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Review

# Anemia in diabetes mellitus in Africa: A systematic review and meta-analysis

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ABSTRACT

*Aims:* Anemia accelerates chronic complications of diabetes mellitus (DM). We aimed to conduct a systematic review and meta-analysis to estimate the prevalence of anemia among people with DM in Africa.

*Methods:* A search of studies was conducted in the main databases (Medline, EMBASE, Scopus, CINAHL, AJOL and Google Scholar) and the reference lists of selected studies. Observational studies that met the eligibility criteria were included in this meta-analysis. There was no limitation in terms of language.

*Results:* We obtained data from 27 eligible studies, including 5913 patients. The pooled prevalence of anemia was 35% (95% CI: 28%–42%, $I^2 = 97.7\%$, $p < 0.01$). In sub-group analysis, the pooled prevalence was higher in people with diabetic foot lesions (56%, 95% CI: 49%–63%, $I^2 = 51.04\%$, $p = 0.100$) than in the general population of people with diabetes (30%, 95% CI: 23%–37%, $I^2 = 97.6\%$, $p < 0.01$). Pooled prevalence rates were also higher in; males than females (34% vs 31%), type II DM than type I DM (35% vs 26%), and in patients with poor glycemic control compared to those with good glycemic control (33% vs. 22%).

*Conclusions:* The prevalence of anemia in DM was high warranting enhanced clinical and public health interventions.



## 1. Introduction

The International Diabetes Federation (IDF) estimates that over 463 million people worldwide are living with diabetes mellitus (DM) [1]. In the African region, 3.9% (an estimated 19.4 million adults) are living with undiagnosed DM [1,2]. Additionally, DM costs African countries about I3.5 billion - 4.5 billion international dollars per annum of which patients incur the largest cost [3]. Mortality rates remain unacceptably high in Africa, with over 70% of all-cause mortality occurring in people living with DM under the age of 60 years [1].

DM is a complex, heterogenous and multi-systemic metabolic syndrome characterized by chronic hyperglycemia due to absolute or relatively insulin resistance or both [4]. It is associated with acute life-threatening metabolic disturbances as well as long-term chronic micro- and macro-vascular complications, and hematological dyscrasias [5,6]. Patients with advancing age, declining estimated glomerular filtration rate, poor glycemic control, and longer disease duration are more likely to develop these complications [7,8].

The etiology of anemia in diabetes is poorly understood but can be explained by several factors, including chronic inflammation, nutritional deficiencies, concomitant autoimmune diseases (especially in those with type 1 diabetes), concurrent hypertension medication (particularly, angiotensin II receptor blockers) and anti-hyperglycemic agents (notably, metformin), hormonal changes and kidney disease [9,10]. Irrespective of the underlying mechanisms of diabetogenesis, anemia is independent predictor of increased risk for macrovascular and microvascular complications of DM [8,9].

The precise prevalence and characterization of anemia among

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persons with DM in Africa is unknown. A recent system review of published studies on the prevalence of anemia among persons with diabetes in Ethiopia revealed a prevalence of 22%, with a much higher prevalence in patients with type 2 compared to those with type 1 diabetes (31% vs. 17%) [7]. Anemia is easy to prevent, diagnose and treat. Therefore, early detection and recognition of the cause(s) of anemia in patients with DM could help to prevent other complications of DM such as chronic kidney disease and stroke.

In this systematic review, therefore, we estimated the prevalence of anemia among people with DM in Africa.

## 2. Methods

### 2.1. Study design

The systematic review was performed in concordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [11]. The protocol was prospectively registered with PROSPERO (CRD42021264483).

### 2.2. Study setting

This review and meta-analysis were conducted for all studies published in African countries.

### 2.3. Search strategy

A systematic search was done in PubMed, EMBASE, CINAHL, Scopus, Google Scholar and African Journals Online (AJOL). The medical subheading (MeSH) terms used were ("anemia" OR "anaemia") AND ("diabetes mellitus") AND ("Africa" OR the individual names of all the 54 countries in Africa). We also searched the for the references of eligible studies to identify additional studies that were not retrieved in the literature search. The studies were not limited by language, although all of the studies were in English and a few in French.

