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Indicators of optimal diabetes care and burden of diabetes complications in Africa: A systematic review and meta-analysis

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ABSTRACT

Objective

Contemporary data on attainment of optimal diabetes treatment goals and the burden of diabetes complications in adult populations with type 2 diabetes in Africa is lacking. We aimed to document the current status of attainment of three key indicators of optimal diabetes care and the prevalence of five diabetes complications in adult African populations with type 2 diabetes.

Methods

We systematically searched EMBASE, PubMed and the Cochrane library for published studies from January 2000 to December 2020. Included studies reported any information on proportion of attainment of optimal glycated haemoglobin (HbA1c), blood pressure (BP) and low-density lipoprotein cholesterol (LDLC) goals, and/or prevalence of five diabetes complications (diabetic peripheral neuropathy, retinopathy, nephropathy, foot ulcers, and peripheral arterial disease). Random-effect model meta-analysis was performed to determine the pooled proportion of attainment of the three treatment goals and the prevalence of five diabetes complications.

Results

In total, 109 studies with a total of 63, 890 participants (53.3% being females) were included in the meta-analysis. Most of the studies were conducted in Eastern African countries (n=44, 40.4%). The pooled proportion of attainment of an optimal HbA1c, BP and LDLC goal were 27% (95% CI 24-30, I^2=94.7%), 38% (95% CI 30-46, I^2=98.7%), and 42% (95% CI 32-52, I^2=97.4%), respectively. The pooled prevalence of diabetic peripheral neuropathy, retinopathy, diabetic nephropathy, peripheral arterial disease, and foot ulcers was 38% (95% CI 31-45, I^2=98.2%), 32% (95% CI 28-

36, I^2=98%), 31% (95% CI 22-41, I^2=99.3%), 19% (95% CI 12-25, I^2=98.1%), and 11% (95% CI 9-14, I^2=97.4%), respectively.

Conclusion

Attainment of optimal treatment goals of diabetes, especially HbA1c, in adult patients with type 2 diabetes in Africa remains a challenge. Diabetes complications, especially diabetic peripheral neuropathy and retinopathy are highly prevalent in adult African populations with type 2 diabetes in Africa.

KEY WORDS

Optimal diabetes care, diabetes complications, adult patients with type 2 diabetes, Africa.

SUMMARY BOX

What is already known?

- Suboptimal diabetes care is highly prevalent in most clinical settings. This ultimately translates to early onset and rapid progression of diabetes complications, increasing morbidity and mortality.

What are the new findings?

- This is the first systematic review and meta-analysis to simultaneously document current status of attainment of three key diabetes treatment goals (optimal glycated haemoglobin, blood pressure, and low-density lipoprotein cholesterol) and prevalence of five diabetes complications in adult patients with type 2 diabetes in Africa.
- It showed that, of the three treatment goals, an optimal glycated haemoglobin target is the least achieved. It also reported that diabetic peripheral neuropathy and retinopathy are the most prevalent diabetes complications.

What do the new findings imply?

- There is an urgent need to develop simple and pragmatic interventions to improve diabetes care and reduce burden of diabetes complications in adult patients with type 2 diabetes in Africa.

Strengths and limitations of the study

- To our knowledge, it is the first systematic review and meta-analysis to simultaneously investigate the status of attainment of the three key diabetes treatment goals and burden of five common diabetes complications in an adult indigenous African population with type 2 diabetes.
- There was high heterogeneity among the studies included in the meta-analysis.
- A relative number of studies included in the meta-analysis had low to moderate quality on assessment.

INTRODUCTION

Globally, the burden of diabetes mellitus (DM) continues to exponentially rise to epidemic proportions, disproportionately affecting low-and middle-income countries. The recent 2021 International Diabetes Federation (IDF) estimates show that about 24 million adults (1 in 22 adults) live with DM in Africa. The IDF also predicts that the greatest future increase in the prevalence of DM will occur in Africa because of the predicted ageing of Africa's currently very young populations, as well as increasing urbanisation and associated lifestyle changes.[1] This will ultimately lead to an immense strain on weak healthcare systems that are poorly structured and inadequately financed to manage non-communicable diseases (NCD) like DM.[2]

In addition, the rates of undiagnosed DM continue to increase in Africa. Among the IDF regions, Africa has the highest proportion of undiagnosed diabetes; about 54% of all cases.[1] The majority of patients are diagnosed late with co-existing debilitating complications and suboptimal diabetes care remains common in most clinical settings

in Africa.[3] This could be explained by low awareness about DM, healthcare systems that are structured mainly to manage communicable diseases as opposed to NCD, low screening rates of DM to ensure early diagnosis, low availability of affordable essential diagnostic tests and medicines of DM and knowledge-practice gaps among healthcare practitioners.[2 4-6]

Published diabetes treatment guidelines by most international organisations like the IDF and American Diabetes Association (ADA) recommend targets of glycated haemoglobin level (HbA1c) of <7% (53 mmol/mol), blood pressure (BP) <140/90 mmHg and low density lipoprotein cholesterol (LDLC) <2.6 mmol/l (100 mg/dl) as key indicators of optimal diabetes care.[7-9] Attainment of these treatment goals in diabetes care ultimately translates to reduced risk of onset and progression of diabetes complications and mortality.

Despite the increasing burden of DM and its related complications, in addition to the prevalent suboptimal diabetes care in clinical settings in Africa, there is an information gap regarding the current status of attainment of the recommended diabetes treatment goals and burden of common diabetes complications. This systematic review and meta-analysis aimed to document the proportion of attainment of optimal HbA1c, BP and LDLC goals and the prevalence of five diabetes complications (diabetic peripheral neuropathy, nephropathy, retinopathy, foot ulcers and peripheral arterial disease) in adult native populations with type 2 diabetes in Africa.

METHODS

This systematic review and meta-analysis was conducted according to the criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[10] The PRISMA checklist is available as a supplementary table

1. The study protocol was registered in the PROSPERO International Prospective Register of systematic reviews (CRD42020215576).

Search strategy

We searched EMBASE, PubMed and the Cochrane library for published studies from January 2000 to December 2020. The following search terms were used after discussion with a medical librarian: “Quality of diabetes care” OR “Indicators of diabetes care” OR “status of diabetes care” OR “diabetes care” OR “glycaemic control” OR “blood pressure control” OR “lipid profile control” OR “screening of diabetes complications” OR “diabetes complications” OR “screening for diabetic retinopathy” OR “screening for diabetic peripheral nephropathy” OR screening for diabetic neuropathy” OR screening for diabetic foot ulcers OR “screening for peripheral arterial disease” OR “prevalence of diabetic retinopathy” OR “prevalence of diabetic peripheral nephropathy” OR “prevalence of diabetic peripheral neuropathy” OR “prevalence of diabetic foot ulcers” OR “prevalence of peripheral arterial disease”, AND “type 2 diabetes mellitus” OR “type 2 diabetes” AND Algeria OR Angola OR Benin OR Botswana OR ‘‘Burkina Faso’’ OR Burundi OR Cameroon OR ‘‘Cape Verde’’ OR ‘‘Central African Republic’’ OR Chad OR Comoros OR ‘‘Democratic Republic of Congo’’ OR Djibouti OR Egypt OR ‘‘Equatorial Guinea’’ OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR ‘‘Guinea Bissau’’ OR ‘‘Ivory Coast’’ OR ‘‘Cote d’Ivoire’’ OR Kenya OR Lesotho OR Liberia OR Libya OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Rwanda OR ‘‘Sao Tome’’ OR Senegal OR Seychelles OR ‘‘Sierra Leone’’ OR Somalia OR ‘‘South Africa’’ OR “South Sudan” OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR Zaire OR Zambia OR Zimbabwe OR ‘‘Central Africa’’ OR ‘‘West Africa’’ OR ‘‘Western

Africa'' OR ''East Africa'' OR ''Eastern Africa'' OR ''North Africa'' OR ''Northern Africa'' OR ''Southern Africa'' OR ''sub Saharan Africa'' OR ''sub-Saharan Africa'' OR Africa. In addition, references of included articles were hand-searched for any other original articles. The search and selection were restricted to studies written only in English language.

Study selection criteria

The preliminary screening of titles and abstracts to identify potentially eligible articles was done by two independent reviewers (NC and DK). This was followed by removing all duplicates. After the initial screening, full texts of the potentially eligible studies were retrieved and closely reviewed for eligibility.

The inclusion criteria of studies were: cross-sectional, cohort or randomised controlled trials published between January 2000 and December 2020 in English language, studies reporting any data on proportion of adult patients with type 2 diabetes who attained the recommended optimal HbA1c, BP or LDLC targets and residing in African countries, and studies reporting data on any of prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers or peripheral arterial disease in adult patients with type 2 diabetes in African countries.

Any disagreements that arose were resolved by consensus. We excluded retrospective studies, case series and reports, studies published in languages other than English, and studies whose full texts could not be retrieved.

Data extraction

After identifying the eligible original studies, they were collated and sent to additional reviewers to extract the relevant study information using a Microsoft Excel 2016 form. The information of interest that was extracted from the eligible studies included: last name of first author and year of publication, country (ies) and region (s) of Africa where

the study was conducted, type of study design, number of study participants, mean age of study participants, proportion of female participants, proportion of participants with a current or history of smoking, proportion of participants on oral hypoglycaemic agents, insulin, lipid lowering agents (statins) and anti-hypertensive agents, mean body mass index (BMI) and HbA1c of study participants, proportions of participants with optimal HbA1c, BP and LDLC targets, and prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers and peripheral arterial disease.

Operational definitions

All included studies defined optimal targets of HbA1c, BP and LDLC as <7% (53 mmol/mol), <140/90 mmHg, and <2.6 mmol/l or 100 mg/dl, respectively as recommended by the IDF and ADA diabetes treatment guidelines.[9 11]

The definitions and measurements of diabetes complications greatly varied between studies. The following definitions were used for each diabetes complication by the various studies: micro/macroalbuminuria and/or an estimated glomerular filtration rate <60 ml/min/1.73 m^2 for presence of diabetic nephropathy, signs and symptoms suggestive of peripheral neuropathy, use of neuropathy screening scores like neuropathy disability score, Michigan Neuropathy Screening Instrument, neuropathy symptom score, and 10g monofilament testing for presence of diabetic peripheral neuropathy, presence of lesions like soft or hard exudates, cotton wool spots, micro-aneurysms, neovascularisation, and retinal hemorrhages on fundoscopy for diabetic retinopathy, presence of foot ulcers on clinical inspection for diabetic foot ulcers, and presence of measured ankle brachial index <0.9 using doppler studies for peripheral arterial disease.

Assessment of quality of studies

Quality of all eligible studies included in the systematic review and meta-analysis were assessed using the Newcastle-Ottawa Scale (NOS).[12] This was done by two independent authors (NC and SNL). The total score of the adapted scale is eight stars. Studies with more than six stars were considered high quality, while those with 5 and 6 stars, and <5 stars were considered moderate and low quality.

Study outcomes

The study outcomes were the pooled proportions of attainment of the recommended optimal HbA1c, BP and LDLC goals and the pooled prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers and peripheral arterial disease in adult patients with type 2 diabetes in Africa.

Data analysis

All analyses were performed using STATA 16.0 statistical software (Stata Corp, USA). The descriptive data of all eligible studies included in the systematic review and meta-analysis was summarised using frequencies and 95% confidence intervals (CI) and mean ± standard deviation (SD). The pooled proportions achieving optimal HbA1c, BP and LDLC goals and prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers and peripheral arterial disease were determined using a random-effect model meta-analysis and presented in forest plots.

Heterogeneity of studies was assessed using I^2 value. The I^2 values of <25, 25-50, and >50% were considered low, medium, and high levels of heterogeneity. To further explore heterogeneity effects across studies, we conducted a meta-regression analysis to assess whether the variations were associated with study level characteristics i.e., age, and sex of participants, and region in which the study was conducted.

We assessed the presence of publication bias using the Egger test of bias with $p<0.05$ indicating significant publication bias.[13] A narrative review was also used to present the study results. Information about all included studies was also summarised in tables.

Patient and Public Involvement

The main research question and outcomes of interest of the systematic review and meta-analysis were informed by the need to understand burden of diabetes complications in patients with type 2 diabetes in Africa and extent of attainment of optimal diabetes care in order to inform strategies aimed to improve optimal management of diabetes in the region. Because it was a systematic review and meta-analysis, we did not involve patients in its design, recruitment, and conduct.

Ethical approval

Because this was a systematic review and meta-analysis of published studies, no prior ethical approval was required.

RESULTS

Figure 1 summarises the article selection in a PRISMA flow diagram.

The literature search returned a total of 835 articles. From these , 222 duplicates were removed. Titles and abstracts of the remaining 613 articles were reviewed and 235 articles were identified for full text retrieval. Of the 235 articles, 126 were excluded and the remaining 109 articles were included in this systematic review and meta-analysis A total of 48 and 89 studies included contained information of optimal diabetes treatment goals and diabetes complications, respectively while 28 studies reported information on both.

The 126 excluded articles included five studies published in French language, 21 retrospective studies, six studies with general populations (not entirely patients with

type 2 DM), 18 studies whose full texts were unable to be retrieved, and 76 studies that did not report outcomes of interest.

Characteristics of included studies

The majority of studies were performed in Eastern African countries (44, 40.4%).[3 14-56] The proportion of studies conducted in Western, Northern, Southern and Central Africa was 22% (n=24 studies) [3 57-78], 16.5% (n=18 studies) [79-97], 15.6% (n=17 studies) [98-114], and 8.3% (n=9 studies) [3 57 115-121], respectively. Three studies were conducted in more than one region of Africa (Western, Central and Eastern).[3 56 57] Most of the studies were cross-sectional in design (100, 91.7%).

A high heterogeneity was noted across all the studies with the I^2 value ranging from 97.4% to 99.3% for studies reporting burden of diabetes complications and 94.7% to 98.7% for studies reporting extent of attainment of optimal diabetes treatment goals. However, on meta-regression after adjusting for age and sex of study participants, and region where each study was conducted, the heterogeneity based on I^2 of studies on prevalence of diabetes complications decreased, ranging from 1.4% for studies on diabetic foot ulcers to 95.6% for studies on diabetic nephropathy. For studies on proportion of attainment of optimal treatment goals, the heterogeneity also decreased, to 56.3%, 92.1%, and 95.4%, for studies on optimal HbA1c, LDLC, and BP goal.

Characteristics of study participants

Table 1 summarises the characteristics of all participants in the studies included in the systematic review and meta-analysis.

The studies had a total of 63, 890 participants (ranging from 40 to 11,866) with 53.3% being female. The cumulative mean ± SD age, BMI, and HbA1c of the participants was 54.9 ± 4.7 years (ranging from 40.5 to 63.9 years), 27.9 ± 0.5 kg/m^2 (ranging from 20.6 to 42.9 kg/m^2), and 9.0 ± 1.5% (ranging from 6.5% to 13.9%), respectively.

Among the studies that reported data on type of glucose-lowering therapies used by participants, treatment with oral hypoglycaemic agents, insulin, statins, and anti-hypertensives was noted in about 65% (95% CI 34-96.6), 31.3% (95% CI 26.3-36.2), 25.7% (95% CI 0.5-86.7), and 73.3% (95% CI 64.1-82.5) of participants, respectively.

Assessment of study quality and publication bias

The assessment of quality of studies and funnel plots assessing publication bias are summarised in supplementary table 2 and supplementary figure 1 and 2, respectively. Based on the NOS, 84 (77.1%) of the included studies were of high quality, with 17 (15.6%) studies and 8 (7.3%) studies being of moderate and low quality, respectively. Regarding assessment of publication bias, there was observed publication bias especially in studies about the prevalence of diabetic nephropathy, peripheral neuropathy, and attainment of optimal BP control. The proportion of studies investigating the prevalence of diabetic nephropathy, peripheral neuropathy, peripheral arterial disease, retinopathy, and foot ulcers located within the funnel plot was 30% (n=12), 46.1% (n=13), 55.6% (n=10), 57% (29), and 90% (n=26), respectively. About 46%, 65%, and 73% of studies that reported proportion of attainment of optimal BP, HbA1c, and LDLC treatment goal were located within the funnel plot respectively.

Extent of attainment of optimal HbA1c, BP and LDLC goals

Data on the reported proportions achieving the three diabetes treatment goals is summarised in tables 2, 3, and 4 and as forest plots in figures 2, 3 and 4.

Data on attainment of optimal HbA1c, BP and LDLC goals was reported in 34 studies[3 18 19 21 33-35 42-45 57-59 61 62 65 82 85 90 91 95-97 102 103 109 114 115 118 122 123], 26 studies[3 16 18 19 22 34 38 39 43 45 59 62 65 68 75 85 89 94 95 103 105 109 111 118 119 122], and 11 studies[19 35 37 45 59 85 95 109 114 122 124], respectively. The pooled proportion of attainment of an optimal HbA1c, BP and

LDLC goal in the respective studies was 27% (95% CI 24-30, I^2=94.7%), 38% (95% CI 30-46, I^2=98.7%), and 42% (95% CI 32-52, I^2=97.4%), respectively.

The lowest proportion of attainment of an optimal HbA1c was reported in a study performed in Egypt (4.4%)[95] and the highest in a study performed in Nigeria (52.5%)[62]. Regarding attainment of an optimal BP goal, the proportion ranged from 1.5% in a study performed in Uganda[45] to 85.9% in a study performed in Ethiopia[22]. Among the studies reporting information on the optimal LDLC goal, attainment of optimal targets ranged from 20.4% in a study performed in Botswana[109] to 84.8% in a study performed in Sudan[92].

Prevalence of diabetic retinopathy, peripheral neuropathy, nephropathy, foot ulcers and peripheral arterial disease

Information on the pooled and specific prevalence of diabetes complications as reported by the different studies is summarised in tables 5, 6, 7, 8, and 9 and as forest plots in figures 5, 6, 7, 8, and 9.

The prevalence of diabetic retinopathy, nephropathy, peripheral neuropathy, foot ulcers and peripheral arterial disease was reported in 51 studies[3 17 22 24 26 28 36 39 46 49 51 52 54-56 64 65 68 70 72 74 75 79 80 84 86 87 89 93-95 101-105 107 110-114 116 118-121 125-127], 40 studies[3 17 19 25 26 28-30 36 44 46 51 55 58 60 62 64 65 67 68 74 79 80 84 86 87 89 94 95 98 103 106-108 111 112 115-117 125], 36 studies[3 17 23 25 26 28 31 32 35 36 41 46 49-51 55 56 65 66 71 74 77 79 83-86 94 95 103 107 116 125 126 128], 29 studies[3 14-17 19 20 23 25 27 36 40 41 46 47 49 51 52 55 56 65 78 83 85 93 95 111 112 125], and 18 studies[3 18 23 28 41 45 48 50 59 65 68 73 76 83 84 89 95 103], respectively.

Prevalence of diabetic peripheral neuropathy and retinopathy

Diabetic peripheral neuropathy and retinopathy were the most prevalent diabetes complications in the included studies with pooled prevalence of 38% (95% CI 31-45, I^2=98.2%) and 32% (95% CI 28-36, I^2=98%), respectively. A wide variation was noted

in the burden of diabetic peripheral neuropathy across the studies, with prevalence ranging from 4% in a study conducted in Eritrea [49] to 83.3% in a study conducted in Nigeria [66]. A study by Makwero and colleagues conducted in Lesotho reported the lowest prevalence of diabetic retinopathy of 4.7% [107] while the study by Megalla and colleagues conducted in Egypt reported the highest (90%)[95].

Prevalence of diabetic nephropathy, peripheral arterial disease, and foot ulcers

The pooled prevalence of diabetic nephropathy, peripheral arterial disease, and foot ulcers in the included studies was 31% (95% CI 22-41, I^2=99.3%), 19% (95% CI 12-25, I^2=98.1%), and 11% (95% CI 9-14, I^2=97.4%), respectively.

The prevalence of diabetic nephropathy and peripheral arterial disease ranged from 2.2% in Ethiopia[17] to 90% in Nigeria[62] and 2.7% in a study performed in Morocco[89] to 52.5% in a study performed in Nigeria[76], respectively. Regarding the burden of diabetic foot ulcers, there was also an observed heterogeneity, with prevalence ranging from 0.4% in Ethiopia[51] to 86.7% in Egypt[95].

DISCUSSION

To our knowledge, this is the first systematic review and meta-analysis to simultaneously document the proportion of attainment of the three key indicators of optimal diabetes care (HbA1c, BP, and LDLC goals) and the burden of five diabetes complications in an indigenous adult population with type 2 diabetes in Africa. In this study of a total of 63,890 study participants, we report that, generally, a small proportion of adult patients with type 2 diabetes in Africa attain optimal diabetes treatment targets, especially HbA1c and BP goals (less than 40%). In addition, diabetes complications are relatively common with diabetic neuropathy being the most prevalent (38%) followed by diabetic retinopathy (32%), nephropathy (31%), peripheral arterial disease (19%), and foot ulcers (11%).

