ACE 2 receptors in kidney cells, such as podocytes and proximal tubular epithelial cells, which reduces erythropoietin synthesis.[28] This results in a decrease in hemoglobin levels during SARS-CoV-2 infection and exacerbates COVID-19 disease.[25-27]

Furthermore, the presence of SARS-CoV-2, such as transmembrane serine protease 2, CD147, and CD26 in erythroid progenitor cells in bone marrow, makes them a

primary target for SARS-CoV-2 infection. This can result in cell lysis and the elimination of immature red blood cells by phagocytic cells.[29,30] The presence of viral receptors in these cells can lead to low hemoglobin levels in COVID-19 patients experiencing severe clinical manifestations of the disease.[31]

In subgroup analysis based on the study area, the prevalence of anemia is higher in Addis Ababa compared to the Amhara region. This difference may be attributed to the higher burden of non-communicable diseases in Addis Ababa.[32] The presence of non-communicable diseases can exacerbate the severity of COVID-19 infection, including anemia.[33] In addition, non-communicable diseases and anemia can often be interlinked, as both conditions have various risk factors that can influence each other.

Furthermore, high heterogeneity was observed in the pooled prevalence analysis performed in our study. The possible factors contributing to the difference in prevalence could include variations in sample size, study area, sampling technique, and study design among the included studies.

In our study, we try to show the pooled prevalence of anemia, but we have not shown the risk factors and specific types of anemia. Furthermore, relatively few investigations were conducted on the issue, limiting our results and conclusions.

5. Conclusion

This systematic review and meta-analysis revealed a moderate prevalence of anemia among COVID-19 patients in Ethiopia, according to the WHO's classification. A higher prevalence of anemia was observed in Addis Ababa compared to the Amhara region. It is important to note that further research is needed to fully understand the relationship between COVID-19 infection and the various types of anemia. Individuals who are infected with COVID-19 and experience symptoms of anemia, such as fatigue, weakness, and pale skin, should consult a health-care provider for proper evaluation and management.

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Conflict of interest

The authors declare no conflicts of interest.

Author contributions

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Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

All data supporting this document are found in the manuscript and supplementary files.

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