### 2.4. Selection criteria

All observational studies designed as cross-sectional, cohort or case-control (DM vs non-DM patients) published in peer-reviewed journals, from inception to 31st June 2021, reporting the prevalence of anemia in patients with DM in African countries were included in the study. We excluded case reports, case series, qualitative research, letters to the editor, commentaries, conference proceedings or abstracts, policy papers, protocols, reviews and meta-analyses. We excluded studies recruiting participants with gestational diabetes.

### 2.5. Study selection

Duplicates were automatically removed through Healthcare Database Advanced Search (HDAS) tool and EBSCO Host. Two reviewers (RO and FB) independently screened all the studies by title and abstract for eligibility, to exclude irrelevant studies and to remove additional duplicates. Full texts were then retrieved and screened for eligibility. Any disagreements were solved by discussion and consensus among all the authors.

### 2.6. Data extraction

The data extraction template was designed using Microsoft Excel 2016 to capture the following details.

i) Study characteristics: authors, year of publication, study design, country/countries in which the study was conducted, study population/recruitment, and sample size of patients with diabetes mellitus enrolled in the study.
ii) Participants' characteristics: sex and median/mean age in years.
iii) DM attributes-type of DM (type I DM vs type II DM), duration since diagnosis with DM in years, and glycemic control (poor/uncontrolled or controlled).
iv) Anemia: frequency/percentage of patients with laboratory-diagnosed anemia stratified by sex, type of DM, and glycemic control (as defined by the authors); factors associated with anemia in individual studies.

### 2.7. Qualitative assessment

Risk of bias between individual studies was assessed by two independent reviewers (RO and FB) using modified Newcastle Ottawa Scale. Studies were graded as poor, moderate, good, very good and excellent quality. All studies included in the systematic review and meta-analysis scored 7 asterisks and above.

### 2.8. Data analysis

Statistical analyses were performed using Microsoft Office 2016 (Microsoft Inc., Washington, USA), and STATA 16.0 software (StataCorp LLC, College station, Texas, USA). Individual study characteristics and participant characteristics were summarized using descriptive statistics. A qualitative narrative synthesis was also used to present results from individual studies.

A random effect model meta-analysis was performed using in STATA 16.0 using the in-built *meta* command to determine the pooled prevalence of anemia in DM patients and presented as a forest plot. Sub-group meta-analysis was performed for studies that reported anemia prevalence by sex (male vs female), type of diabetes (T1DM vs T2DM), glycemic control (uncontrolled vs controlled), patient population (diabetic foot only vs general population of DM patients), and the African region in which the study was conducted. Results of the sub-group analyses are presented in a tabular format. Additionally, meta-analysis of odds ratio was also performed to assess the pooled association between sex, type of DM and glycemic control with anemia.

Heterogeneity across studies was assessed using Q statistics and $I$ [2] -value. Publication bias was assessed visually using a funnel plot and statistically using Egger's test. A sensitivity analysis was performed for all studies within the funnel. A $P < 0.05$ was considered statistically significant at the 95% confidence interval.

## 3. Results

### 3.1. Characteristics of studies and study participants

A total of 217 studies were identified from the literature search (Supplementary Figure 1). Of these, 27 studies published between 1989 and 2021 from 10 countries were eligible for inclusion in the systematic review and meta-analysis. All the studies were observational, 23 (85%) utilizing cross-sectional study designs and four (15%) using case-control design. Ten studies (37%) were from Ethiopia and seven studies (26%) conducted in Nigeria. Data of 5913 patients with DM were pooled from the eligible studies. Nine studies (33%) enrolled only type 2 diabetes mellitus (T2DM) patients, 13 studies (48%) enrolled both type I and type II DM patients and only one study enrolled only T1DM patients. The type of DM was not specified in four studies (15%). Female patients were

slightly more than the male patients (51% vs 49%) and the mean age of the participants was 51 years (95% CI: 46–55 years). The pooled mean duration from the time of diagnosis was 6.8 years (95% CI: 5.6–8 0.0 years). The study population consisted of only patients with diabetic foot lesions in five studies (19%). Of the 15 studies which categorized glycemic control in 2841 patients, the majority (2,211, n = 70.9%) had poor glycemic control with only 29.1% (n = 909) having good glycemic control (see Table 1).