Proportions of attainment of optimal diabetes treatment goals

Similar to our study findings, achievement of optimal HbA1c, BP and LDLC treatment goals has also been widely reported to be a significant clinical challenge in several studies performed in Caucasian and Asian populations with type 2 diabetes in high- and middle-income countries.[129-134] In one large registry-based study of >100, 000 adults with a self-reported diagnosis of diabetes carried out between 1999 to 2010 in USA, 33.4 to 48.7% of adult patients with diabetes did not achieve the recommended HbA1c, BP and LDLC treatment targets. Less than 15% met all the three treatment targets in addition to smoking cessation.[129]

Similarly, a low proportion of achievement of an optimal HbA1c target was also reported by a large international, multicenter observational study of 2,704 multi-racial adult population with diabetes from 10 countries (two from Africa, five from Middle East and three from South Asia). About 46% of the participants were Caucasian. An optimal HbA1c goal of <7% (53 mmol/mol) was reported in only 25.8% of the participants.[131]

In the Japan Epidemiology Collaboration on Occupational Health (J-ECOH) study which enrolled 3,070 adult employees of large manufacturing companies, optimal HbA1c, BP, and LDLC goals as recommended by the American Diabetes Association were noted in 44.9%, 76.6%, and 27.1% of participants, respectively. Only 11.2% of participants attained all the three treatment goals.[132]

Burden of diabetes complications in Africa

Regarding studies on the burden of diabetes complications in Africa, there were few investigating the prevalence of diabetic foot ulcers and peripheral arterial disease with diabetic retinopathy, peripheral nephropathy and neuropathy being the most studied. Diabetic peripheral neuropathy and retinopathy remain the most prevalent diabetes complication and diabetic foot ulcers the least prevalent.

With regards to prevalence of diabetic foot ulcers, an earlier published systematic review and meta-analysis on characteristics, prevalence, and outcomes of diabetic foot ulcers in Africa by Rigato et al reported a pooled prevalence of diabetic foot ulcers of 13%, a finding close to what we observed (11%).[135] In another systematic review and meta-analysis on prevalence of diabetic peripheral neuropathy in African populations with DM, Shiferaw et al reported a slightly higher overall prevalence of 46% compared to what we found in our study (38%), while including fewer studies (n=23).[136]

Similar to our study, considerable heterogeneity was also reported in the documented prevalence of the varied diabetes complications in Africa in most previously published systematic reviews. This may be due to variations in clinical definitions of diabetes complications in the studies. Burgess et al [137] and Achigbu et al[138], reported a wide disparity in prevalence of diabetic retinopathy in the included studies of 7-62.4%, and 13-82.6%, respectively. Noubiap JJ et al in a systematic review on burden of diabetic nephropathy in 2015 reported an overall prevalence of chronic kidney disease in patients with diabetes ranging between 11-83.7%.[139] Johnston LE et al in a systematic review that aimed to assess the epidemiological and clinical reports regarding PAD in SSA documented the prevalence of PAD in patients with diabetes as reported by three studies to range from 39% to 52%.[140]

Compared to Caucasian and Asian adult populations with type 2 diabetes, our study has demonstrated that adult African patients are disproportionately affected by complications of DM. The Joint Asia Diabetes Evaluation (JADE) program that undertook comprehensive risk assessments of 3,687 adult patients with type 2 DM recruited from seven Asian countries reported prevalence of peripheral arterial

disease, diabetic neuropathy, macro-and microalbuminuria, and diabetic retinopathy of 3.1%, 15%, 18.8%, and 20.4%, respectively.[141]

The National Health and Nutrition Examination Survey conducted from the 1988–1994 and 1999–2018 in USA in 1,486 nonpregnant adults (aged ≥20 years) with newly diagnosed diabetes (diagnosed within the past 2 years) also documented a low burden of most diabetes complications. Diabetic foot ulcers, peripheral arterial disease, diabetic retinopathy, neuropathy, and nephropathy (albuminuria) were prevalent in 6.3%, 9.2%, 12.1%, 14.5%, 18.7%, respectively.[142]

The documented low proportions of attainment of optimal diabetes treatment goals (optimal HbA1c, BP and LDLC targets) in Africa is associated with an increased risk of onset and progression of diabetes complications, hence increasing morbidity and mortality in addition to causing a significant economic strain on meagre health resources. This generally observed low proportion of attainment of key diabetes treatment goals and high prevalence of diabetes complications, notably diabetic neuropathy, retinopathy, and nephropathy in Africa exists broadly due to challenges related to screening, diagnosis, and management of DM.

Awareness of diabetes in the general African population and healthcare practitioners remains very poor, resulting in delayed diagnosis of diabetes. The challenge of ready access to affordable essential diabetes medicines like insulin and statins and diagnostic tests or equipment like glucometers for home self-monitoring of glucose, HbA1c and lipid profile tests remains highly prevalent in most African countries.[143-147]

Effective management of diabetes and its related cardiovascular risk factors like hypertension and dyslipidaemia in most healthcare settings in Africa also remains a significant clinical challenge.[3] Most healthcare facilities especially the lower-tier ones lack local or institution-specific comprehensive diabetes treatment guidelines to guide

healthcare practitioners on how to optimally manage diabetes, in addition to the evident knowledge-practice gaps in healthcare practitioners.[2]

Healthcare systems in most African countries remain poorly structured to optimally manage most non-communicable diseases like diabetes along with an inadequately funded health sector. Most African countries have not yet fulfilled the 2001 Abuja Declaration of allocating 15% of their national annual budget to the health sector.[2 148]

This systematic review and meta-analysis had its strengths and limitations. To our knowledge, it is the first to simultaneously investigate the status of attainment of the three key diabetes treatment goals and burden of five common diabetes complications in an adult indigenous African population with type 2 diabetes.

It also had its limitations. There was also an observed heterogeneity in the included studies. This could be explained by the differences in study sites (tertiary vs low-tier hospitals or private vs public hospitals), patient characteristics (age, duration of diabetes, co-existing medical conditions), regions of study, and diagnostic modalities used to identify diabetes complications. The systematic review also excluded studies published in French which is an official language of some African countries. However, these were very few. There was evidence of publication bias some the included studies especially studies investigating the prevalence of diabetic nephropathy and peripheral neuropathy and proportion of attainment of an optimal BP goal. About 23% of the included studies had moderate and low quality on assessment using the adapted NOS for cross-sectional studies.

CONCLUSION

Achievement of optimal diabetes treatment goals, especially HbA1c and BP, in adult African patients with type 2 diabetes remains low in Africa. Diabetes complications especially diabetic peripheral neuropathy and retinopathy also remain highly

prevalent. Implementation of universal diabetes screening and education initiatives coupled with improving knowledge about diabetes management among healthcare practitioners, ready access to affordable essential diabetes diagnostic tests and medicines in Africa are integral in improving overall optimal diabetes care and reducing the burden of diabetes complications.

Considering the projected future increase in the prevalence of diabetes globally, with Africa to be the most affected region, there is an urgent need to address glaring gaps in diabetes care and to develop simple and pragmatic interventions to improve treatment outcomes and reduce burden of diabetes complications

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Conflict of interest statement

All the authors report no conflict of interest.

Availability of data

The data sets that were analysed are available on reasonable request to the corresponding author.

Contributorship statement

DK and NC-Conceived the research idea, performed the preliminary screening of titles and abstracts to identify potentially eligible articles, and wrote the initial draft of the manuscript, DK, NC, IAB, SNL, IS (Sekitoleko), APK, SN- Retrieved full texts and identified the eligible articles, KK, SNL, APK, SN, PS, FB, LEM, WO, TDM, NEN, IS (Sabi)-extracted data from the identified eligible articles, DK and IS (Sekitoleko) performed the data analysis and interpretation, NC, KK, and SNL- performed the assessment of quality of studies, KS, PCH, LB, JVM, RVC, JC- offered additional data interpretation and supervised this work. All the authors reviewed the different versions of the manuscript and read and approved the final draft of the manuscript.

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Table 1. General characteristics of all participants (n=63,890) included in the systematic review and meta-analysis

Characteristic	Cumulative value	Number of studies
Mean ± SD age, years	54.9 ± 4.7	88
Gender-Females (%, 95% CI)	55.3 (95% CI 52.7-57.8)	101
Smokers, (%,95% CI)	9.9 (95% CI 0.5-55.6)	44
Participants on OHA, (%,95% CI)	65 (95% CI 34-96.6)	51
Participants on insulin, (%,95% CI)	31.3 (95% CI 26.3-36.2)	52
Participants on lipid lowering agents, (%,95% CI)	25.7 (95% CI 0.5-86.7)	14
Participants on anti-hypertensive agents, (%,95% CI)	73.3 (95% CI 64.1-82.5)	18
Mean ± SD, BMI, kg/m^2	27.9 ± 0.5	40
Mean ± SD, HbA1c, %	9 ± 1.5	40
Mean ± SD, HbA1c, mmol/mol	75 ± 1.5	40

BMI- Body mass index, HbA1c- Glycated haemoglobin, OHA- Oral hypoglycaemic agents, SD- Standard deviation

Table 2. Indicators of optimal glycated haemoglobin goal

Optimal glycated haemoglobin (HbA1c) goal (n= 34 studies) Pooled rate of attainment of optimal HbA1c goal = 27% (95% CI 24-30, I^2=94.7% and I^2 after meta-regression-56.3%)						
Author & year	**Country (ies)**	**Region of Africa**	**No of study participants**	**Mean age of participants**	**% of females**	**% with optimal HbA1c**
Megallaa et al, 2019	Egypt	Northern	180		24.4	4.4
Muddu et al. 2019	Uganda	Eastern	175	46	48.6	8.1
Muddu et al., 2016	Uganda	Eastern	202	46	49.5	8.4
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	9.2
Blum et al 2020	DRC	Central	319		33.5	14.1
Noor et al., 2016	Sudan	Northern	387		49.6	15
Awadalla et al, 2017	Sudan	Northern	424		49.3	15.6
Agboghoroma et al, 2020	Nigeria	Western	200			19.0
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	19.2
Ashur et al 2016	Libya	Northern	523	54.4	47	21.8
Kisozi et al 2017	Uganda	Eastern	288	48.5	38	23.3
Camara et al 2015	Cameroon and Guinea Conakry	Central and Western	1267	58	61	26
Kibirige et al 2017	Uganda	Eastern	425		67	26.5
Chadli et al. 2016	Morocco	Northern	498	58	62.4	26.8
Hall et al, 2017	Cameroon	Central	261	56	56.3	27.2
Omar et al 2018	Sudan	Northern	339	54.8	69.9	28.1
Sobngwi et al 2011	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	2352	53	61.1	29.2
Molefe-Baikai et al, 2018	Botswana	Southern	289	50.7	66.1	29.4
Bentata et al, 2015	Morocco	Northern	637	58.5	62.3	30.1
Amod et al 2012	South Africa	Southern	701	57.4	43.9	30.4
Cairncross et al, 2017	South Africa	Southern	203		72.5	31.3
Mwita et al 2019	Botswana	Southern	500	58.9	66	32.3
Uloko et al., 2012	Nigeria	Western	531	57.1	60.5	32.4
Chetoui et al 2019	Morocco	Northern	1456	56.2	73.4	33.7
Attoye et al 2020	Nigeria	Western	260			34.62
Cohen DB et al 2010	Malawi	Southern	620	52.2	60.1	36
Chamba et al 2017	Tanzania	Eastern	119	58.1	49.6	39.3
Kimando et al 2017	Kenya	Eastern	385	62.1	65.5	39.5
Akalu et al 2020	Ethiopia	Eastern	378		38.6	40.7
Iwuala et al 2015	Nigeria	Western	100	59.9	62	45
Mbwete et al., 2020	Tanzania	Eastern	161	63.9	67.1	49.7
Diaf et al 2017	Algeria	Northern	210	55.6	65	51.4
Adentunji et al 2006	Nigeria	Western	50			52
Balogun et al 2011	Nigeria	Western	40	59.4	62.5	52.5

Table 3. Indicators of optimal blood pressure goal

Optimal blood pressure goal (n=26 studies) Pooled rate of attainment of optimal blood pressure goal = 38% (95% CI 30-46, I^2=98.7% and I^2 after meta-regression-95.4%)						
Author & year	**Country (ies)**	**Region of Africa**	**No of study participants**	**Mean age of participants**	**% of females**	**% with optimal BP**
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	1.5
Rotchford et al., 2002	South Africa	Southern	253	56.5	73.1	14
Uloko et al., 2012	Nigeria	Western	531	57.1	60.5	17
Chadli et al. 2016	Morocco	Northern	498	58	62.4	20.2
Sobngwi et al 2011	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern Western, Central	2352	53	61.1	21
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	21.7
Onakpoya et al, 2015	Nigeria	Western	133		48.1	24.1
Agboghoroma et al, 2020	Nigeria	Western	200			30.0
Abdissa et al, 2020	Ethiopia	Eastern	229		40.4	31
Chahbi et al, 2018	Morocco	Northern	300		93	32.6
Magan et al, 2019	Uganda	Eastern	44	50.4	63.4	34.1
Megallaa et al, 2019	Egypt	Northern	180		24.4	37.8
Hayfron-Benjamin et al, 2019	Ghana	Western	206	52.9	68.9	37.9
Muddu et al., 2016	Uganda	Eastern	202	46	49.5	38.1
Jingi et al, 2015	Cameroon	Central	407	54.2	41.8	40.4
Hall et al, 2017	Cameroon	Central	261	56	56.3	43
Lewis et al, 2018	Zambia	Southern	921	56	45	46.6
Cohen DB et al 2010	Malawi	Southern	620	52.2	60.1	48
Kimando et al 2017	Kenya	Eastern	385	62.1	65.5	50.4
Mwita JC et al 2019	Botswana	Southern	500	58.9	66	54.2
Lumu et al 2017	Uganda	Eastern	425	52.2	67	54.7
Balogun et al 2011	Nigeria	Western	40	59.4	62.5	55
Akalu et al 2020	Ethiopia	Eastern	378		38.6	57.7
Awadalla et al, 2017	Sudan	Northern	424		49.3	60.1
Kahloun et al, 2014	Tunisia	Northern	2320	54.5	60.2	62.5
Chisha et al 2017	Ethiopia	Eastern	270		48.9	85.9

Table 4. Indicators of optimal LDLC goal

Optimal LDLC goal (n= 11 studies) Pooled rate of attainment of optimal LDLC goal = 42% (95% CI 32-52, I^2=97.4% and I^2 after meta-regression-92.1%)						
Author & year	**Country (ies)**	**Region of Africa**	**No of study participants**	**Mean age of participants**	**% of females**	**% with optimal LDLC**
Mwita et al 2019	Botswana	Southern	500	58.9	66	20.4
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	26
Chamba et al 2017	Tanzania	Eastern	119	58.1	49.6	27.7
Kisozi et al 2017	Uganda	Eastern	288	48.5	38	37.0
Megallaa et al, 2019	Egypt	Northern	180		24.4	37.8
Chadli et al. 2016	Morocco	Northern	498	58	62.4	38.6
Lumu et al 2017	Uganda	Eastern	425	52.2	67	38.9
Awadalla et al, 2017	Sudan	Northern	424		49.3	47.4
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	48.6
Agboghoroma et al, 2020	Nigeria	Western	200			50.5
Elnasri et al. 2008	Sudan	Northern	250	52	62	84.8

Table 5. Burden of diabetic nephropathy

Burden of diabetic nephropathy (n= 40 studies) Pooled prevalence= 31% (95% CI 22-41, I^2=99.3% and I^2 after meta-regression-95.6%)						
Author & year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of nephropathy, %**
Abejew et al, 2015	216	Ethiopia	Eastern	45	42.6	2.2
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53	61.1	2.4
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	3.2
Kahloun et al, 2014	2320	Tunisia	Northern		60.2	3.4
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	4.4
Thinyane et al 2013	80	Lesotho	Southern	49	49	6.0
Tesfaye et al 2015	247	Ethiopia	Eastern		40.5	6.5
Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	6.7
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46	7.5
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	8.8
Bouaziz et al 2012	73	Tunisia	Northern	59.3		11.0
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	11.4
Efundem et al, 2017	162	Cameroon	Central	55.3	67.3	14.2
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	15.7
Dzudie et al 2012	420	Cameroon	Central	56.7	51	15.9
Adeniyi et al, 2020	327	South Africa	Southern		70.3	24.5
Goro et al, 2019	208	Ethiopia	Eastern	54.8	47.1	26
Chahbi et al, 2018	300	Morocco	Northern		93	26.3
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	26.4
Alebiosu et al 2013	342	Nigeria	Western	53.4		28.4
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	32
Khalil et al 2019	506	Egypt	Northern			33.2
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	34.7
Blum et al 2020	319	DRC	Central		33.5	38.6
Ahmed et al, 2017	316	Sudan	Northern	58	41.5	40.2
Eghan-Jr et al 2007	109	Ghana	Western	54.1	75	43.0
Molefe-Baikai et al, 2018	289	Botswana	Southern	50.7	66.1	44.6
Machingura et al, 2017	260	Zimbabwe	Southern	57.6	72.7	45.4
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	46.4
Muddu et al. 2019	175	Uganda	Eastern	46	48.6	47.4
Mohmad et al 2011	71	Sudan	Central		42	50.7
Gill et al 2008	105	Ethiopia	Eastern	41	30	51
Bello et al, 2017	358	Nigeria	Western	57.8	61.7	53.4
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50	54.3
Amour et al 2019	315	Tanzania	Eastern	57.2	65.7	72.2
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	77.2

Adentunji et al 2006	50	Nigeria	Western			83
Janmohamed at al 2013	369	Tanzania	Eastern	54	53.4	83.7
Megallaa et al, 2019	180	Egypt	Northern		24.4	86.1
Balogun et al 2011	40	Nigeria	Western	59.4	62.5	90

Table 6. Burden of diabetic peripheral neuropathy

Burden of diabetic peripheral neuropathy (n=36 studies) Pooled prevalence= 38% (95% CI 31-45, I^2=98.2% and I^2 after meta-regression-88%)						
Author & year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of neuropathy, %**
Seyum et al 2010	429	Eritrea	Eastern	57.4		4
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	7.7
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	7.9
Miriam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	10
Tesfaye et al 2015	247	Ethiopia	Eastern		40.5	10.1
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	10.6
Abejew et al, 2015	216	Ethiopia	Eastern	45	42.6	14.4
Kahloun et al, 2014	2320	Tunisia	Northern		60.2	18.7
Khalil et al 2019	506	Egypt	Northern			20.0
Dzudie et al 2012	420	Cameroon	Central	56.7	51	22.4
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	25.4
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50	29.3
Kisozi et al 2017	288	Uganda	Eastern	48.5	38	29.4
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	29.5
Smide et al 2009	145	Tanzania	Eastern	46	48	30
Kuate-Tegueu et al 2016	321	Cameroon	Western	59.8	64.1	33.3
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	39.6
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	40.3
Gill et al 2008	105	Ethiopia	Eastern	41	30	41
Bello et al 2019	175	Nigeria	Western	59.8	57.7	41.7
Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	43.3
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	44
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46	44.0
Vogt et al 2017	100	Zanzibar	Eastern	54	49	45.0
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56	61	46
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	46.4
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53	61.1	48.4
Jember et al 2017	368	Ethiopia	Eastern	49	41.6	52.2
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	59.2
Awadalla et al 2017	424	Sudan	Northern		49.3	68.2

Mohmad et al 2011	71	Sudan	Central		42	69.0
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50	69.6
Ugoya et al 2006	180	Nigeria	Western	53	51.6	75
Jarso et al 2011	384	Ethiopia	Eastern		54.1	77.0
Megallaa et al, 2019	180	Egypt	Northern		24.4	82
Ede et al 2018	90	Nigeria	Western	58.6	34.4	83.3

Table 7. Burden of diabetic retinopathy

Burden of diabetic retinopathy (n= 51 studies) Pooled prevalence= 32% (95% CI 28-36, I^2=98% and I^2 after meta-regression-88.5%)						
Author &year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of retinopathy, %**
Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	4.7
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	11.0
Tesfaye et al 2015	247	Ethiopia	Eastern		40.5	11.7
Chisha et al 2017	270	Ethiopia	Eastern		48.9	13.0
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46	14.0
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56	61	15.0
Lartey et al, 2018	208	Ghana	Western	57.5	70.7	15.5
Ozudie et al 2012	420	Cameroon	Central	56.7	51	15.7
Blake et al 2015	1307	Botswana	Southern	55	67.9	17.7
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	17.7
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, and Central	53	61.1	18.3
Magan et al, 2019	44	Uganda	Eastern	50.4	63.4	19.5
Bello et al, 2017	358	Nigeria	Western	57.8	61.7	20.1
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	20.3
Thomas et al 2013	3978	South Africa	Southern	56.8	33.3	20.5
Gill et al 2008	105	Ethiopia	Eastern	41	30	21.0
Webb et al 2016	599	South Arica	Southern	57.8	68	24.9
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	25.5
Kahloun et al, 2014	2320	Tunisia	Northern		60.2	26.3
Bouaziz et al 2012	73	Tunisia	Northern	59.3		27.0
Hall et al, 2017	261	Cameroon	Central	56	56.3	27.2
Onakpoya et al, 2015	133	Nigeria	Western		48.1	27.8
Cleland et al, 2015	5729	Tanzania	Eastern	60.8	60.3	27.9
Abejew et al, 2015	216	Ethiopia	Eastern	45	42.6	28.9