### 3.2. Prevalence of anemia in diabetes mellitus

The pooled prevalence of anemia in patients with DM was 35% (95% CI: 28%–42%, $I^2 = 97.7\%$, P < 0.01), Fig. 1. In sub-group analysis (Table 2), the pooled prevalence was higher in patients with diabetic foot lesions (56%, 95% CI: 49%–63%, $I^2 = 51.04\%$, p = 0.100) than in the general population of patients with DM (30%, 95% CI: 23%–37%, $I^2 = 97.6\%$, p < 0.01). The pooled prevalence was also

**Table 1**
Characteristics of the studies, study participants and prevalence of anemia in individual studies included in the systematic review.

| Study | Study Design | Country | Sample size | Type 1 DM | Type 2 DM | Male sex | Age (Median) | Duration of DM | Poor glycemic control | Anemia |
|---|---|---|---|---|---|---|---|---|---|---|
| Arkew et al., 2021 [17] | Case control | Ethiopia | 134 | 0 (0%) | 134 (100%) | 85 (63.4%) | 43.1 | 7y | 78 (58.2%) | 24 (17.9%) |
| Kebede et al., 2021 [12] | Cross-sectional | Ethiopia | 372 | 0 (0%) | 372 (100%) | 142 (38.2%) | NS | 8.9y; <5y (17.5%), 6 - 10y (51.9%), >10y (30.7%) | 346 (93.0%) | 30 (8.1%) |
| Shabhay et al., 2021 [28] | Cross-sectional | Tanzania | 60[a] | 1 (1.7%) | 59 (98.3%) | 35 (58.3%) | 60.1 | <1y (8.3%), 1 - 5y (35%), >5y (56.7%) | 42 (70.0%) | 42 (70%) |
| Tujuba et al., 2021 [13] | Cross-sectional | Ethiopia | 325 | 155 (47.7%) | 170 (52.3%) | 203 (62.5%) | 40 | 4.5y; <1y (28%), 1 - 5y (34.2%), 5 + y (37.8%) | 243 (74.8%) | 98 (30.2%) |
| Adane et al., 2020 [29] | Cross-sectional | Ethiopia | 164 | NS | NS | 96 (58.5%) | 50 | <5y (45.1%), 5 - 10y (39%), >10y (15.9%) | NS | 22 (13.4%) |
| Engidaw & Feyisa, 2020 [30] | Cross-sectional | Ethiopia | 265 | NS | NS | 144 (54.3%) | 48.7 | NS | NS | 79 (29.8%) |
| Hailu et al., 2020 [31] | Cross-sectional | Ethiopia | 262 | 58 (22.1%) | 204 (77.9%) | 134 (51.1%) | NS | 8.7y | NS | 47 (17.9%) |
| Taderegew et al., 2020 [18] | Cross-sectional | Ethiopia | 249 | 0 (0%) | 249 (100%) | 121 (48.6%) | 53.7 | 7.5y; <5 (41%), 5 - 10y (33.7%), >10y (25.3%) | 135 (54.2%) | 50 (20.1%) |
| Ali et al., 2020 [32] | Cross-sectional | Libya | 473 | 0 (0%) | 473 (100%) | 251 (53.1%) | 67 | NS | NS | 42 (8.9%) |
| Bekele et al., 2019 [14] | Cross-sectional | Ethiopia | 374 | 0 (0%) | 374 (100%) | 176 (47.1%) | 56.3 | 5y; <5y (52.4%), 5+ y (47.6%) | 231 (61.8%) | 130 (34.8%) |
| Dachi et al., 2019 [25] | Case-control | Nigeria | 82 | 5 (6.1%) | 77 (93.9%) | 45 (54.9%) | 53.7 | 8.4y | 36 (43.9%) | 36 (43.9%) |