Kizor-Akarairwe et al 2018	80	Nigeria	Western	61.2	48.8	32.1
Glover et al 2011	281	Malawi	Southern	56.4	72.8	32.5
Seyum et al 2010	429	Eritrea	Eastern	57.4		33
Bello et al 2019	175	Nigeria	Western	59.8	57.7	33.1
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	33.8
Chahbi et al, 2018	300	Morocco	Northern		93	34.3
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	34.6
Assaad-Khalil et al 2019	506	Egypt	Northern			34.6
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	34.7
Thinyane et al 2013	80	Lesotho	Southern	49	49	35.0
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	35.5
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	35.6
Jingi et al, 2014	407	Cameroon	Central	54.2	41.8	38.8
Pirie et al, 2014	292	South Africa	Southern	59.2	79	39.0
Ahmed et al, 2017	316	Sudan	Northern	58	41.5	39.8
Jingi et al, 2015	407	Cameroon	Central		41.8	40.3
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	40.3
Woodward et al, 2020	91	Tanzania	Eastern	59.2	62.6	42.9
Lewis et al, 2018	921	Zambia	Southern	56	45	44.0
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50	48.9
Njikam et al, 2016	371	Cameroon	Central	59.2	54.7	49.9
Burgress et al 2014	322	Malawi	Southern	55.2	64.6	50.1
Mohmad et al 2011	71	Sudan	Central		42	71.2
Awadalla et al 2017	424	Sudan	Northern		49.3	72.6
Elwali et al 2017	316	Sudan	Northern	58.7	40.8	82.6
Megallaa et al, 2019	180	Egypt	Northern		24.4	90.0

Table 8. Burden of diabetic foot ulcers

Burden of diabetic foot ulcers (n= 29 studies) Pooled prevalence= 11% (95% CI 9-14, I^2=97.4% and I^2 after meta-regression-1.4%)						
Author & year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of foot ulcers, %**
Tesfaye et al 2015	247	Ethiopia	Eastern		40.5	0.4
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	2.5
Chalya et al, 2011 105	136	Tanzania	Eastern	54.3	45.6	3.2
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	3.8
Abejew et al, 2015	216	Ethiopia	Eastern	45	42.6	4.4
Nyamu et al, 2003	1788	Kenya	Eastern	56.9		4.6
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	4.6
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56	61	5
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	6
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50	6.1
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	8.5
Amour et al 2019	315	Tanzania	Eastern	57.2	65.7	10.0
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46	10.0
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53	61.1	11.7
Abbas et al, 2011	11866	Tanzania	Eastern			12
Gebrekirstos et al, 2015	228	Ethiopia	Eastern		38	12
Abdissa et al, 2020	229	Ethiopia	Eastern		40.4	12.7
Awadalla et al 2017	424	Sudan	Northern		49.3	12.7
Mariam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	13.6
Seyum et al 2010	429	Eritrea	Eastern	57.4		14
Thinyane et al 2013	80	Lesotho	Southern	49	49	14
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	14.8
Abbas et al, 2002	627	Tanzania	Eastern	53	35	15
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	15
Mamo et al, 2015	200	Ethiopia	Eastern	50	72.5	15
Elwali et al 2017	316	Sudan	Northern	58.7	40.8	17.7
Unachukwu et al, 2006	315	Nigeria	Western	54.6	36.7	19.1
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	21.2
Megallaa et al, 2019	180	Egypt	Northern		24.4	86.7

Table 9. Burden of peripheral arterial disease

Burden of Peripheral arterial disease (n= 18 studies) Pooled prevalence= 19% (95% CI 12-25, I^2=98.1% and I^2 after meta-regression-70.9%)						
Author & year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of PAD, %**
Chahbi et al, 2018	300	Morocco	Northern		93	2.7
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53	61.1	4.7
Gill et al 2008	105	Ethiopia	Eastern	41	30	6
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	7.6
Mariam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	9.7
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	10.7
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50	11.0
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	11.2
Smide et al 2008	145	Tanzania	Eastern	46	48	13
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	15
Megallaa et al, 2019	180	Egypt	Northern		24.4	20
Okello et al 2014	229	Uganda	Eastern	60	63.7	24.0
Akalu et al, 2020	280	Ethiopia	Eastern		38.6	30.7
Khalil et al 2019	506	Egypt	Northern			32.6
Agboghoroma et al, 2020	200	Nigeria	Western			38.5
Mwebaze et al 2014	146	Uganda	Eastern	53.9	48.6	39.0
Ogbera et al 2015	225	Nigeria	Western	61.4	57	40.0
Oyelade et al 2012	219	Nigeria	Western		58.9	52.5

Figure 1. PRISMA flow diagram of selection of eligible studies

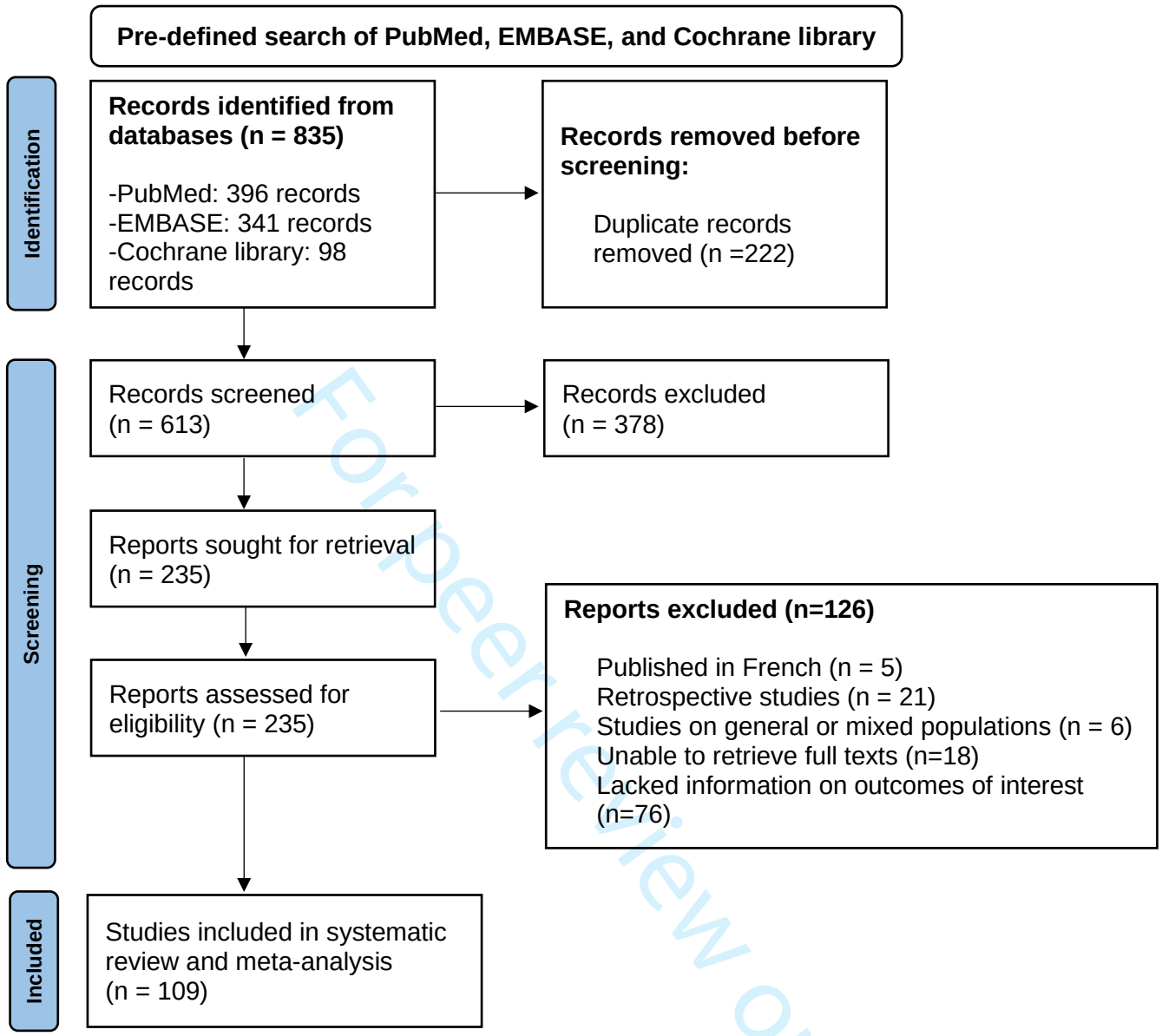


Figure 2. Forest plot summarising studies on proportion of attainment of an optimal low-density lipoprotein cholesterol goal in percentage

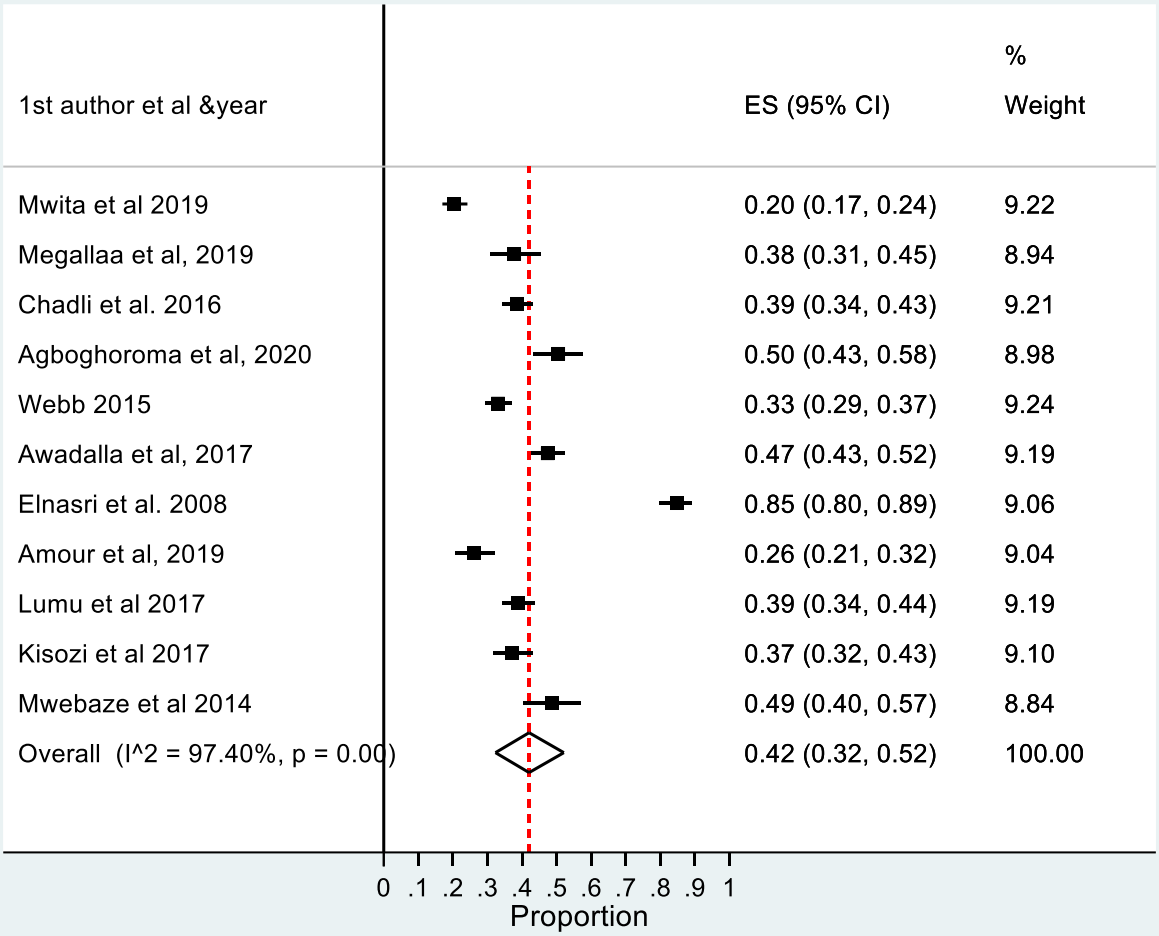


Figure 3. Forest plot summarising studies on proportion of attainment of an optimal blood pressure goal in percentage

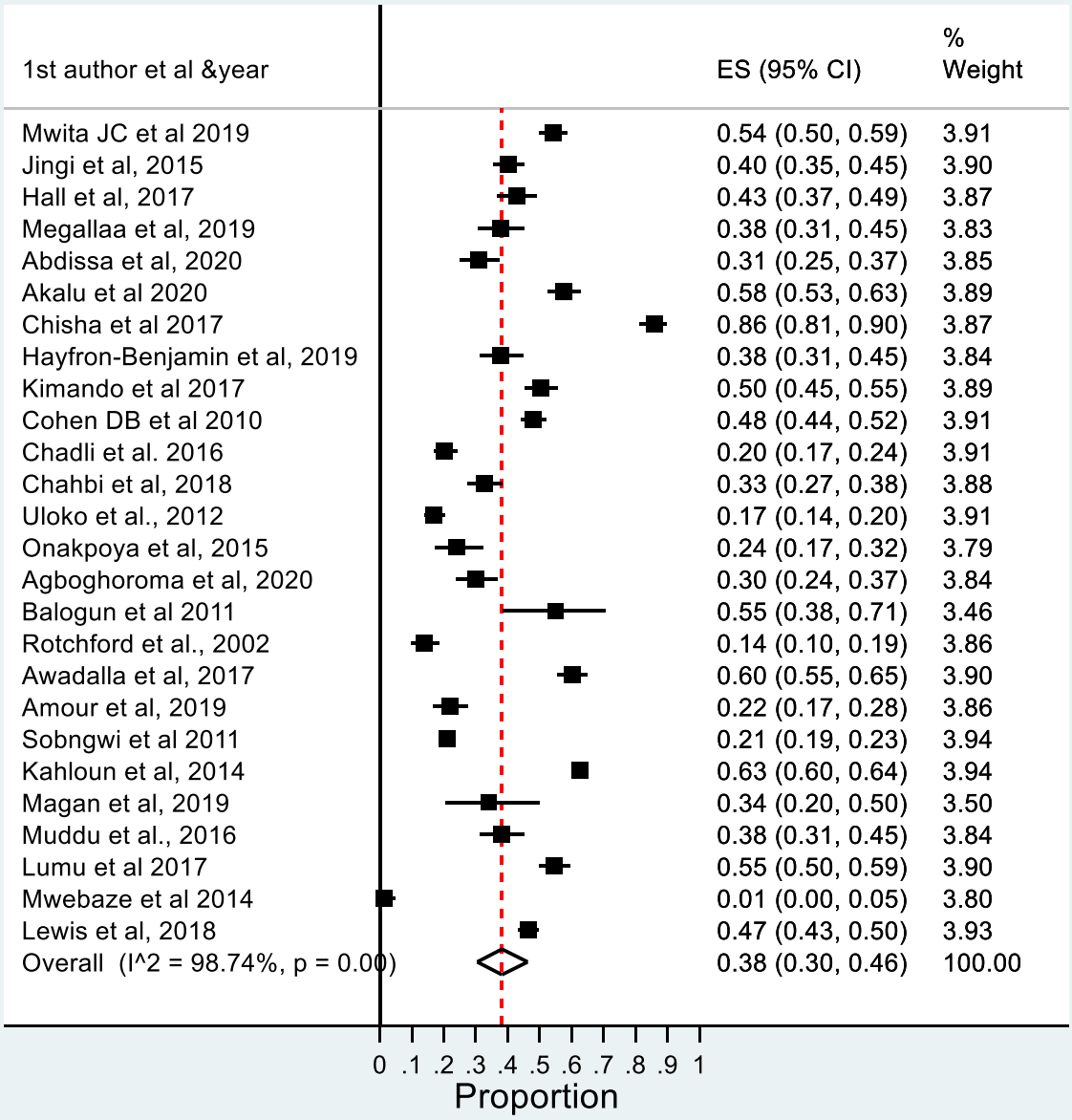


Figure 4. Forest plot summarising studies on proportion of attainment of an optimal glycated haemoglobin goal in percentage