| Fiseha et al., 2019 [15] | Cross-sectional | Ethiopia | 412 | 123 (29.9%) | 289 (70.1%) | 183 (44.4%) | 45 | 4y; <5y (61.4%), 5 - 10y (26%), >10y (12.6%) | NS | 110 (26.7%) |
| Gezawa et al., 2019 [21] | Cross-sectional | Nigeria | 336[a] | 13 (3.9%) | 323 (96.1%) | 185 (55.1%) | 55.9 | 8.5y | 281 (83.6%) | 180 (53.6%) |
| Hodel et al., 2019 [24] | Cross-sectional | Tanzania | 67 | NS | NS | 20 (29.9%) | 54 | NS | 57 (85.1%) | 18 (26.9%) |
| Awofisoye et al., 2019 [19] | Cross-sectional | Nigeria | 150 | 0 (0%) | 150 (100%) | 43 (28.7%) | 57.7 | 7y | NS | 70 (46.7%) |
| Mulavu et al., 2019 [22] | Cross-sectional | Zambia | 101 | 0 (0%) | 101 (100%) | 30 (29.7%) | 54.4 | NS | 79 (78.2%) | 23 (22.8%) |
| Antwi-Bafour et al., 2016 [26] | Case-control | Ghana | 50 | 0 (0%) | 50 (100%) | 15 (30%) | 55.6 | NS | NS | 42 (84%) |
| Feteh et al., 2016 [23] | Cross-sectional | Cameroon | 636 | 0 (0%) | 636 (100%) | 338 (53.1%) | 56.5 | 4y | NS | 263 (41.4%) |
| Almahdi et al., 2016 [27] | Case-control | Libya | 200 | 100 (50%) | 100 (50%) | 71 (35.5%) | 49 | 1.5–31y | 161 (80.5%) | 67 (33.5%) |
| Akabwai et al., 2015 [33] | Cross-sectional | Uganda | 280 | 56 (20%) | 224 (80%) | 87 (31.1%) | 50 | <2y (23.6%), 2 - 4y (32.5%), 5 - 7y (12.5%), >7y (31.4%) | 204 (72.9%) | 51 (18.2%) |
| Abate et al., 2013 [20] | Cross-sectional | Ethiopia | 384 | 193 (50.3%) | 191 (49.7%) | 236 (61.5%) | 41.0 | 5.9y; <5y (53.6%), 6–10y (32.6%), >11 (14.1%) | 279 (72.7%) | 73 (19%) |
| Akinbo et al., 2013 [34] | Cross-sectional | Benin | 150 | 18 (12%) | 132 (88%) | 41 (27.3%) | NS | 1y (20.7%), 2y (20.7%), 3 + y (58.7%) | 0 (0.0%) | 79 (52.7%) |
| Ekpebegh et al., 2009 [35] | Cross-sectional | Nigeria | 42[a] | 4 (9.5%) | 38 (90.5%) | 28 (66.7%) | 56.1 | 8.3y | NS | 21 (50%) |
| Ogbera et al., 2008 [36] | Cross-sectional | Nigeria | 47[a] | 7 (14.9%) | 40 (85.1%) | 28 (59.6%) | 56 | NS | 39 (83.0%) | 27 (57.4%) |
| Kagu et al., 2005 [16] | Cross-sectional | Nigeria | 53 | NS | NS | NS | NS | NS | – | 21 (39.6%) |
| Salah et al., 2005 [37] | Cross-sectional | Egypt | 200 | 200 (100%) | 0 (0%) | NS | 11.7 | NS | NS | 75 (37.5%) |
| Akanji et al., 1989 [38] | Cross-sectional | Nigeria | 45[a] | 18 (40%) | 27 (60%) | 21 (47%) | 54.8 | 6.6y | NS | 22 (48.9%) |

Footnotes.
a- Only patients with diabetic foot lesions or ulcers constituted the study population.
DM- Diabetes mellitus.
y- Year.
NS- Not specified or unavailable or missing information.