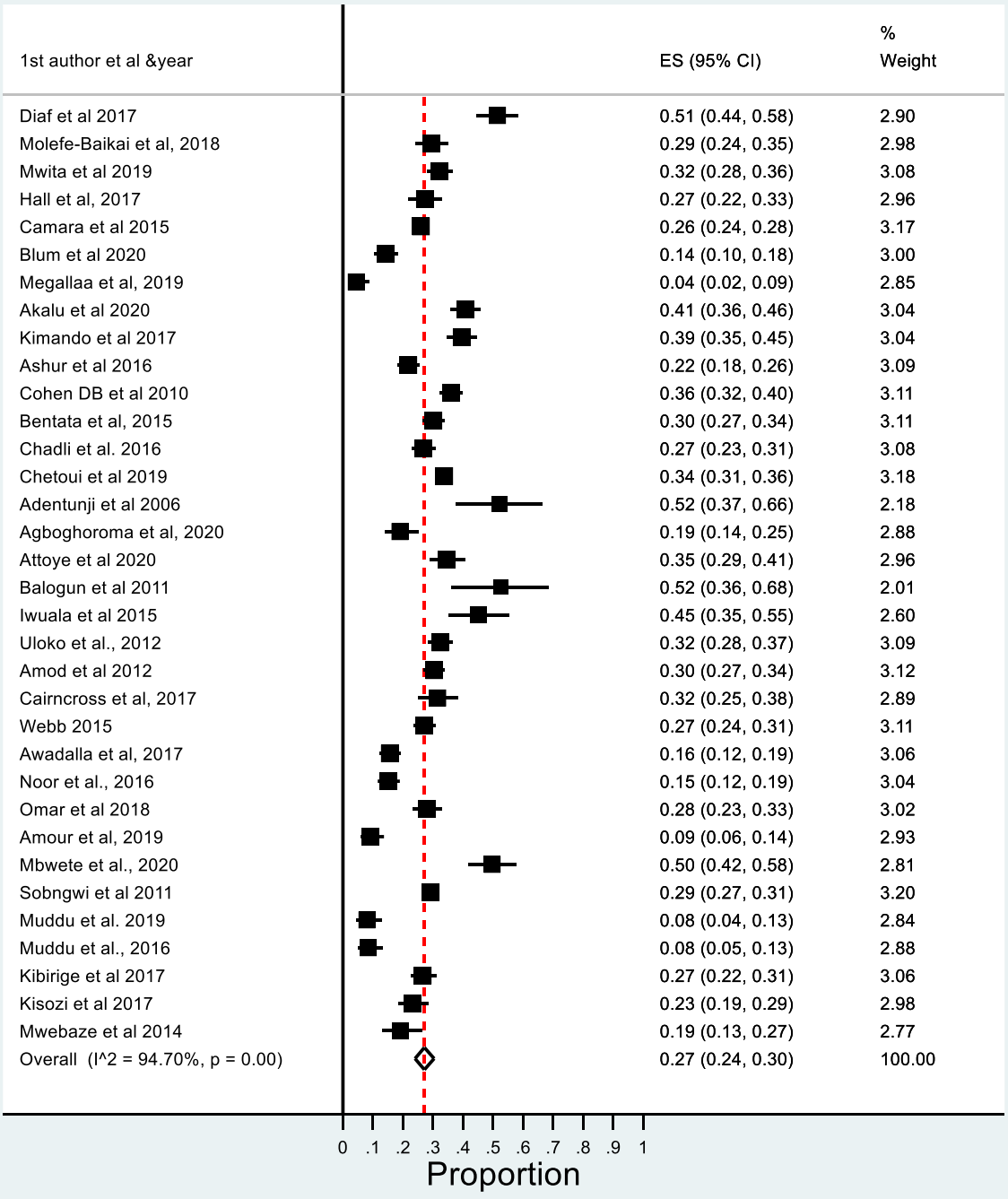


Figure 5. Forest plot summarising studies on prevalence of diabetic retinopathy

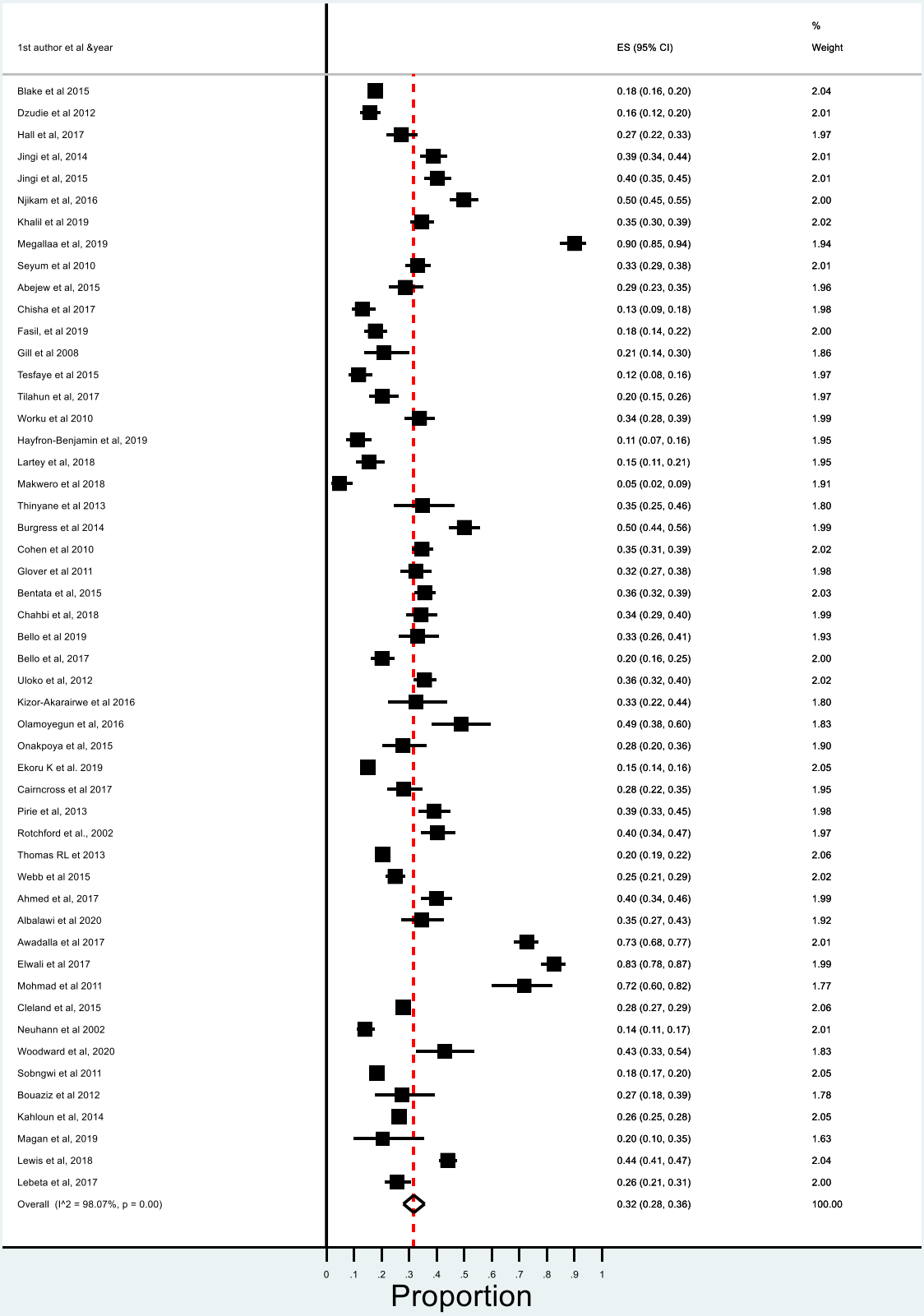


Figure 6. Forest plot summarising studies on prevalence of diabetic foot ulcers

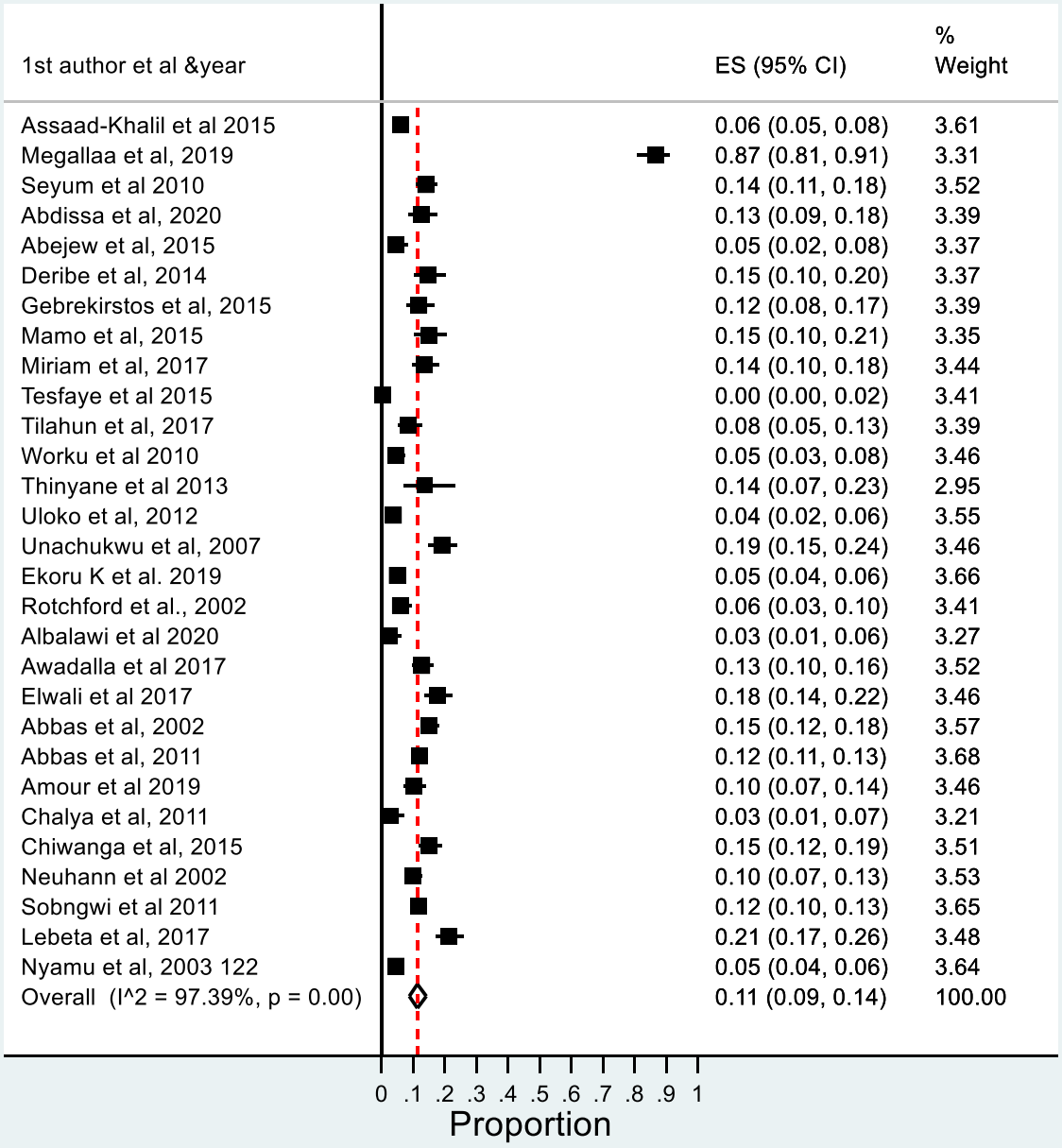


Figure 7. Forest plot summarising studies on prevalence of diabetic nephropathy

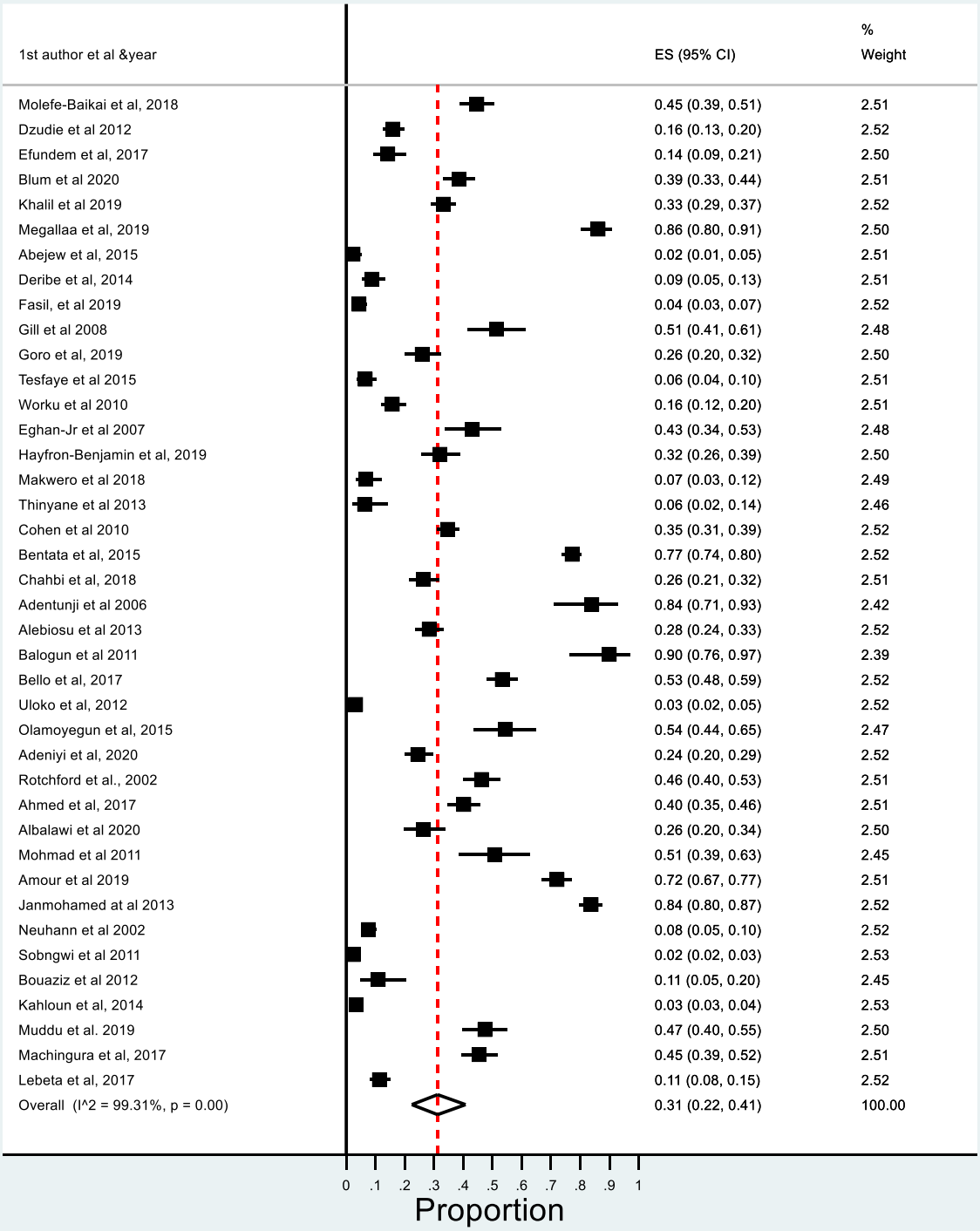


Figure 8. Forest plot summarising studies on prevalence of diabetic neuropathy

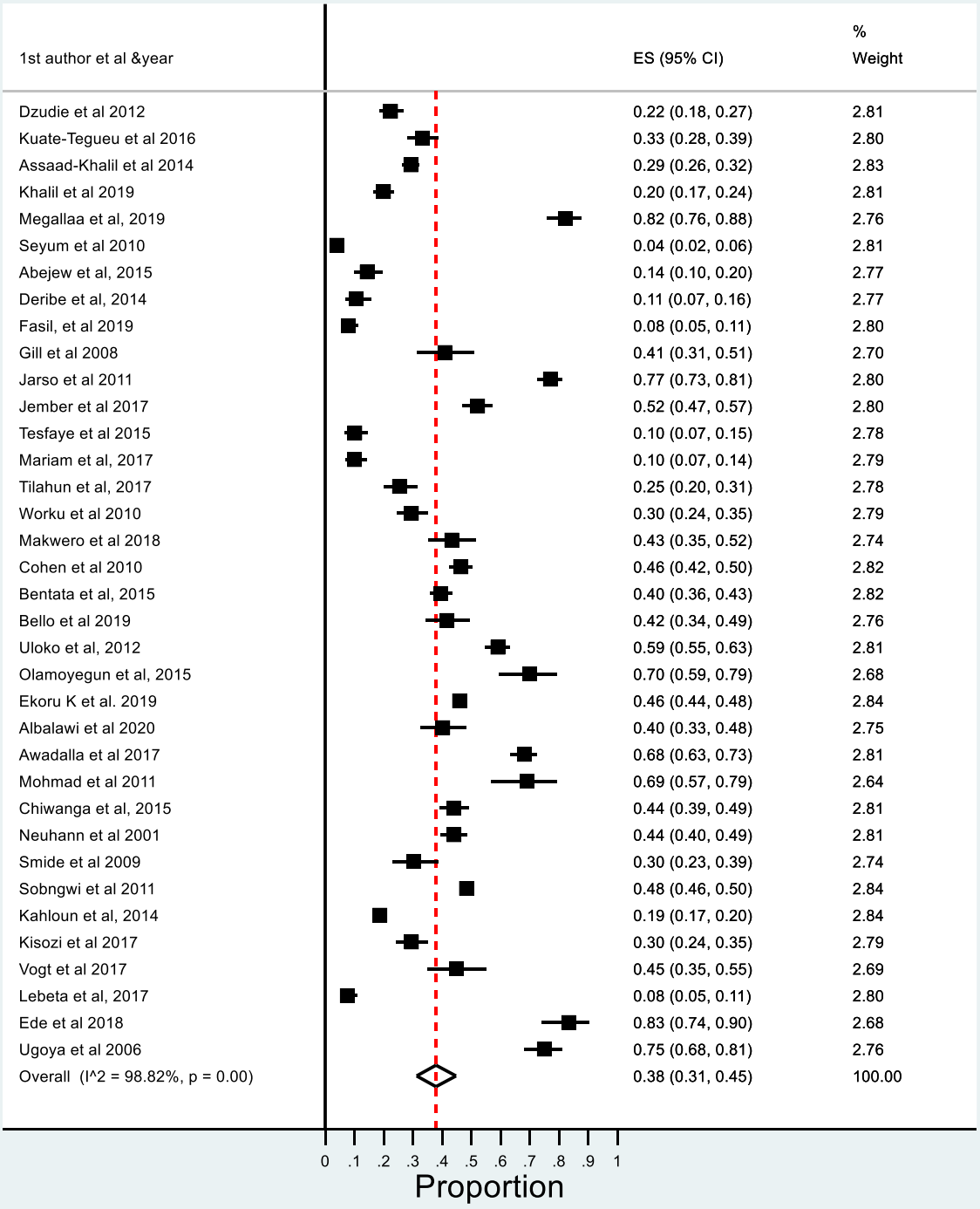
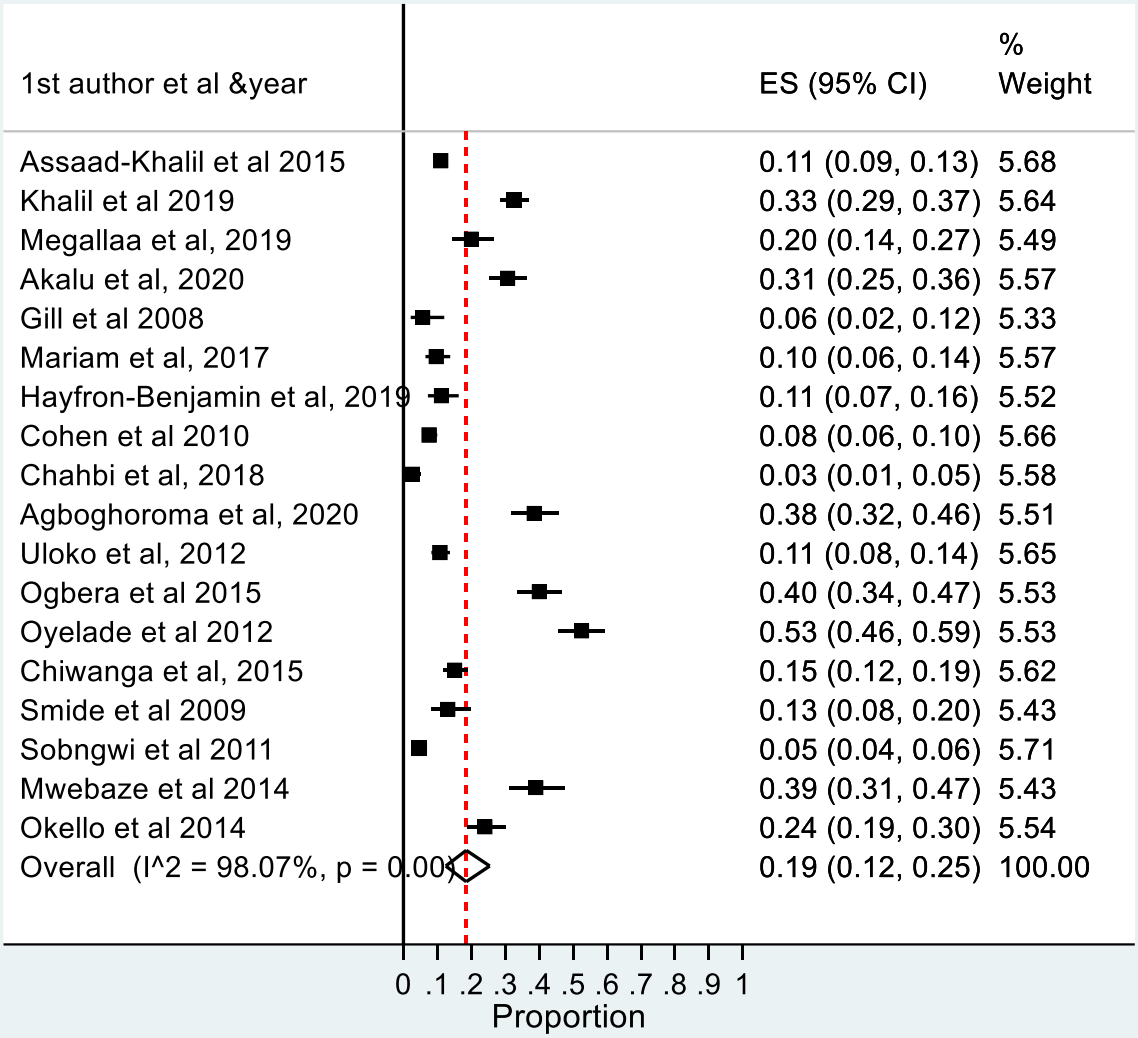
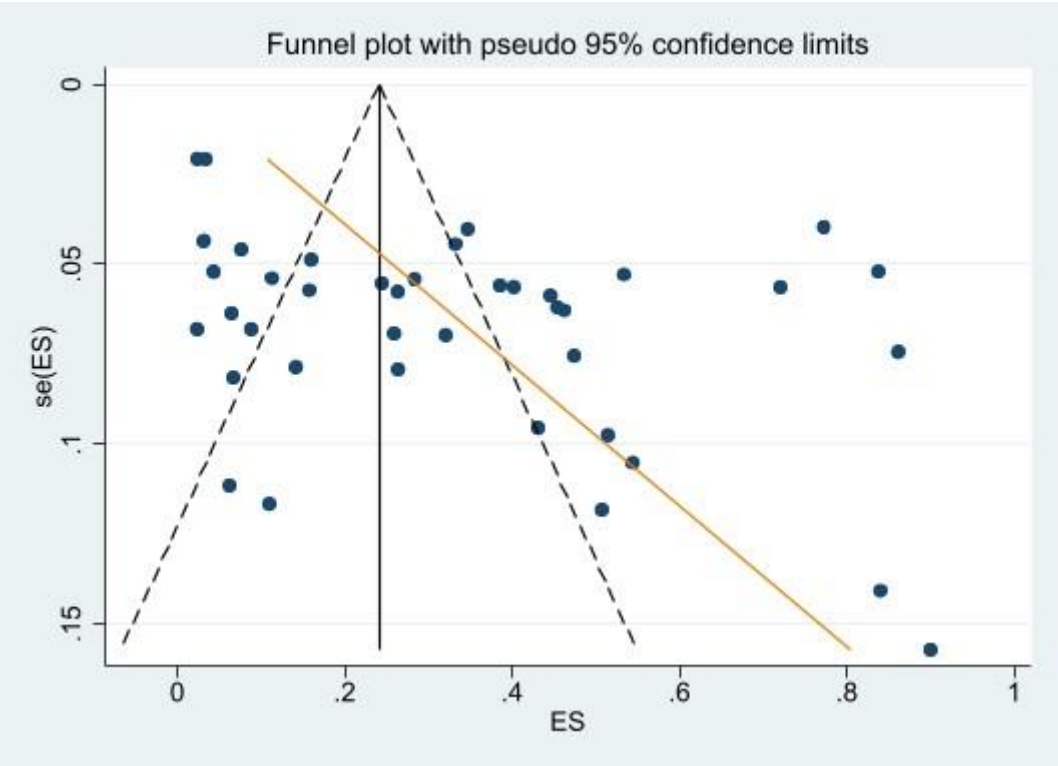


Figure 9. Forest plot summarising studies on prevalence of peripheral arterial disease

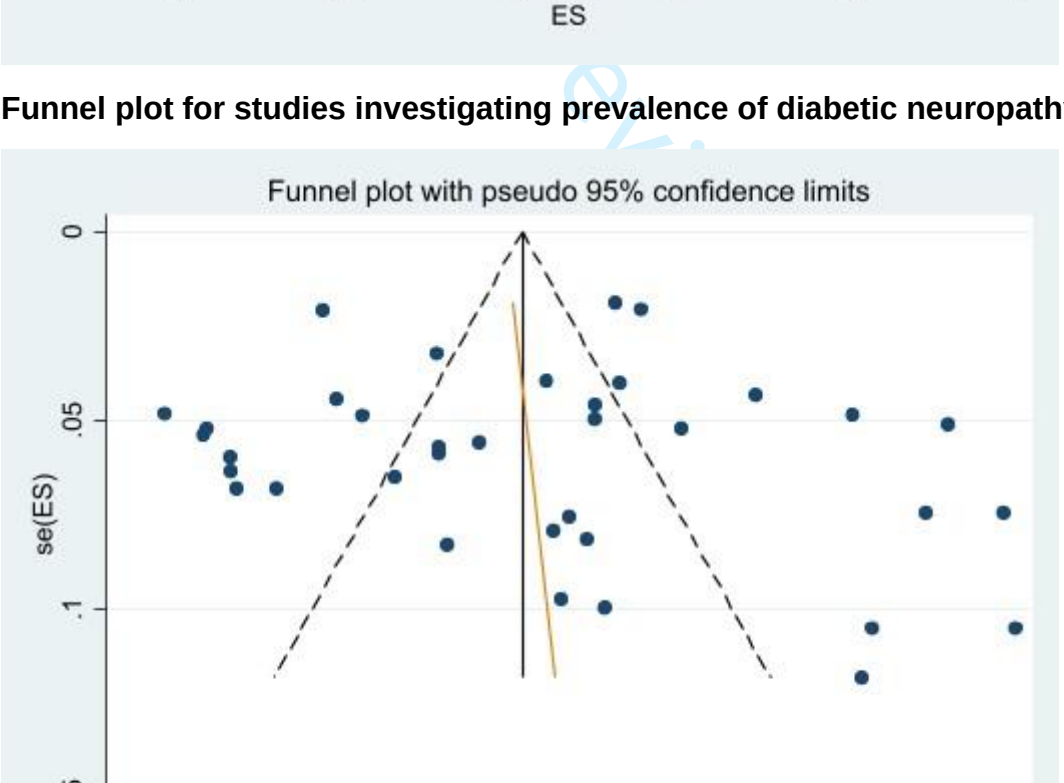


Supplementary figure 1.

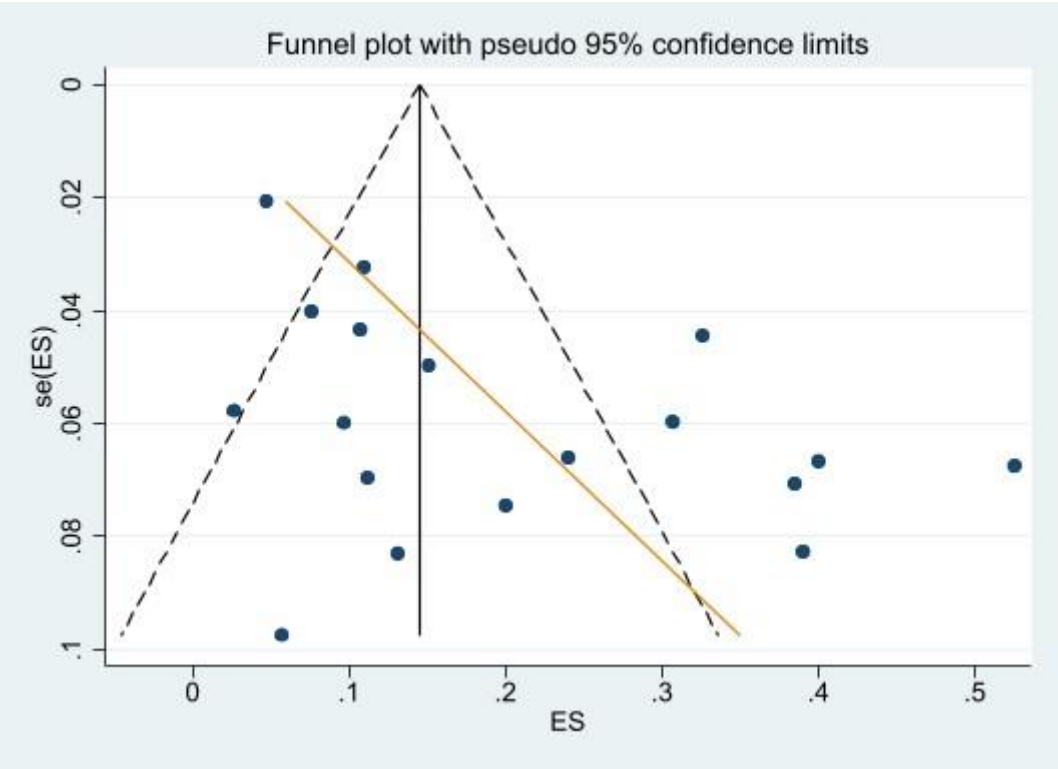
Funnel plot for studies investigating prevalence of diabetic nephropathy



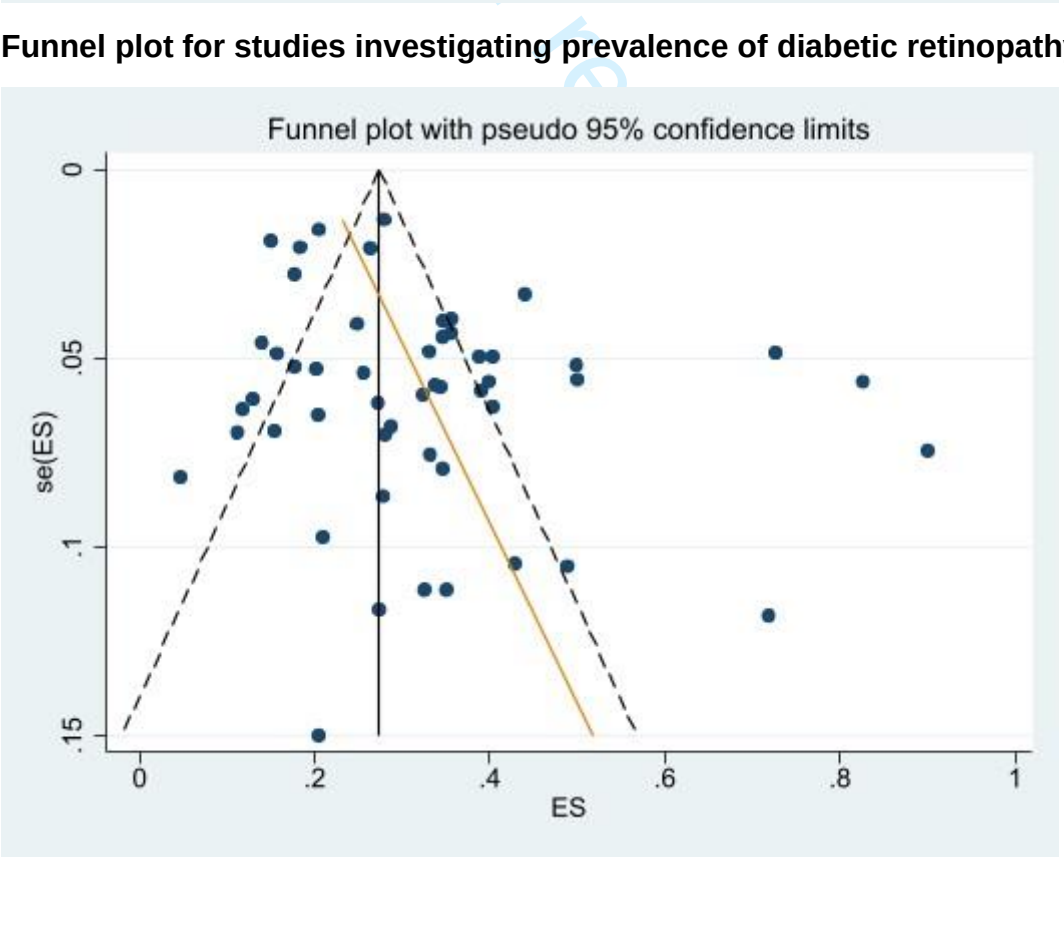
Funnel plot for studies investigating prevalence of diabetic neuropathy



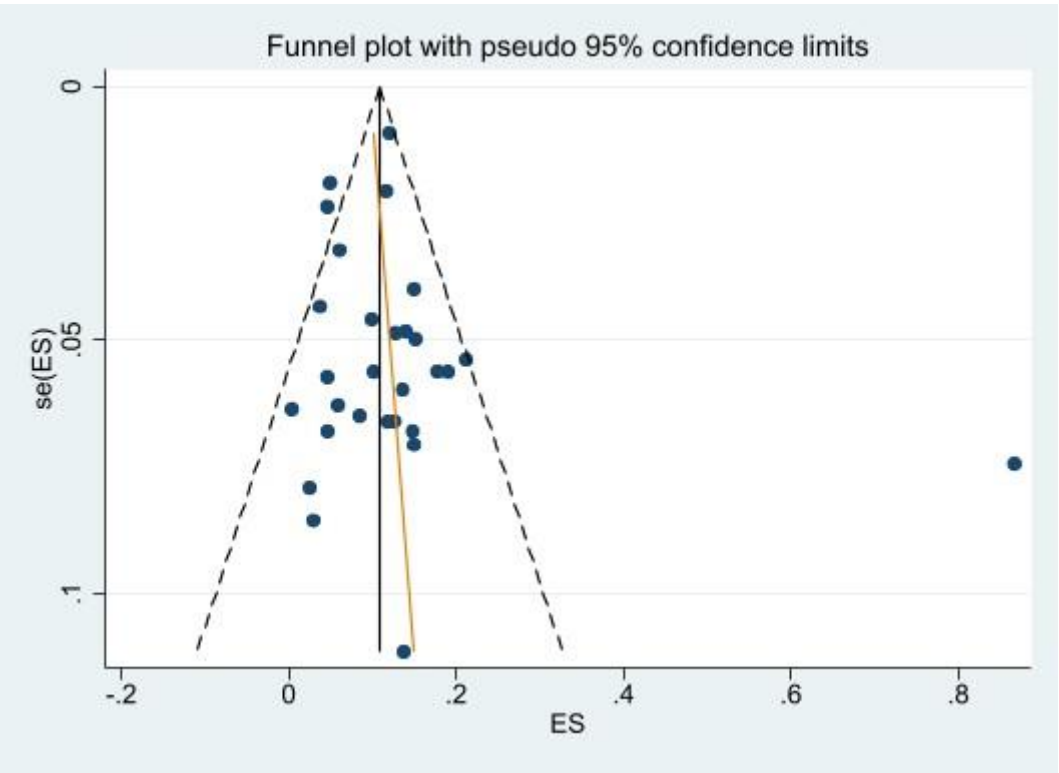
Funnel plot for studies investigating prevalence of peripheral arterial disease



Funnel plot for studies investigating prevalence of diabetic retinopathy

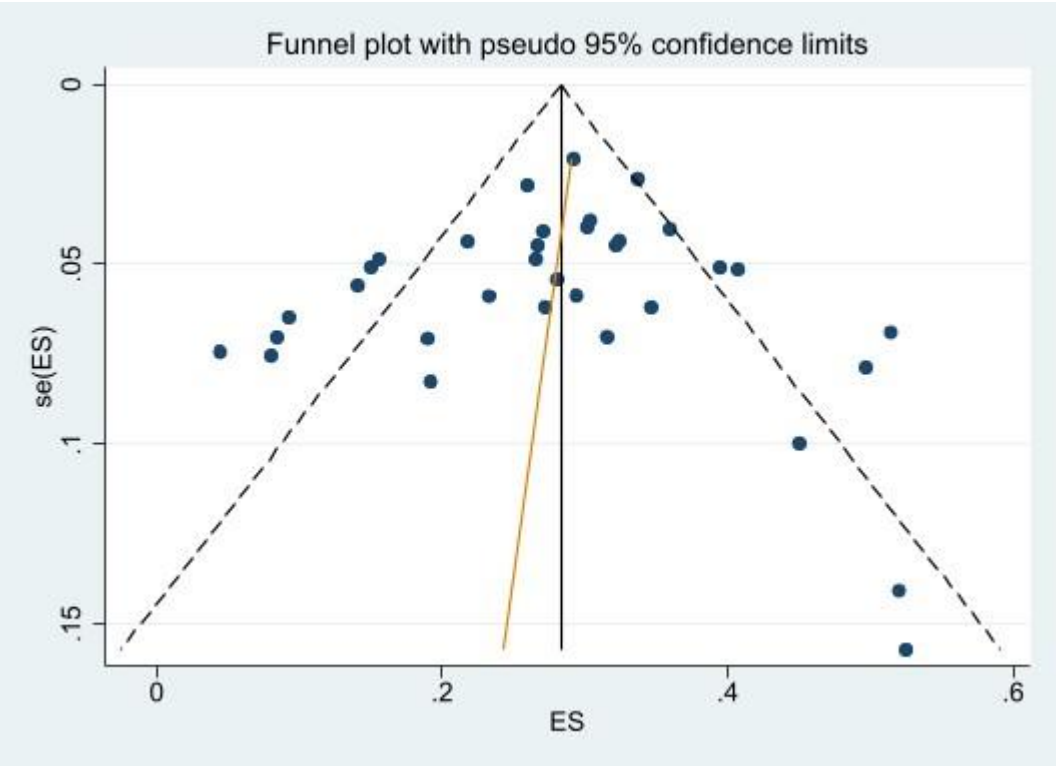


Funnel plot for studies investigating prevalence of diabetic foot ulcers

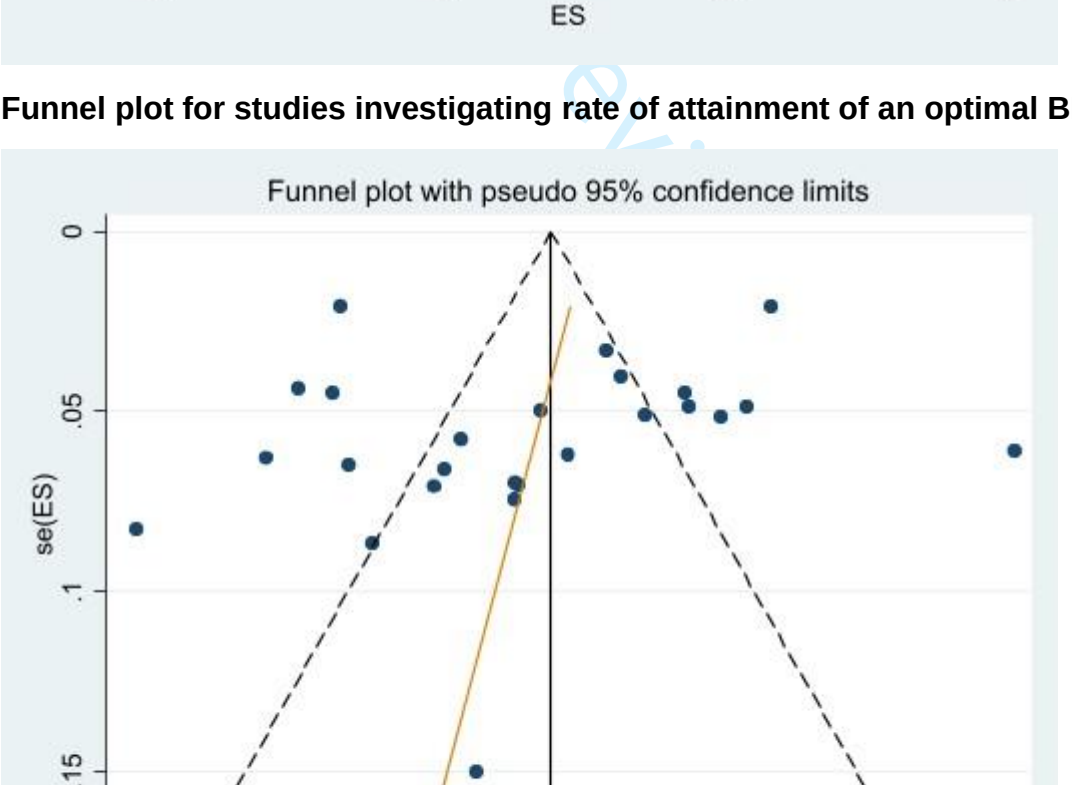


Supplementary figure 2.

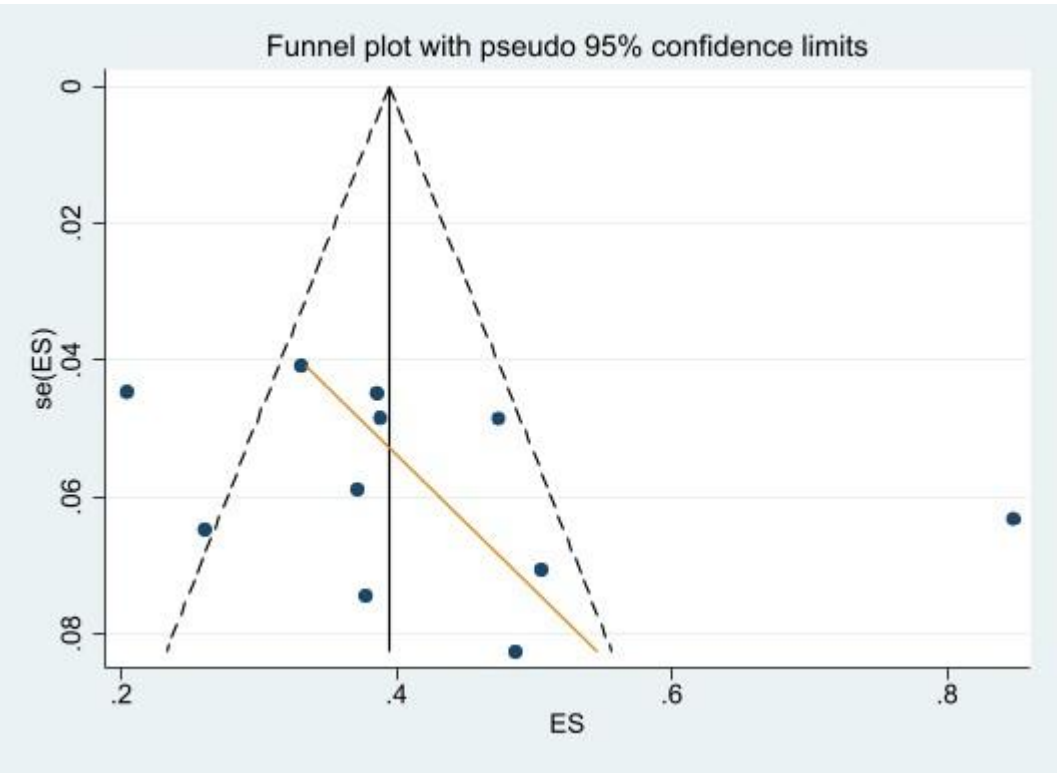
Funnel plot for studies investigating rate of attainment of an optimal HbA1c goal



Funnel plot for studies investigating rate of attainment of an optimal BP goal



Funnel plot for studies investigating rate of attainment of an optimal LDLC goal



Supplementary table 1. PRISMA checklist for the systematic review and meta-analysis

Section and Topic	Item #	Checklist item	Page where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	5-6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	7-8
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6-7
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	8-9
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	9
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	9
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	9
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	9
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	9
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity,	9

Section and Topic	Item #	Checklist item	Page where item is reported
		and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	9-10
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Not done
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	11
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	11
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	10
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	10
Study characteristics	17	Cite each included study and present its characteristics.	10-11
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	11
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	11-13
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	11
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	11-13
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Not done
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Not done
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	13
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	13
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	13-16
	23b	Discuss any limitations of the evidence included in the review.	16
	23c	Discuss any limitations of the review processes used.	16
	23d	Discuss implications of the results for practice, policy, and future research.	17
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Protocol was not prepared
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Search period was changed from September 2020 to December 2020
Support	25	Describe sources of financial or non-financial support for the review, and	17

Section and Topic	Item #	Checklist item	Page where item is reported
		the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	17
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	17

Supplementary table 2. Criteria for the adapted Newcastle-Ottawa Scale regarding star allocation to assess quality of included studies