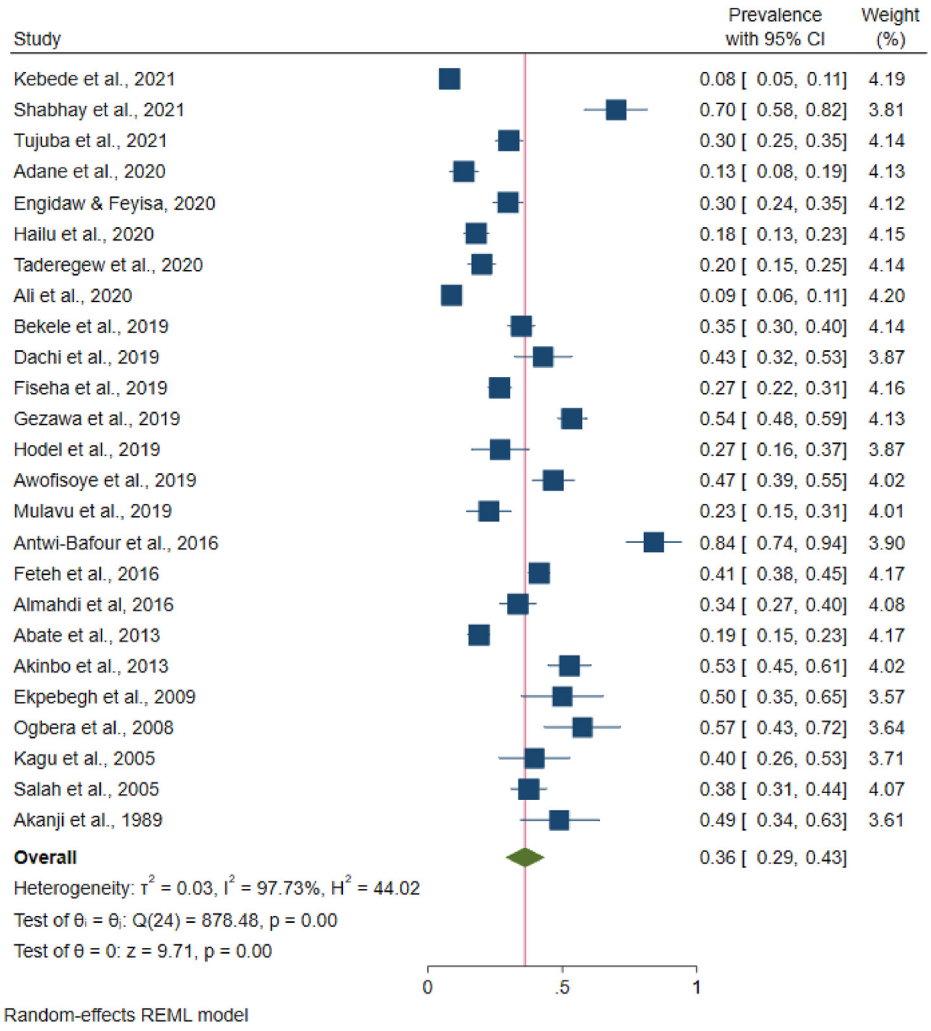


**Fig. 1.** A forest plot showing the individual-study and pooled prevalence of anemia in patients with diabetes mellitus in Africa.

**Table 2**
Subgroup analyses showing pooled prevalence of anemia in DM across patients' characteristics.

| Subgroup | Number of studies | Prevalence (95% CI) | I [2] | P |
|---|---|---|---|---|
| Gender | | | | |
| Male | 14 | 34% (23%–44%) | 96.9 | <0.001 |
| Female | 14 | 31% (21%–42%) | 97.1 | <0.001 |
| Type of DM | | | | |
| Type I | 4 | 26% (14%–37%) | 89.4 | <0.001 |
| Type II | 13 | 35% (24%–46%) | 98.0 | <0.001 |
| Glycemic control | | | | |
| Good glycemic control | 7 | 22% (11%–33%) | 91.7 | <0.001 |
| Poor glycemic control | 7 | 33% (19%–46%) | 97.4 | <0.001 |
| Sample population | | | | |
| General DM population | | 30% (23%–27%) | 97.6 | <0.001 |
| Patients with diabetic foot lesions | | 56% (49%–63%) | 51.0 | 0.100 |
| Region | | | | |
| East Africa | 14 | 25% (18%–32%) | 96.5 | <0.001 |
| West Africa | 10 | 52% (44%–60%) | 88.6 | <0.001 |
| North Africa | 3 | 26% (9%–44%) | 97.2 | <0.001 |