	Selection				Comparability	Outcome		
Study details (Author et al, year)	**Representativeness of sample (⋆)**	**Sample size (⋆)**	**Non respondents (⋆)**	**Ascertainment of exposure (*)**	**(⋆⋆)**	**Assessment of outcome (⋆)**	**Statistical test (⋆)**	**Total (8*)**
Mariam et al, 2017	*	*	*	*	**	*	*	8
Okello et al, 2014	*	*	*	*	**	*	*	8
Amour et al, 2019	*	*	*	*	**	*	*	8
Abdissa et al, 2019	*	*	*	*	**	*	*	8
Fasil et al, 2019	*	*	*	*	**	*	*	8
Jember et al,2017	*	*	*	*	**	*	*	8
Chisha et al, 2017	*	*	*	*	**	*	*	8
Deribe et al, 2014	*	*	*	*	**	*	*	8
Seyum et al, 2008	*	*	*	*	**	*	*	8
Muddu et al,2019	*	*	*	*	**	*	*	8
Mamo et al., 2015	*	*	*	*	**	*	*	8
Muddu et al., 2019	*	*	*	*	**	*	*	8
Blake et al., 2015	*	*	*	*	**	*	*	8
Bello et al., 2019	*	*	*	*	**	*	*	8
Elnasri et al., 2008	*	*	*	*	**	*	*	8
Iwuala et al., 2015	*	*	*	*	**	*	*	8
Chadli et al., 2016	*	*	*	*	**	*	*	8
Jingi et al., 2014	*	*	*	*	**	*	*	8
Hall et al., 2017	*	*	*	*	**	*	*	8
Efundem et al., 2017	*	*	*	*	**	*	*	8
Attoye et al., 2020	*	*	*	*	**	*	*	8
Chetoui et al., 2020	*	*	*	*	**	*	*	8
Diaf et al., 2017	*	*	*	*	**	*	*	8
Elwali et al., 2017	*	*	*	*	**	*	*	8
Kahloun et al., 2014	*	*	*	*	**	*	*	8
Noor et al., 2017	*	*	*	*	**	*	*	8
Bello et al., 2017	*	*	*	*	**	*	*	8
Uloko et al., 2012	*	*	*	*	**	*	*	8
Ede et al., 2018	*	*	*	*	**	*	*	8

Hayfron-Benjamin et al., 2019	*	*	*	*	**	*	8
Kizor-Akaraiwe et al., 2016	*	*	*	*	**	*	8
Ogbera et al., 2015	*	*	*	*	**	*	8
Olamoyegun et al., 2015	*	*	*	*	**	*	8
Oyelade et al., 2012	*	*	*	*	**	*	8
Ugoya et al., 2006	*	*	*	*	**	*	8
Ahmed et al., 2017	*	*	*	*	**	*	8
Albalawi et al., 2020	*	*	*	*	**	*	8
Ashur et al., 2016	*	*	*	*	**	*	8
Blum et al., 2020	*	*	*	*	**	*	8
Burgess et al., 2014	*	*	*	*	**	*	8
Glover et al., 2012	*	*	*	*	**	*	8
Lewis et al., 2018	*	*	*	*	**	*	8
Machingura et al., 2017	*	*	*	*	**	*	8
Molefe-Baikai et al., 2018	*	*	*	*	**	*	8
Mwita et al., 2019	*	*	*	*	**	*	8
Pirie et al., 2014	*	*	*	*	**	*	8
Rotchford et al., 2002	*	*	*	*	**	*	8
Thomas et al., 2013	*	*	*	*	**	*	8
Webb et al., 2015	*	*	*	*	**	*	8
Omar et al., 2018	*	*	*	*	**	*	8
Adeniyi et al., 2020	*	*	*	*	**	*	8
Assaad-Khalil et al., 2015	*	*	*	*	**	*	8
Khalil et al., 2019	*	*	*	*	**	*	8
Awadalla et al., 2017	*	*	*	*	**	*	8
Bentata et al., 2015	*	*	*	*	**	*	8
Bouaziz et al., 2012	*	*	*	*	**	*	8
Jingi et al., 2015	*	*	*	*	**	*	8

Chahbi et al., 2018	*	*	*	*	**	*	*	8
Adetunji et al., 2006	*	*	*	*	**	*	*	8
Jarso et al., 2011	*	*	*	*	**	*	*	8
Janmohamed et al, 2013	*	*	*	*	*	*	*	7
Chalya et al, 2011	*	*	*	*	*	*	*	7
Goro et al, 2019	*	*	*	*	*	*	*	7
Muddu et al, 2016	*	*	-	*	**	*	*	7
Kisozi et al, 2017	*	*	*	*	*	*	*	7
Akalu et al, 2020	*	*	*	*	*	*	*	7
Lumu et al, 2017	*	*	*	*	*	*	*	7
Chamba et al, 2017	*	*	-	*	**	*	*	7
Smide et al, 2008	*	-	*	*	**	*	*	7
Sobngwi et al 2011	*	-	*	*	**	*	*	7
Camara et al, 2014	*	-	*	*	**	*	*	7
Ekoru et al,2019	*	-	*	*	**	*	*	7
Mwebaze et al, 2014	*	*	*	*	*	*	*	7
Agboghoroma et al,2020	*	*	*	*	*	*	*	7
Kimando et al, 2017	*	*	-	*	**	*	*	7
Clealand et al, 2015	*	*	*	*	*	*	*	7
Njikam et al., 2016	*	*	-	*	**	*	*	7
Dzudie et al., 2012	*	*	*	-	**	*	-	7
Alebiosu et al., 2003	*	*	-	*	**	*	*	7
Kuate-Tegueu et al., 2015	*	*	-	*	**	*	*	7
Mohmad et al., 2011	*	*	-	*	**	*	*	7
Cohen et al., 2010	*	*	-	*	**	*	*	7
Makwero et al., 2018	*	*	-	*	**	*	*	7
Onakpoya et al., 2016	*	-	-	*	**	*	*	7
Lebeta et al, 2016	*	*	*	*	-	*	*	6
Kibirige et al, 2017	*	-	-	*	**	*	*	6
Mbwete et al, 2020	*	-	*	*	*	*	*	6
Tiahun et al,2017	*	*	*	*	-	*	*	6

Chiwanga et al, 2015	*	-	*	*	*	*	*	6
Lumu et al, 2017	*	-		*	**	*	*	6
Balogu et al., 2011	*	-	-	*	**	*	*	6
Megallaa et al., 2019	*	*	*	*	-	*	*	6
Eghan et al., 2007	*	*	-	-	**	*	*	6
Unachukwu et al., 2007	*	-	-	*	**	*	*	6
Abejew et al, 2015	*	*	-	*	-	*	*	5
Nyamu et al, 2003	*	-	*	*	-	*	*	5
Gulam-Abbas et al, 2002	*	-	*	*	-	*	*	5
Abbas et al, 2011	*	*	*	*	-	*	-	5
Gill et al, 2008	*	*	*	*	-	*	-	5
Cairncross et al., 2017	-	-	-	*	**	*	*	5
Amod et al., 2012	*	*	*	-	-	*	*	5
Vogt et al, 2017	*	-	-	*	-	*	*	4
Worku et al, 2010	*	*	*	-	-	*	-	4
Gebrekirstos et al, 2015	*	-	*	*	-	*	-	4
Magan et al, 2019	-	-	-	*	-	*	*	3
Woodward et al, 2020	-	-	-	*	-	*	*	3
Lartey et al., 2018	-	-	-	*	-	*	*	3
Tesfatsion et al, 2015	-	-	-	*	-	*	-	2
Neuhann et al, 2001	-	-	-	*	-	*	-	2

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Indicators of optimal diabetes care and burden of diabetes complications in Africa: A systematic review and meta-analysis

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ABSTRACT

Objective

Contemporary data on the attainment of optimal diabetes treatment goals and the burden of diabetes complications in adult populations with type 2 diabetes in Africa is lacking. We aimed to document the current status of attainment of three key indicators of optimal diabetes care and the prevalence of five diabetes complications in adult African populations with type 2 diabetes.

Methods

We systematically searched EMBASE, PubMed, and the Cochrane library for published studies from January 2000 to December 2020. Included studies reported any information on the proportion of attainment of optimal glycated haemoglobin (HbA1c), blood pressure (BP), and low-density lipoprotein cholesterol (LDLC) goals, and/or prevalence of five diabetes complications (diabetic peripheral neuropathy, retinopathy, nephropathy, foot ulcers, and peripheral arterial disease). Random-effect model meta-analysis was performed to determine the pooled proportion of attainment of the three treatment goals and the prevalence of five diabetes complications.

Results

In total, 109 studies with a total of 63, 890 participants (53.3% being females) were included in the meta-analysis. Most of the studies were conducted in Eastern African countries (n=44, 40.4%). The pooled proportion of attainment of an optimal HbA1c, BP, and LDLC goal was 27% (95% CI 24-30, I^2=94.7%), 38% (95% CI 30-46, I^2=98.7%), and 42% (95% CI 32-52, I^2=97.4%), respectively. The pooled prevalence of diabetic peripheral neuropathy, retinopathy, diabetic nephropathy, peripheral arterial disease, and foot ulcers was 38% (95% CI 31-45, I^2=98.2%), 32% (95% CI 28-

36, I^2=98%), 31% (95% CI 22-41, I^2=99.3%), 19% (95% CI 12-25, I^2=98.1%), and 11% (95% CI 9-14, I^2=97.4%), respectively.

Conclusion

Attainment of optimal diabetes treatment goals, especially HbA1c, in adult patients with type 2 diabetes in Africa remains a challenge. Diabetes complications, especially diabetic peripheral neuropathy and retinopathy are highly prevalent in adult populations with type 2 diabetes in Africa.

KEYWORDS

Optimal diabetes care, diabetes complications, adult patients with type 2 diabetes, Africa.

Strengths and limitations of the study

- To our knowledge, it is the first systematic review and meta-analysis to simultaneously investigate the status of attainment of the three key diabetes treatment goals and the burden of five common diabetes complications in an adult indigenous African population with type 2 diabetes.
- The systematic review and meta-analysis included a large number of studies that assessed the extent of attainment of diabetes treatment goals and the prevalence of diabetes complications based on recommendations or definitions by internationally recognised associations.
- There was high heterogeneity among the studies included in the meta-analysis.
- A relative number of studies included in the meta-analysis had low to moderate quality on assessment.

INTRODUCTION

Globally, the burden of diabetes mellitus (DM) continues to exponentially rise to epidemic proportions, disproportionately affecting low-and middle-income countries. The recent 2021 International Diabetes Federation (IDF) estimates show that about 24 million adults (1 in 22 adults) live with DM in Africa. The IDF also predicts that the greatest future increase in the prevalence of DM will occur in Africa because of the predicted aging of Africa's currently very young populations, as well as increasing urbanisation and associated lifestyle changes.[1] This will ultimately lead to an immense strain on weak healthcare systems that are poorly structured and inadequately financed to manage non-communicable diseases (NCD) like DM.[2]

In addition, the rates of undiagnosed DM continue to increase in Africa. Among the IDF regions, Africa has the highest proportion of undiagnosed diabetes; about 54% of all cases.[1] The majority of patients are diagnosed late with co-existing debilitating complications and suboptimal diabetes care remains common in most clinical settings in Africa.[3] This could be explained by low awareness about DM, healthcare systems that are structured mainly to manage communicable diseases as opposed to NCD, low screening rates of DM to ensure early diagnosis, low availability of affordable essential diagnostic tests and medicines for DM, and knowledge-practice gaps among healthcare practitioners.[2 4-6]

Published diabetes treatment guidelines by most international organisations like the IDF and American Diabetes Association (ADA) recommend targets of glycated haemoglobin level (HbA1c) of <7% (53 mmol/mol), blood pressure (BP) <140/90 mmHg, and low-density lipoprotein cholesterol (LDLC) <2.6 mmol/l (100 mg/dl) as key indicators of optimal diabetes care.[7-9] Attainment of these treatment goals in diabetes

care ultimately translates to reduced risk of onset and progression of diabetes complications and mortality.

Despite the increasing burden of DM and its related complications, late diagnosis of diabetes, and prevalent suboptimal diabetes care in clinical settings in Africa, there is an information gap regarding the current status of attainment of the recommended diabetes treatment goals and the prevalence of common diabetes complications to inform targeted strategies or interventions to reduce diabetes-related morbidity and mortality. This systematic review and meta-analysis aimed to document the proportion of attainment of optimal HbA1c, BP, and LDLC goals and the prevalence of five diabetes complications (diabetic peripheral neuropathy, nephropathy, retinopathy, foot ulcers, and peripheral arterial disease) in adult native populations with type 2 diabetes in Africa.

METHODS

This systematic review and meta-analysis was conducted according to the criteria outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[10] The PRISMA checklist is available as a supplementary table 1. The study protocol was registered in the PROSPERO International Prospective Register of systematic reviews (CRD42020215576).

Search strategy

We searched EMBASE, PubMed, and the Cochrane library for published studies from January 2000 to December 2020. The following search terms were used after discussion with a medical librarian: “Quality of diabetes care” OR “Indicators of diabetes care” OR “status of diabetes care” OR “diabetes care” OR “glycaemic control” OR “blood pressure control” OR “lipid profile control” OR “screening of diabetes complications” OR “diabetes complications” OR “screening for diabetic retinopathy”

OR “screening for diabetic peripheral nephropathy” OR screening for diabetic neuropathy” OR screening for diabetic foot ulcers OR “screening for peripheral arterial disease” OR “prevalence of diabetic retinopathy” OR “prevalence of diabetic peripheral nephropathy” OR “prevalence of diabetic peripheral neuropathy” OR “prevalence of diabetic foot ulcers” OR “prevalence of peripheral arterial disease”, AND “type 2 diabetes mellitus” OR “type 2 diabetes” AND Algeria OR Angola OR Benin OR Botswana OR ‘‘Burkina Faso’’ OR Burundi OR Cameroon OR ‘‘Cape Verde’’ OR ‘‘Central African Republic’’ OR Chad OR Comoros OR ‘‘Democratic Republic of Congo’’ OR Djibouti OR Egypt OR ‘‘Equatorial Guinea’’ OR Eritrea OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR ‘‘Guinea Bissau’’ OR ‘‘Ivory Coast’’ OR ‘‘Cote d’Ivoire’’ OR Kenya OR Lesotho OR Liberia OR Libya OR Libya OR Madagascar OR Malawi OR Mali OR Mauritania OR Mauritius OR Morocco OR Mozambique OR Namibia OR Niger OR Nigeria OR Rwanda OR ‘‘Sao Tome’’ OR Senegal OR Seychelles OR ‘‘Sierra Leone’’ OR Somalia OR ‘‘South Africa’’ OR “South Sudan” OR Sudan OR Swaziland OR Tanzania OR Togo OR Tunisia OR Uganda OR Zaire OR Zambia OR Zimbabwe OR ‘‘Central Africa’’ OR ‘‘West Africa’’ OR ‘‘Western Africa’’ OR ‘‘East Africa’’ OR ‘‘Eastern Africa’’ OR ‘‘North Africa’’ OR ‘‘Northern Africa’’ OR ‘‘Southern Africa’’ OR ‘‘sub Saharan Africa’’ OR ‘‘sub-Saharan Africa’’ OR Africa. In addition, references of included articles were hand-searched for any other original articles. The search and selection were restricted to studies written only in the English language.

Study selection criteria

The preliminary screening of titles and abstracts to identify potentially eligible articles was done by two independent reviewers (NC and DK). This was followed by removing

all duplicates. After the initial screening, full texts of the potentially eligible studies were retrieved and closely reviewed for eligibility.

The inclusion criteria of studies were: cross-sectional, cohort, or randomised controlled trials published between January 2000 and December 2020 in English language, studies reporting any data on proportion of adult patients with type 2 diabetes who attained the recommended optimal HbA1c, BP, or LDLC targets and residing in African countries, and studies reporting data on any of prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers, or peripheral arterial disease in adult patients with type 2 diabetes in African countries.

Any disagreements that arose were resolved by consensus. We excluded retrospective studies, case series and reports, studies published in languages other than English, and studies whose full texts could not be retrieved.

Data extraction

After identifying the eligible original studies, they were collated and sent to additional reviewers to extract the relevant study information using a Microsoft Excel 2016 form. The information of interest that was extracted from the eligible studies included: the last name of the first author and year of publication, country (ies) and region (s) of Africa where the study was conducted, type of study design, number of study participants, the mean age of study participants, the proportion of female participants, the proportion of participants with a current or history of smoking, the proportion of participants on oral hypoglycaemic agents, insulin, lipid-lowering agents (statins), and anti-hypertensive agents, mean body mass index (BMI) and HbA1c of study participants, the proportions of participants with optimal HbA1c, BP, and LDLC targets, and the prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers, and peripheral arterial disease.

Operational definitions

All included studies defined optimal targets of HbA1c, BP, and LDLC as <7% (53 mmol/mol), <140/90 mmHg, and <2.6 mmol/l or 100 mg/dl, respectively as recommended by the IDF and ADA diabetes treatment guidelines.[9 11]

The definitions and measurements of diabetes complications greatly varied between studies. The following definitions were used for each diabetes complication by the various studies: micro/macroalbuminuria and/or an estimated glomerular filtration rate <60 ml/min/1.73 m^2 for the presence of diabetic nephropathy, signs and symptoms suggestive of peripheral neuropathy, use of neuropathy screening scores like neuropathy disability score, Michigan Neuropathy Screening Instrument, neuropathy symptom score, and 10g monofilament testing for the presence of diabetic peripheral neuropathy, presence of lesions like soft or hard exudates, cotton wool spots, micro-aneurysms, neovascularisation, and retinal hemorrhages on fundoscopy for diabetic retinopathy, presence of foot ulcers on clinical inspection for diabetic foot ulcers, and the presence of measured ankle brachial index <0.9 using doppler studies for peripheral arterial disease.

Assessment of quality of studies

The quality of all eligible studies included in the systematic review and meta-analysis was assessed using the Newcastle-Ottawa Scale (NOS).[12] This was done by two independent authors (NC and SNL). The total score of the adapted scale is eight stars. Studies with more than six stars were considered high quality, while those with 5 and 6 stars, and <5 stars were considered of moderate and low quality.

Study outcomes

The study outcomes were the pooled proportions of attainment of the recommended optimal HbA1c, BP, and LDLC goals and the pooled prevalence of diabetic

nephropathy, peripheral neuropathy, retinopathy, foot ulcers, and peripheral arterial disease in adult patients with type 2 diabetes in Africa.

Data analysis

All analyses were performed using STATA 16.0 statistical software (Stata Corp, USA). The descriptive data of all eligible studies included in the systematic review and meta-analysis like age, gender, the proportion of participants on specific glucose-lowering agents, BMI, and HbA1c were summarised using frequencies and 95% confidence intervals (CI) and mean ± standard deviation (SD).

For the continuous variables, the average estimated value was obtained from each of the studies, and this was used in the final analysis while for the categorical variables, the proportions were estimated for each of the studies and used in the final analysis.

The pooled proportions of achievement of optimal HbA1c, BP, and LDLC goals and the prevalence of diabetic nephropathy, peripheral neuropathy, retinopathy, foot ulcers, and peripheral arterial disease were determined using a random-effect model meta-analysis and presented in forest plots. The DerSimonian and Laird method was used for pooling random effects estimates.[13]

The heterogeneity of studies was assessed using the I^2 value and corresponding 95% confidence intervals. Based on the Cochrane collaboration guide, the I^2 values of 0-40%, 30-60%, 50–90%, and 75-100% were considered not important, moderate, substantial, and considerable levels of heterogeneity, respectively.[14] To further explore heterogeneity effects across studies, we conducted a meta-regression analysis to assess whether the heterogeneity could be explained by the study level characteristics i.e., age, sex of participants, and region in which the study was conducted. The age, BMI, and sex of the participants was defined as the estimated mean age and BMI of participants and the proportion of females from each of the

study, respectively. The region of the study was defined as the area (Northern, Southern, Eastern, Western, and Central Africa) where the study was conducted. One effect measure per study was considered in the meta-regression. All the variables were included in the model together to assess for variability.

We assessed the presence of publication bias using the Egger test of bias with $p<0.05$ indicating significant publication bias.[15] A narrative review was also used to present the study results. Information about all included studies was also summarised in tables.

We also performed a sensitivity analysis based on the NOS scores of the studies (excluding moderate and low-quality studies) and compared the analysis with all the eligible studies and with only high-quality studies to identify any differences in the pooled estimates of the rates of attainment of optimal diabetes treatment goals and the prevalence of the five diabetes complications.

Patient and Public Involvement

The main research question and outcomes of interest of the systematic review and meta-analysis were informed by the need to understand the burden of diabetes complications in patients with type 2 diabetes in Africa and the extent of attainment of optimal diabetes care to inform strategies aimed to improve optimal management of diabetes in the region. Because it was a systematic review and meta-analysis, we did not involve patients in its design, recruitment, and conduct.

RESULTS

Figure 1 summarises the article selection in a PRISMA flow diagram.

The literature search returned a total of 835 articles. From these, 222 duplicates were removed. Titles and abstracts of the remaining 613 articles were reviewed and 235 articles were identified for full-text retrieval. Of the 235 articles, 126 were excluded and

the remaining 109 articles were included in this systematic review and meta-analysis. A total of 48 and 89 eligible studies contained information on optimal diabetes treatment goals and diabetes complications, respectively while 28 studies reported information on both.

The 126 excluded articles included five studies published in French language, 21 retrospective studies, six studies with general populations (not entirely patients with type 2 DM), 18 studies whose full texts were unable to be retrieved, and 76 studies that did not report outcomes of interest.

Characteristics of included studies

The majority of studies were performed in Eastern African countries (44, 40.4%).[3 16-58] The proportion of studies conducted in Western, Northern, Southern, and Central Africa was 22% (n=24 studies) [3 59-80], 16.5% (n=18 studies) [81-99], 15.6% (n=17 studies) [100-116], and 8.3% (n=9 studies) [3 59 117-123], respectively. Three studies were conducted in more than one region of Africa (Western, Central, and Eastern).[3 58 59] Most of the studies were cross-sectional in design (100, 91.7%).

Considerable heterogeneity was noted across the studies with the I^2 value ranging from 97.4% to 99.3% for studies reporting the burden of diabetes complications and 94.7% to 98.7% for studies reporting the extent of attainment of optimal diabetes treatment goals. However, on meta-regression after adjusting for age and sex of study participants, and region where each study was conducted, the heterogeneity based on I^2 of studies on the prevalence of diabetes complications decreased, ranging from 1.4% for studies on diabetic foot ulcers to 95.6% for studies on diabetic nephropathy. For studies on the proportion of attainment of optimal treatment goals, the heterogeneity also decreased, to 56.3%, 92.1%, and 95.4%, for studies reporting optimal HbA1c, LDLC, and BP goals.

Characteristics of study participants

Table 1 summarises the characteristics of all participants in the studies included in the systematic review and meta-analysis.

The studies had a total of 63, 890 participants (ranging from 40 to 11,866) with 53.3% being female. The mean ± SD age, BMI, and HbA1c of the participants was 54.9 ± 4.7 years (ranging from 40.5 to 63.9 years), 27.9 ± 0.5 kg/m^2 (ranging from 20.6 to 42.9 kg/m^2), and 9.0 ± 1.5% (ranging from 6.5% to 13.9%), respectively. Among the studies that reported data on the type of glucose-lowering therapies used by participants, treatment with oral hypoglycaemic agents, insulin, statins, and anti-hypertensives was reported in about 65% (95% CI 34-96.6), 31.3% (95% CI 26.3-36.2), 25.7% (95% CI 0.5-86.7), and 73.3% (95% CI 64.1-82.5) of participants, respectively.

Assessment of study quality and publication bias

The assessment of the quality of studies and funnel plots assessing publication bias are summarised in supplementary table 2 and supplementary figures 1-8, respectively. Based on the NOS, 84 (77.1%) of the included studies were of high quality, with 17 (15.6%) studies and 8 (7.3%) studies being of moderate and low quality, respectively. Regarding the assessment of publication bias, there was observed publication bias, especially in studies about the prevalence of diabetic nephropathy, peripheral neuropathy, and attainment of optimal BP control. The proportion of studies investigating the prevalence of diabetic nephropathy, peripheral neuropathy, peripheral arterial disease, retinopathy, and foot ulcers located within the funnel plot was 30% (n=12), 46.1% (n=13), 55.6% (n=10), 57% (29), and 90% (n=26), respectively. About 46%, 65%, and 73% of studies that reported the proportion of attainment of optimal BP, HbA1c, and LDLC treatment goal were located within the funnel plot respectively.

Extent of attainment of optimal HbA1c, BP and LDLC goals

Data on the reported proportions achieving the three diabetes treatment goals is summarised in tables 2, 3, and 4 and as forest plots in figures 2, 3 and 4.

Data on attainment of optimal HbA1c, BP and LDLC goals was reported in 34 studies[3 20 21 23 35-37 44-47 59-61 63 64 67 84 87 92 93 97-99 104 105 111 116 117 120 124 125], 26 studies[3 18 20 21 24 36 40 41 45 47 61 64 67 70 77 87 91 96 97 105 107 111 113 120 121 124], and 11 studies[21 37 39 47 61 87 97 111 116 124 126], respectively. The pooled proportion of attainment of an optimal HbA1c, BP, and LDLC goal in the respective studies was 27% (95% CI 24-30, I^2=94.7%), 38% (95% CI 30-46, I^2=98.7%), and 42% (95% CI 32-52, I^2=97.4%), respectively.

The lowest proportion of attainment of optimal HbA1c was reported in a study performed in Egypt (4.4%)[97] and the highest in a study performed in Nigeria (52.5%)[64]. Among studies reporting the extent of attainment of an optimal BP goal, the proportion ranged from 1.5% in a study performed in Uganda[47] to 85.9% in a study performed in Ethiopia[24]. Among the studies reporting information on the optimal LDLC goal, attainment of optimal targets ranged from 20.4% in a study performed in Botswana[111] to 84.8% in a study performed in Sudan[94].

Regarding the attainment of the diabetes treatment goals in each region of Africa surveyed, the lowest and highest proportion of attainment of an optimal HbA1c goal was noted in the Central (20%, 95% CI 16-23) and Western region (37%, 95% CI 29-46), respectively. For the attainment of an optimal blood pressure control, the Western region had the least proportion (31%, 95% CI 20-43) while the Northern region had the highest (42%, 95% CI 24-61). An optimal LDLC target was least achieved in the Southern region (27%, 95% CI 24-30) and most achieved in the Northern region (53%, 95% CI 32-74).

Prevalence of diabetic retinopathy, peripheral neuropathy, nephropathy, foot ulcers and peripheral arterial disease

Information on the pooled and specific prevalence of diabetes complications as reported by the different studies is summarised in tables 5, 6, 7, 8, and 9 and as forest plots in figures 5, 6, 7, 8, and 9.

The prevalence of diabetic retinopathy, nephropathy, peripheral neuropathy, foot ulcers, and peripheral arterial disease was reported in 51 studies[3 19 24 26 28 30 38 41 48 51 53 54 56-58 66 67 70 72 74 76 77 81 82 86 88 89 91 95-97 103-107 109 112-116 118 120-123 127-129], 40 studies[3 19 21 27 28 30-32 38 46 48 53 57 60 62 64 66 67 69 70 76 81 82 86 88 89 91 96 97 100 105 108-110 113 114 117-119 127], 36 studies[3 19 25 27 28 30 33 34 37 38 43 48 51-53 57 58 67 68 73 76 79 81 85-88 96 97 105 109 118 127 128 130], 29 studies[3 16-19 21 22 25 27 29 38 42 43 48 49 51 53 54 57 58 67 80 85 87 95 97 113 114 127], and 18 studies[3 20 25 30 43 47 50 52 61 67 70 75 78 85 86 91 97 105], respectively.

Prevalence of diabetic peripheral neuropathy and retinopathy

Diabetic peripheral neuropathy and retinopathy were the most prevalent diabetes complications in the included studies with a pooled prevalence of 38% (95% CI 31-45, I^2=98.2%) and 32% (95% CI 28-36, I^2=98%), respectively. A wide variation was noted in the prevalence of diabetic peripheral neuropathy across the studies, with prevalence ranging from 4% in a study conducted in Eritrea [51] to 83.3% in a study conducted in Nigeria [68]. A study by Makwero and colleagues conducted in Lesotho reported the lowest prevalence of diabetic retinopathy of 4.7% [109] while the study by Megalla and colleagues conducted in Egypt reported the highest (90%)[97].

According to the regions of Africa surveyed, the lowest and highest prevalence of diabetic peripheral neuropathy was noted in the Central (22%, 95% CI 18-27) and Western regions (61%, 95% CI 45-75), respectively. Studies conducted in the Eastern region reported the lowest prevalence of diabetic retinopathy (23%, 95% CI 19-28)

while studies conducted in the Northern region reported the highest prevalence (51%, 95% CI 37-65).

Prevalence of diabetic nephropathy, peripheral arterial disease, and foot ulcers

The pooled prevalence of diabetic nephropathy, peripheral arterial disease, and foot ulcers in the included studies was 31% (95% CI 22-41, I^2=99.3%), 19% (95% CI 12-25, I^2=98.1%), and 11% (95% CI 9-14, I^2=97.4%), respectively.

The prevalence of diabetic nephropathy and peripheral arterial disease ranged from 2.2% in Ethiopia[19] to 90% in Nigeria[64] and 2.7% in a study performed in Morocco[91] to 52.5% in a study performed in Nigeria[78], respectively. Regarding the burden of diabetic foot ulcers, there was also an observed heterogeneity, with prevalence ranging from 0.4% in Ethiopia[53] to 86.7% in Egypt[97].

Studies conducted in the Central, Eastern, and Southern regions reported a comparable prevalence of diabetic nephropathy (22%, 25%, and 28%, respectively) with the highest prevalence reported in studies conducted in the Western region (47%). Regarding the prevalence of PAD, studies conducted in the Southern (8%, 95% CI 6-10) and Western (29%, 95% CI 13-48) regions reported the lowest and highest prevalence, respectively. A comparable prevalence of diabetic foot ulcers was noted in studies conducted in the Southern, Western, and Eastern regions (7%, 8%, and 10%, respectively), with the highest prevalence noted in studies conducted in the Northern region (21%).

On sensitivity analysis considering only high-quality studies, the pooled prevalence of the five diabetic complications and the proportion of attainment of the three optimal diabetes treatment goals did not differ from those obtained in the preliminary analysis with all eligible studies included. The pooled prevalence of diabetic foot ulcers, peripheral arterial disease, diabetic nephropathy, diabetic retinopathy, and diabetic

peripheral neuropathy after sensitivity analysis was 9% (95% CI 7-12, I^2= 92.9%), 20% (95% CI 13-28, I^2= 98.4%), 31% (95% CI 21-42, I^2= 99.4%), 33% (95% CI 28-37, I^2= 98.2%), and 40% (95% CI 32-48, I^2= 99%), respectively. The pooled proportion of attainment of optimal HbA1c, blood pressure, and LDLC treatment goal was 27% (95% CI 23-30, I^2= 94.5%), 37% (95% CI 29-46, I^2= 99.0%), and 43% (95% CI 31-55, I^2= 97.9%), respectively.

DISCUSSION

To our knowledge, this is the first systematic review and meta-analysis to simultaneously document the proportion of attainment of the three key indicators of optimal diabetes care (HbA1c, BP, and LDLC goals) and the burden of five diabetes complications in an indigenous adult population with type 2 diabetes in Africa. In this study of a total of 63,890 study participants, we report that, generally, a small proportion of adult patients with type 2 diabetes in Africa attain optimal diabetes treatment targets, especially HbA1c and BP goals (less than 40%). In addition, diabetes complications are relatively common with diabetic neuropathy being the most prevalent (38%) followed by diabetic retinopathy (32%), nephropathy (31%), peripheral arterial disease (19%), and foot ulcers (11%).

Proportions of attainment of the optimal diabetes treatment goals

A wide heterogeneity in the attainment of the optimal diabetes treatment goals was noted across all five regions of Africa. This could probably be explained by the marked differences in the populations studied, healthcare systems, and knowledge-practice gaps among healthcare practitioners.

Similar to our study findings, achievement of optimal HbA1c, BP, and LDLC treatment goals has also been widely reported to be a significant clinical challenge in several studies performed in Caucasian and Asian populations with type 2 diabetes in high-

and middle-income countries.[131-136] In one large registry-based study of >100, 000 adults with a self-reported diagnosis of diabetes carried out between 1999 to 2010 in USA, 33.4 to 48.7% of adult patients with diabetes did not achieve the recommended HbA1c, BP, and LDLC treatment targets. Less than 15% met all the three treatment targets in addition to smoking cessation.[131]

Similarly, a low proportion of achievement of an optimal HbA1c target was also reported by a large international, multicenter observational study of 2,704 multi-racial adult populations with diabetes from 10 countries (two from Africa, five from the Middle East, and three from South Asia). About 46% of the participants were Caucasian. An optimal HbA1c goal of <7% (53 mmol/mol) was reported in only 25.8% of the participants.[133]

In the Japan Epidemiology Collaboration on Occupational Health (J-ECOH) study which enrolled 3,070 adult employees of large manufacturing companies, optimal HbA1c, BP, and LDLC goals as recommended by the American Diabetes Association were noted in 44.9%, 76.6%, and 27.1% of participants, respectively. Only 11.2% of participants attained all three treatment goals.[134]

The burden of diabetes complications in Africa

Regarding studies on the burden of diabetes complications in Africa, there were few that investigated the prevalence of diabetic foot ulcers and peripheral arterial disease with diabetic retinopathy, peripheral nephropathy and neuropathy being the most studied. Diabetic peripheral neuropathy and retinopathy remain the most prevalent diabetes complication and diabetic foot ulcers the least prevalent.

With regards to the prevalence of diabetic foot ulcers, an earlier published systematic review and meta-analysis on the characteristics, prevalence, and outcomes of diabetic foot ulcers in Africa by Rigato et al reported a pooled prevalence of diabetic foot ulcers

of 13%, a finding close to what we observed (11%).[137] In another systematic review and meta-analysis on the prevalence of diabetic peripheral neuropathy in African populations with DM, Shiferaw et al reported a slightly higher overall prevalence of 46% compared to what we found in our study (38%), while including fewer studies (n=23).[138]

Similar to our study, considerable heterogeneity was also reported in the documented prevalence of the varied diabetes complications in Africa in most previously published systematic reviews. This may be due to variations in clinical definitions of diabetes complications in the studies. Burgess et al [139] and Achigbu et al[140], reported a wide disparity in the prevalence of diabetic retinopathy in the included studies of 7-62.4%, and 13-82.6%, respectively. Noubiap JJ et al in a systematic review on the burden of diabetic nephropathy in 2015 reported an overall prevalence of chronic kidney disease in patients with diabetes ranging between 11-83.7%.[141] Johnston LE et al in a systematic review that aimed to assess the epidemiological and clinical reports regarding PAD in SSA documented the prevalence of PAD in patients with diabetes as reported by three studies to range from 39% to 52%.[142]

Compared to Caucasian and Asian adult populations with type 2 diabetes, our study has demonstrated that adult African patients are disproportionately affected by complications of DM. The Joint Asia Diabetes Evaluation (JADE) program that undertook comprehensive risk assessments of 3,687 adult patients with type 2 DM recruited from seven Asian countries reported a prevalence of peripheral arterial disease, diabetic neuropathy, macro-and microalbuminuria, and diabetic retinopathy of 3.1%, 15%, 18.8%, and 20.4%, respectively.[143]

The National Health and Nutrition Examination Survey conducted from 1988–1994 and 1999–2018 in USA in 1,486 nonpregnant adults (aged ≥20 years) with newly

diagnosed diabetes (diagnosed within the past 2 years) also documented a low burden of most diabetes complications. Diabetic foot ulcers, peripheral arterial disease, diabetic retinopathy, neuropathy, and nephropathy (albuminuria) were prevalent in 6.3%, 9.2%, 12.1%, 14.5%, 18.7%, respectively.[144]

The documented low proportions of attainment of optimal diabetes treatment goals (optimal HbA1c, BP, and LDLC targets) in Africa is associated with an increased risk of onset and progression of diabetes complications, hence increasing morbidity and mortality in addition to causing a significant economic strain on the meager health resources. This generally observed low proportion of attainment of key diabetes treatment goals and high prevalence of diabetes complications, notably diabetic neuropathy, retinopathy, and nephropathy in Africa exists broadly due to challenges related to screening, diagnosis, and management of DM.

Awareness of diabetes in the general African population and healthcare practitioners remains very poor, resulting in delayed diagnosis of diabetes. The challenge of ready access to affordable essential diabetes medicines like insulin and statins and diagnostic tests or equipment like glucometers for home self-monitoring of glucose, HbA1c, and lipid profile tests remains highly prevalent in most African countries.[145-149]

Effective management of diabetes and its related cardiovascular risk factors like hypertension and dyslipidaemia in most healthcare settings in Africa also remains a significant clinical challenge.[3] Most healthcare facilities especially the lower-tier ones lack local or institution-specific comprehensive diabetes treatment guidelines to guide healthcare practitioners on how to optimally manage diabetes, in addition to the evident knowledge-practice gaps among healthcare practitioners.[2]

Healthcare systems in most African countries remain poorly structured to optimally manage most non-communicable diseases like diabetes along with an inadequately

funded health sector. Most African countries have not yet fulfilled the 2001 Abuja Declaration of allocating 15% of their national annual budget to the health sector.[2 150]

This systematic review and meta-analysis had its strengths and limitations. To our knowledge, it is the first to simultaneously investigate the status of attainment of the three key diabetes treatment goals and the burden of five common diabetes complications in an adult indigenous African population with type 2 diabetes. The systematic review and meta-analysis included a large number of studies that assessed the extent of attainment of diabetes treatment goals and the prevalence of diabetes complications based on recommendations or definitions by internationally recognised associations.

It also had its limitations. There was considerable heterogeneity in the included studies. This could be explained by the differences in study sites (tertiary vs low-tier hospitals or private vs public hospitals), patient characteristics (age, duration of diabetes, co-existing medical conditions), regions where the studies were conducted, and diagnostic modalities used to identify diabetes complications. The systematic review also excluded studies published in French which is the official language of some African countries. However, these were very few. There was evidence of publication bias in some of the included studies especially studies investigating the prevalence of diabetic nephropathy and peripheral neuropathy and the proportion of attainment of an optimal BP goal. About 23% of the included studies were moderate and low-quality on assessment using the NOS for cross-sectional studies.

CONCLUSION

Achievement of optimal diabetes treatment goals, especially HbA1c and BP, in adult African patients with type 2 diabetes remains low in Africa. Diabetes complications especially diabetic peripheral neuropathy and retinopathy also remain highly

prevalent. Implementation of universal diabetes screening and education initiatives coupled with improving knowledge about diabetes management among healthcare practitioners, and ready access to affordable essential diabetes diagnostic tests and medicines in Africa are integral in improving overall optimal diabetes care and reducing the burden of diabetes complications.

Considering the projected future increase in the prevalence of diabetes globally, especially in the African region, there is an urgent need to address glaring gaps in diabetes care and to develop simple and pragmatic interventions to improve treatment outcomes and reduce the burden of diabetes complications

Contributorship statement

DK and NC-Conceived the research idea, performed the preliminary screening of titles and abstracts to identify potentially eligible articles, and wrote the initial draft of the manuscript, DK, NC, IAB, SNL, IS (Sekitoleko), APK, SN- Retrieved full texts and identified the eligible articles, KK, SNL, APK, SN, PS, FB, LEM, WO, TDM, NEN, IS (Sabi)-extracted data from the identified eligible articles, DK and IS (Sekitoleko) performed the data analysis and interpretation, NC, KK, and SNL- performed the assessment of the quality of studies, KS, PCH, LB, JVM, RVC, JC- offered additional data interpretation and supervised this work. All the authors reviewed the different versions of the manuscript and read and approved the final draft of the manuscript.

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Conflict of interest statement

There are no competing interests for any author.

Ethical approval

This study involves human participants but was not approved by an Ethics Committee(s) or Institutional Board(s) because it is a systematic review and meta-analysis of published studies.

Data sharing

Data are available upon reasonable request.

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Table 1. General characteristics of all participants (n=63,890) included in the systematic review and meta-analysis

Characteristic	Cumulative value	Number of studies
Age in years (Mean ± SD)	54.9 ± 4.7	88
Gender- Females (%, 95% CI)	55.3, 95% CI 52.7-57.8	101
Smokers (%, 95% CI)	9.9, 95% CI 0.5-55.6	44
Participants on OHA (%, 95% CI)	65.0, 95% CI 34.0-96.6	51
Participants on insulin (%, 95% CI)	31.3, 95% CI 26.3-36.2	52
Participants on lipid lowering agents (%, 95% CI)	25.7, 95% CI 0.5-86.7	14
Participants on anti-hypertensive agents (%, 95% CI)	73.3, 95% CI 64.1-82.5	18
BMI in kg/m^2 (Mean ± SD)	27.9 ± 0.5	40
HbA1c in % (Mean ± SD)	9.0 ± 1.5	40
HbA1c in mmol/mol (Mean ± SD)	75.0 ± 1.5	40

BMI- Body mass index, HbA1c- Glycated haemoglobin, OHA- Oral hypoglycaemic agents, SD- Standard deviation

Table 2. Indicators of optimal glycated haemoglobin goal

Optimal glycated haemoglobin (HbA1c) goal (n= 34 studies): Pooled rate of attainment of optimal HbA1c goal = 27% (95% CI 24-30, I^2=94.7%, 95% CI 93.6-95.8), and I^2 after meta-regression-56.3%)
Attainment of the optimal HbA1c goal per region: Central: 20% (95% CI 16-23), Eastern: 23% (95% CI 15-34), Northern: 24% (95% CI 17-31), Southern: 31% (95% CI 28-34), and Western: 37% (95% CI 29-46)

First author & year	Country (ies)	Region of Africa	No of study participants	Mean age of participants	% of females	% with optimal HbA1c
Adentunji et al 2006	Nigeria	Western	50	------	------	52.0
Agboghoroma et al, 2020	Nigeria	Western	200	------	------	19.0
Akalu et al 2020	Ethiopia	Eastern	378	------	38.6	40.7
Amod et al 2012	South Africa	Southern	701	57.4	43.9	30.4
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	9.2
Ashur et al 2016	Libya	Northern	523	54.4	47.0	21.8
Attoye et al 2020	Nigeria	Western	260	------	------	34.6
Awadalla et al, 2017	Sudan	Northern	424	------	49.3	15.6
Balogun et al 2011	Nigeria	Western	40	59.4	62.5	52.5
Bentata et al, 2015	Morocco	Northern	637	58.5	62.3	30.1
Blum et al 2020	DRC	Central	319	------	33.5	14.1
Cairncross et al, 2017	South Africa	Southern	203	------	72.5	31.3
Camara et al 2015	Cameroon and Guinea Conakry	Central and Western	1267	58.0	61.0	26.0
Chadli et al. 2016	Morocco	Northern	498	58.0	62.4	26.8
Chamba et al 2017	Tanzania	Eastern	119	58.1	49.6	39.3
Chetoui et al 2019	Morocco	Northern	1456	56.2	73.4	33.7
Cohen DB et al 2010	Malawi	Southern	620	52.2	60.1	36.0
Diaf et al 2017	Algeria	Northern	210	55.6	65.0	51.4
Hall et al, 2017	Cameroon	Central	261	56.0	56.3	27.2
Iwuala et al 2015	Nigeria	Western	100	59.9	62.0	45.0
Kibirige et al 2017	Uganda	Eastern	425	------	67.0	26.5
Kimando et al 2017	Kenya	Eastern	385	62.1	65.5	39.5
Kisozi et al 2017	Uganda	Eastern	288	48.5	38.0	23.3
Mbwete et al., 2020	Tanzania	Eastern	161	63.9	67.1	49.7
Megallaa et al, 2019	Egypt	Northern	180	------	24.4	4.4
Molefe-Baikai et al, 2018	Botswana	Southern	289	50.7	66.1	29.4
Muddu et al. 2019	Uganda	Eastern	175	46.0	48.6	8.1
Muddu et al., 2016	Uganda	Eastern	202	46.0	49.5	8.4
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	19.2
Mwita et al 2019	Botswana	Southern	500	58.9	66.0	32.3
Noor et al., 2016	Sudan	Northern	387	------	49.6	15.0
Omar et al 2018	Sudan	Northern	339	54.8	69.9	28.1

Sobngwi et al 2011	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	2352	53.0	61.1	29.2
Uloko et al., 2012	Nigeria	Western	531	57.1	60.5	32.4

Table 3. Indicators of optimal blood pressure goal

Optimal blood pressure goal (n=26 studies): Pooled rate of attainment of optimal blood pressure goal = 38% (95% CI 30-46, I^2=98.7% 95% CI 98.6-99.0), and I^2 after meta-regression-95.4%)
Attainment of the optimal blood pressure goal per region: Western: 31% (95% CI 20-43), Eastern: 40% (95% CI 24-57), Southern: 40% (95% CI 26-55), Central: 41% (95% CI 38-45), and Northern: 42% (95% CI 24-61).