significantly higher in West Africa (52%, 95% CI: 44%–60%, $I^2$ = 88.55%, P < 0.01) than the other regions even after excluding studies of patients with diabetic foot lesions only (51%, 95% CI: 38%–64%, $I^2$ = 93.83%, P < 0.01). Pooled prevalence rates were also higher in; males than females (34% vs 31%), type II than type I DM (35% vs 26%), and in patients with poor glycemic control compared to those with good glycemic control (33% vs 22%) (see Table 3).

### 3.3. Factors associated with anemia in diabetes mellitus

Male gender were found to be significantly associated with anemia in DM patients across five studies [12–16]. Longer duration with the diagnosis of DM were also significant in 7 studies, with the significance mostly present at > 5 years [13–15,17–20]. Anemia was also associated with presence of a comorbidity (commonly

**Table 3**
Factors associated with anemia in patients with diabetes mellitus in Africa.

| Study | Factors significantly associated with anemia in diabetes mellitus |
|---|---|
| Arkew et al., 2021 [17] | Longer duration of diabetes and milk consumption. |
| Kebede et al., 2021 [12] | Male sex, combined type of treatment (oral + intravenous) and presence of microvascular complications. |
| Tujuba et al., 2021 [13] | Male gender, DM duration 5+ years, presence of comorbidity and presence of DM complication. |
| Hailu et al., 2020 [31] | Age >60 years, female sex, HIV positive and rural residency. |
| Taderegew et al., 2020 [18] | Age >60 years, poor glycaemic control, DM > 10 years, DM complications, estimated glomerular filtration rate (eGFR) < 90 significant. |
| Bekele et al., 2019 [14] | Male sex, lack of physical activity, nephropathy, glycaemic control, recent blood loss and DM duration >5 years. |
| Dachi et al., 2019 [25] | Type 2 DM and type of treatment were significant. Hemoglobin concentration did not correlate with fasting blood sugar. |
| Fiseha et al., 2019 [15] | Male sex, increasing age, type 2 diabetes, longer duration of diabetes, alcohol consumers, hypertension, high current systolic BP, fasting blood glucose, serum creatinine, low eGFR and chronic kidney disease. |
| Gezawa et al., 2019 [21] | Ulcer duration >1-month, peripheral artery disease, presence of gangrene, proteinuria, osteomyelitis, vascular stenosis, stroke at bivariate; none was significant at multivariable |
| Hodel et al., 2019 [24] | No correlation between HBA1C and hemoglobin concentration. |
| Awofisoye et al., 2019 [19] | eGFR<60 and DM duration>10 years were significant; hemoglobin concentration inversely correlated with duration of DM diagnosis. |
| Mulavu et al., 2019 [22] | Impaired kidney function, high fasting blood glucose and use of metformin. |
| Antwi-Bafour et al., 2016 [26] | Positive correlation between degree of anaemia vs HBA1C, negative correlation between hemoglobin concentration and fasting blood glucose. |
| Feteh et al., 2016 [23] | Patients with anemia had lower mean eGFR than those without anemia. eGFR significantly correlated with hemoglobin concentration. |
| Abate et al., 2013 [20] | Type 2 DM, duration with DM > 5 years, decreased mean cell volume, glomerular filtration rate <90, raised serum creatinine and marital status (single). |
| Akinbo et al., 2013 [34] | Presence of a parasitic infection. |
| Ekpebegh et al., 2009 [35] | Mortality during admission for diabetic foot ulceration. |
| Kagu et al., 2005 [16] | Male sex and chronic renal insufficiency. |

hypertension), and presence of DM complications [12–14,16,18–22]. In many of these studies, anemia was associated with renal impairment (as measured by reduced eGFR or raised creatinine) and chronic kidney disease or both [14–16,18–20,23]. There were conflicting findings on the correlation between hemoglobin concentration and glycemic control-two studies found no significant correlation [24,25] whereas one study reported a positive correlation [26]. However, anemia was associated with poor glycemic control in two studies [14,27].

Our meta-analysis showed that male sex was not significantly associated with the odds of anemia in DM (odds ratio (OR): 1.13, 95% CI: 0.83–1.52, p = 0.44, $I^2$ = 70.64%, Supplementary Figure 2). Patients with poor glycemic control (OR: 1.78, 95% CI:0.98–3.22, p = 0.06, $I^2$ = 73.96%, Supplementary Figure 3) and type 2 diabetes mellitus (OR: 4.37, 95% CI: 0.97–19.67, p = 0.05, $I^2$ = 94.76%, Supplementary Figure 4) were more likely to have anemia but these associations were marginally insignificant.

### 3.4. Publication bias and sensitivity analysis

Publication bias was assessed visually using a funnel plot and statistically using Egger's test. The funnel plot is markedly asymmetrical, reflecting a significant publication bias (Supplementary Figure 5). The estimated slope from Egger's test was 6.46 (standard error = 1.52, p < 0.001) suggesting publication bias from small study effects. Due to the high heterogeneity, a sensitivity meta-analysis was performed for all studies within the funnel. The pooled prevalence of anemia in DM was 28% (95% CI: 25%–30%, $I^2$ = 0.00%, p < 0.001), Fig. 2.

## 4. Discussion

Anemia is a common public health problem estimated to affect a quarter of the global population and disproportionately affects low- and middle-income countries [39]. In persons with DM, anemia adversely affects quality of life and is associated with progression of vascular complications as well as all-cause mortality [8,9,40]. However, the global estimate of the burden of anemia in DM is lacking. In this systematic review and meta-analysis, involving more than 5900 people with DM from ten countries in Africa, the pooled prevalence of anemia was 36%, which corresponds to moderate public health significance according to the World Health Organization (WHO) classification [41]. With an estimated 19.4 million people living with DM in Africa [1], this prevalence translates to nearly 700,000 individuals being affected with anemia in the region. Furthermore, our analysis showed that people with diabetic foot ulcers had a higher prevalence of anemia compared to the general population of people with DM without foot ulcers (56% vs. 30%). Anemia is associated with delayed wound healing and increases the risk of amputation in DM patients with diabetic foot ulcers [9,42].

In sub-group analysis, we showed that the prevalence of anemia was higher among type 2 compared to type 1 DM patients (35% vs. 26%). This is consistent with findings from Ethiopia where the prevalence of the overall prevalence of anemia was 22% overall, but as high as 31% among type II DM compared to 17% in type I DM [7]. A similar prevalence was also reported among type II DM patients in Brazil [43]. However, it is much higher than a prevalence of 16% reported among type II DM in the United Kingdom [44] and 23% reported in Australia [45]. The possible explanation for the high prevalence of anemia in people with type II diabetes could be due to the insidious onset of type II DM, with a vast majority of patients having complications such as diabetic nephropathy and unrecognized anemia at the time of presentation to care [45,46].

Our study highlights several risk factors associated with anemia in DM in Africa including, age >60 years, male gender, concomitant underlying co-morbidities, presence of DM vascular complications including renal impairment, poor glycemic control and duration of DM > 5 years [7,23]. The cause of anemia in DM is multifactorial, may differ with type of DM and often is poorly understood. In type II DM, oral anti-hyperglycemic agents such as metformin, use of angiotensin II converting enzyme inhibitors and angiotensin II receptor blocker, and renal impairment are the major causes of anemia [9,23]. In addition, hematological parameters such as reduced erythropoietin, reticulocytes, hemoglobin, hematocrit, mean cell volume, and iron profiles are significantly reduced in type

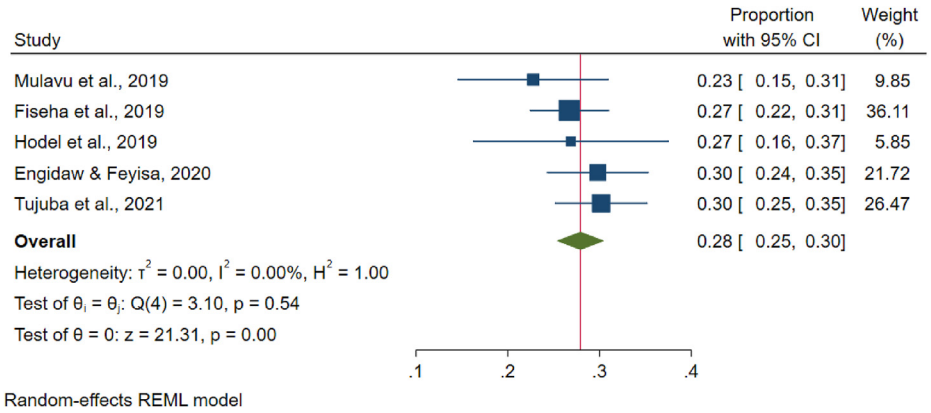


**Fig. 2.** Sensitivity analysis showing the pooled prevalence of anemia in patients with DM in Africa.

II DM [47]. On the other hand, type I DM may be associated with other autoimmune etiologies such as pernicious anemia [9].

Kidney impairment, chronic inflammation and nutritional deficiencies associated with DM are some the most important underlying causes of anemia. DM is the leading cause of chronic kidney disease (CKD) globally [48]. CKD leads to impaired iron metabolism and reduced production of erythropoietin leading to reduced production of red blood cells [48]. There is an inverse relationship between declining estimated glomerular filtration rate and the prevalence of anemia [23]. Chronic hyperglycemia seen in DM results into a hyper-inflammatory state [49]. This results into macrophages being stimulated to produce pro-inflammatory cytokines, notably interleukin-6 (IL-6), and interleukin-1 beta (IL-1β), which has three main effects. First, induction of the production of hepcidin by the liver, which impairs absorption of iron from the gastrointestinal tract and release of iron from macrophages [48]. Secondly, the elevation of proinflammatory cytokines plays an essential role in insulin resistance and promotes long-term vascular complications and anemia [9]. Thirdly, IL-6 reduces erythropoietin production and the efficiency of erythropoiesis, and also promotes apoptosis of immature erythrocytes causing a further reduction in the number of circulating erythrocytes [9,47].

This review has several important limitations and therefore should be interpreted with caution. First, high heterogeneity existed both in the overall and the subgroup analysis of all influencing factors. Second, only 10 countries were represented in this meta-analysis, representing only about 6000 of the nearly 20 million of DM patients in Africa. Moreover, there was over-representation of some countries like Ethiopia which could skew the data. Thirdly, there were different cut-offs for anemias and control of DM across the different studies. Fourthly, we were unable to extract data regarding the type of anemia in the study population. However, our data provides an important insight into the prevalence of anemia among patients with DM, informing public health interventions and directing future interventional and empirical research. Particularly, patients with diabetic foot ulcers requires special considerations for early screening for anemia.

## 5. Conclusions

Our findings suggests that the prevalence of anemia is among patients with DM in Africa. Male patients, those with type 2 DM, poor glycemia control and diabetic foot lesions had higher prevalence of anemia. However, enhanced epidemiologic research precisely investigating on the type, severity, causes and impact of anemia among DM patients are warranted in most of the countries in Africa to clearly define the burden of anemia in this population.

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## Authors' contribution

Conceptualization: Felix Bongomin; Data curation: Ronald Olum; Formal analysis: Ronald Olum; Writing – initial draft: Felix Bongomin and Ronald Olum; Writing- Review and Editing: Ronald Olum, Felix Bongomin, Mark Mohan Kaggwa, Irene Andia-Biraro, Joseph Baruch Baluku. All authors read and approved of the final version of the manuscript.

## Ethics

No ethical approval was required as the research in this article relates to review of the literature.

## Declaration of competing interest

Please check the following as appropriate:

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.
- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.
- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript
- The following authors have affiliations with organizations with direct or indirect financial interest in the subject matter discussed in the manuscript:

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dsx.2021.102260.

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