Author & year	Country (ies)	Region of Africa	No of study participants	Mean age of participants	% of females	% with optimal BP
Abdissa et al, 2020	Ethiopia	Eastern	229	------	40.4	31.0
Agboghoroma et al, 2020	Nigeria	Western	200	------	------	30.0
Akalu et al 2020	Ethiopia	Eastern	378	------	38.6	57.7
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	21.7
Awadalla et al, 2017	Sudan	Northern	424	------	49.3	60.1
Balogun et al 2011	Nigeria	Western	40	59.4	62.5	55.0
Chadli et al. 2016	Morocco	Northern	498	58.0	62.4	20.2
Chahbi et al, 2018	Morocco	Northern	300	------	93.0	32.6
Chisha et al 2017	Ethiopia	Eastern	270	------	48.9	85.9
Cohen DB et al 2010	Malawi	Southern	620	52.2	60.1	48.0
Hall et al, 2017	Cameroon	Central	261	56.0	56.3	43.0
Hayfron-Benjamin et al, 2019	Ghana	Western	206	52.9	68.9	37.9
Jingi et al, 2015	Cameroon	Central	407	54.2	41.8	40.4
Kahloun et al, 2014	Tunisia	Northern	2320	54.5	60.2	62.5
Kimando et al 2017	Kenya	Eastern	385	62.1	65.5	50.4
Lewis et al, 2018	Zambia	Southern	921	56.0	45.0	46.6
Lumu et al 2017	Uganda	Eastern	425	52.2	67.0	54.7
Magan et al, 2019	Uganda	Eastern	44	50.4	63.4	34.1
Megallaa et al, 2019	Egypt	Northern	180	------	24.4	37.8
Muddu et al., 2016	Uganda	Eastern	202	46.0	49.5	38.1
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	1.5
Mwita JC et al 2019	Botswana	Southern	500	58.9	66.0	54.2
Onakpoya et al, 2015	Nigeria	Western	133	------	48.1	24.1
Rotchford et al., 2002	South Africa	Southern	253	56.5	73.1	14.0
Sobngwi et al 2011	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	2352	53.0	61.1	21.0
Uloko et al., 2012	Nigeria	Western	531	57.1	60.5	17.0

Table 4. Indicators of optimal LDLC goal

Optimal LDLC goal (n= 11 studies)
Pooled rate of attainment of optimal LDLC goal = 42% (95% CI 32-52, I^2=97.4% 95% CI 96.5-98.1), and I^2 after meta-regression-92.1%)
Attainment of the optimal LDLC goal per region: Southern: 27% (95% CI 24-30), Eastern: 37% (95% CI 30-45), Western: 51% (95% CI 43-58), and Northern: 53% (95% CI 32-74).

Author & year	Country (ies)	Region of Africa	No of study participants	Mean age of participants	% of females	% with optimal LDLC
Agboghoroma et al, 2020	Nigeria	Western	200	------	------	50.5
Amour et al, 2019	Tanzania	Eastern	238	57.2	65.7	26.0
Awadalla et al, 2017	Sudan	Northern	424	------	49.3	47.4
Chadli et al. 2016	Morocco	Northern	498	58.0	62.4	38.6
Chamba et al 2017	Tanzania	Eastern	119	58.1	49.6	27.7
Elnasri et al. 2008	Sudan	Northern	250	52.0	62.0	84.8
Kisozi et al 2017	Uganda	Eastern	288	48.5	38.0	37.0
Lumu et al 2017	Uganda	Eastern	425	52.2	67.0	38.9
Megallaa et al, 2019	Egypt	Northern	180	------	24.4	37.8
Mwebaze et al 2014	Uganda	Eastern	146	53.9	48.6	48.6
Mwita et al 2019	Botswana	Southern	500	58.9	66.0	20.4

Table 5. Prevalence of diabetic nephropathy

Prevalence of diabetic nephropathy (n= 40 studies): Pooled prevalence= 31% (95% CI 22-41, I^2=99.3% 95% CI 99.2-99.4), and I^2 after meta-regression-95.6%).
Prevalence of diabetic nephropathy per region: Central: 22% (95% CI 9-39), Eastern: 25% (95% CI 10-43), Southern: 28% (95% CI 18-40), Northern: 38% (95% CI 14-65), and Western: 47% (95% CI 25-69)

Author & year	No of study participants	Country (ies)	Region of Africa	Mean age of participants	% of females	Prevalence of nephropathy, %
Abejew et al, 2015	216	Ethiopia	Eastern	45.0	42.6	2.2
Adeniyi et al, 2020	327	South Africa	Southern	------	70.3	24.5
Adentunji et al 2006	50	Nigeria	Western	------	------	83.0
Ahmed et al, 2017	316	Sudan	Northern	58.0	41.5	40.2
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	26.4
Alebiosu et al 2013	342	Nigeria	Western	53.4	------	28.4
Amour et al 2019	315	Tanzania	Eastern	57.2	65.7	72.2
Balogun et al 2011	40	Nigeria	Western	59.4	62.5	90.0
Bello et al, 2017	358	Nigeria	Western	57.8	61.7	53.4
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	77.2
Blum et al 2020	319	DRC	Central	------	33.5	38.6
Bouaziz et al 2012	73	Tunisia	Northern	59.3	------	11.0
Chahbi et al, 2018	300	Morocco	Northern	------	93.0	26.3
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	34.7
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	8.8
Dzudie et al 2012	420	Cameroon	Central	56.7	51.0	15.9
Efundem et al, 2017	162	Cameroon	Central	55.3	67.3	14.2
Eghan-Jr et al 2007	109	Ghana	Western	54.1	75.0	43.0
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	4.4
Gill et al 2008	105	Ethiopia	Eastern	41.0	30.0	51.0
Goro et al, 2019	208	Ethiopia	Eastern	54.8	47.1	26.0
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	32.0
Janmohamed at al 2013	369	Tanzania	Eastern	54.0	53.4	83.7
Kahloun et al, 2014	2320	Tunisia	Northern	------	60.2	3.4
Khalil et al 2019	506	Egypt	Northern	------	------	33.2
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	11.4
Machingura et al, 2017	260	Zimbabwe	Southern	57.6	72.7	45.4
Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	6.7
Megallaa et al, 2019	180	Egypt	Northern	------	24.4	86.1
Mohmad et al 2011	71	Sudan	Central	------	42.0	50.7

Molefe-Baikai et al, 2018	289	Botswana	Southern	50.7	66.1	44.6
Muddu et al. 2019	175	Uganda	Eastern	46.0	48.6	47.4
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46.0	7.5
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50.0	54.3
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	46.4
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53.0	61.1	2.4
Tesfaye et al 2015	247	Ethiopia	Eastern	------	40.5	6.5
Thinyane et al 2013	80	Lesotho	Southern	49.0	49.0	6.0
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	3.2
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	15.7

Table 6. Prevalence of diabetic peripheral neuropathy

Prevalence of diabetic peripheral neuropathy (n=36 studies): Pooled prevalence= 38% (95% CI 31-45, I^2=98.2% 95% CI 98.7-99.0), and I^2 after meta-regression-88%).
Prevalence of diabetic peripheral neuropathy per region: Central: 22% (95% CI 18-27), Eastern: 26% (95% CI 16-38), Northern: 45% (95% CI 30-61), Southern: 46% (95% CI 42-49), and Western: 61% (95% CI 45-75)

Author & year	No of study participants	Country (ies)	Region of Africa	Mean age of participants	% of females	Prevalence of neuropathy, %
Abejew et al, 2015	216	Ethiopia	Eastern	45.0	42.6	14.4
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	40.3
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50.0	29.3
Awadalla et al 2017	424	Sudan	Northern	------	49.3	68.2
Bello et al 2019	175	Nigeria	Western	59.8	57.7	41.7
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	39.6
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	44.0
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	46.4
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	10.6
Dzudie et al 2012	420	Cameroon	Central	56.7	51.0	22.4
Ede et al 2018	90	Nigeria	Western	58.6	34.4	83.3
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56.0	61.0	46.0
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	7.9
Gill et al 2008	105	Ethiopia	Eastern	41.0	30.0	41.0
Jarso et al 2011	384	Ethiopia	Eastern	------	54.1	77.0
Jember et al 2017	368	Ethiopia	Eastern	49.0	41.6	52.2
Kahloun et al, 2014	2320	Tunisia	Northern	------	60.2	18.7
Khalil et al 2019	506	Egypt	Northern	------	------	20.0
Kisozi et al 2017	288	Uganda	Eastern	48.5	38.0	29.4
Kuate-Tegueu et al 2016	321	Cameroon	Western	59.8	64.1	33.3
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	7.7
Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	43.3
Megallaa et al, 2019	180	Egypt	Northern	------	24.4	82.0
Miriam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	10.0
Mohmad et al 2011	71	Sudan	Central	------	42.0	69.0
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46.0	44.0
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50.0	69.6
Seyum et al 2010	429	Eritrea	Eastern	57.4	------	4.0
Smide et al 2009	145	Tanzania	Eastern	46.0	48.0	30.0

Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53.0	61.1	48.4
Tesfaye et al 2015	247	Ethiopia	Eastern	------	40.5	10.1
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	25.4
Ugoya et al 2006	180	Nigeria	Western	53.0	51.6	75.0
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	59.2
Vogt et al 2017	100	Zanzibar	Eastern	54.0	49.0	45.0
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	29.5

Table 7. Prevalence of diabetic retinopathy

Prevalence of diabetic retinopathy (n= 51 studies): Pooled prevalence= 32% (95% CI 28-36, I^2=98% 95% CI 97.8-98.3), and I^2 after meta-regression-88.5%).
Prevalence of diabetic retinopathy per region: Eastern: 23% (95% CI 19-28), Western: 27% (95% CI 19-36), Southern: 30% (95% CI 23-37), Central: 34% (95% CI 22-47), and Northern: 51% (95% CI 37-65).

Author &year	No of study participants	Country (ies)	Region of Africa	Mean age of participants	% of females	Prevalence of retinopathy, %
Abejew et al, 2015	216	Ethiopia	Eastern	45.0	42.6	28.9
Ahmed et al, 2017	316	Sudan	Northern	58.0	41.5	39.8
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	34.6
Assaad-Khalil et al 2019	506	Egypt	Northern	------	------	34.6
Awadalla et al 2017	424	Sudan	Northern	------	49.3	72.6
Bello et al 2019	175	Nigeria	Western	59.8	57.7	33.1
Bello et al, 2017	358	Nigeria	Western	57.8	61.7	20.1
Bentata et al, 2015	637	Morocco	Northern	58.5	62.3	35.6
Blake et al 2015	1307	Botswana	Southern	55.0	67.9	17.7
Bouaziz et al 2012	73	Tunisia	Northern	59.3		27.0
Burgress et al 2014	322	Malawi	Southern	55.2	64.6	50.1
Chahbi et al, 2018	300	Morocco	Northern	------	93.0	34.3
Chisha et al 2017	270	Ethiopia	Eastern	------	48.9	13.0
Cleland et al, 2015	5729	Tanzania	Eastern	60.8	60.3	27.9
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	34.7
Dzudie et al 2012	420	Cameroon	Central	56.7	51.0	15.7
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56.0	61.0	15.0
Elwali et al 2017	316	Sudan	Northern	58.7	40.8	82.6
Fasil, et al 2019	367	Ethiopia	Eastern	48.6	59.3	17.7
Gill et al 2008	105	Ethiopia	Eastern	41.0	30.0	21.0
Glover et al 2011	281	Malawi	Southern	56.4	72.8	32.5
Hall et al, 2017	261	Cameroon	Central	56.0	56.3	27.2
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	11.0
Jingi et al, 2014	407	Cameroon	Central	54.2	41.8	38.8
Jingi et al, 2015	407	Cameroon	Central	------	41.8	40.3
Kahloun et al, 2014	2320	Tunisia	Northern	------	60.2	26.3
Kizor-Akarairwe et al 2018	80	Nigeria	Western	61.2	48.8	32.1
Lartey et al, 2018	208	Ghana	Western	57.5	70.7	15.5
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	25.5
Lewis et al, 2018	921	Zambia	Southern	56.0	45.0	44.0
Magan et al, 2019	44	Uganda	Eastern	50.4	63.4	19.5

Makwero et al 2018	150	Lesotho	Southern	58.2	80.7	4.7
Megallaa et al, 2019	180	Egypt	Northern	------	24.4	90.0
Mohmad et al 2011	71	Sudan	Central	------	42.0	71.2
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46.0	14.0
Njikam et al, 2016	371	Cameroon	Central	59.2	54.7	49.9
Olamoyegun et al, 2015	90	Nigeria	Western	62.5	50.0	48.9
Onakpoya et al, 2015	133	Nigeria	Western		48.1	27.8
Pirie et al, 2014	292	South Africa	Southern	59.2	79.0	39.0
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	40.3
Seyum et al 2010	429	Eritrea	Eastern	57.4	------	33.0
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, and Central	53.0	61.1	18.3
Tesfaye et al 2015	247	Ethiopia	Eastern	------	40.5	11.7
Thinyane et al 2013	80	Lesotho	Southern	49.0	49.0	35.0
Thomas et al 2013	3978	South Africa	Southern	56.8	33.3	20.5
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	20.3
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	35.5
Webb et al 2016	599	South Arica	Southern	57.8	68.0	24.9
Woodward et al, 2020	91	Tanzania	Eastern	59.2	62.6	42.9
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	33.8

Table 8. Prevalence of diabetic foot ulcers

Prevalence of diabetic foot ulcers (n= 29 studies): Pooled prevalence= 11% (95% CI 9-14, I^2=97.4% 95% CI 96.9-97.8), and I^2 after meta-regression-1.4%)
Prevalence of diabetic foot ulcers per region: Southern: 7% (95% CI 5-11), Western: 8% (95% CI 6-10), Eastern: 10% (95% CI 8-12), and Northern: 21% (95% CI 4-48).

Author & year	No of study participants	Country (ies)	Region of Africa	Mean age of participants	% of females	Prevalence of foot ulcers, %
Abbas et al, 2002	627	Tanzania	Eastern	53.0	35.0	15.0
Abbas et al, 2011	11866	Tanzania	Eastern	------	------	12.0
Abdissa et al, 2020	229	Ethiopia	Eastern	------	40.4	12.7
Abejew et al, 2015	216	Ethiopia	Eastern	45.0	42.6	4.4
Albalawi et al 2020	159	Sudan	Northern	58.1	65.4	2.5
Amour et al 2019	315	Tanzania	Eastern	57.2	65.7	10.0
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50.0	6.1
Awadalla et al 2017	424	Sudan	Northern	------	49.3	12.7
Chalya et al, 2011 105	136	Tanzania	Eastern	54.3	45.6	3.2
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	15.0
Deribe et al, 2014	216	Ethiopia	Eastern	50.7	40.3	14.8
Ekoru K et al. 2019	2784	Nigeria, Ghana, Kenya	Western and Eastern	56.0	61.0	5.0
Elwali et al 2017	316	Sudan	Northern	58.7	40.8	17.7
Gebrekirstos et al, 2015	228	Ethiopia	Eastern	------	38.0	12.0
Lebeta et al, 2017	344	Ethiopia	Eastern	40.5	42.7	21.2
Mamo et al, 2015	200	Ethiopia	Eastern	50.0	72.5	15.0
Mariam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	13.6
Megallaa et al, 2019	180	Egypt	Northern	------	24.4	86.7
Neuhann et al 2001	474	Tanzania	Eastern	53.8	46.0	10.0
Nyamu et al, 2003	1788	Kenya	Eastern	56.9	------	4.6
Rotchford et al., 2002	253	South Africa	Southern	56.5	73.1	6.0
Seyum et al 2010	429	Eritrea	Eastern	57.4	------	14.0
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53.0	61.1	11.7

Tesfaye et al 2015	247	Ethiopia	Eastern	------	40.5	0.4
Thinyane et al 2013	80	Lesotho	Southern	49.0	49.0	14.0
Tilahun et al, 2017	236	Ethiopia	Eastern	47.8	46.6	8.5
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	3.8
Unachukwu et al, 2006	315	Nigeria	Western	54.6	36.7	19.1
Worku et al 2010	305	Ethiopia	Eastern	44.4	37.1	4.6

Table 9. Prevalence of peripheral arterial disease

Prevalence of peripheral arterial disease (PAD) (n= 18 studies): Pooled prevalence= 19% (95% CI 12-25, I^2=98.1% 95% CI 97.6-98.4), and I^2 after meta-regression-70.9%). **Prevalence of PAD per region:** Southern: 8% (95% CI 6-10), Northern: 15% (95% CI 4-29), Eastern: 18% (95% CI 11-27), and Western: 29% (95% CI 13-48)						
Author & year	**No of study participants**	**Country (ies)**	**Region of Africa**	**Mean age of participants**	**% of females**	**Prevalence of PAD, %**
Agboghoroma et al, 2020	200	Nigeria	Western	------	------	38.5
Akalu et al, 2020	280	Ethiopia	Eastern	------	38.6	30.7
Assaad-Khalil et al 2014	958	Egypt	Northern	57.3	50.0	11.0
Chahbi et al, 2018	300	Morocco	Northern	------	93.0	2.7
Chiwanga et al, 2015	404	Tanzania	Eastern	53.6	55.4	15.0
Cohen et al 2010	620	Malawi	Southern	52.2	60.1	7.6
Gill et al 2008	105	Ethiopia	Eastern	41.0	30.0	6.0
Hayfron-Benjamin et al, 2019	206	Ghana	Western	52.9	68.9	11.2
Khalil et al 2019	506	Egypt	Northern	------	------	32.6
Mariam et al, 2017	279	Ethiopia	Eastern	48.8	44.8	9.7
Megallaa et al, 2019	180	Egypt	Northern	------	24.4	20.0
Mwebaze et al 2014	146	Uganda	Eastern	53.9	48.6	39.0
Ogbera et al 2015	225	Nigeria	Western	61.4	57.0	40.0
Okello et al 2014	229	Uganda	Eastern	60.0	63.7	24.0
Oyelade et al 2012	219	Nigeria	Western	------	58.9	52.5
Smide et al 2008	145	Tanzania	Eastern	46.0	48.0	13.0
Sobngwi et al 2011	2352	Tanzania, Kenya, Cameroon, Ghana, Senegal, and Nigeria	Eastern, Western, Central	53.0	61.1	4.7
Uloko et al, 2012	531	Nigeria	Western	57.1	60.5	10.7

Figures caption

Figure 1: PRISMA flow diagram of selection of eligible studies

Figure 2: Forest plot summarising studies on the proportion of attainment of an optimal low-density lipoprotein cholesterol goal in percentage

Figure 3: Forest plot summarising studies on the proportion of attainment of an optimal blood pressure goal in percentage

Figure 4: Forest plot summarising studies on the proportion of attainment of an optimal glycated haemoglobin goal in percentage

Figure 5: Forest plot summarising studies on the prevalence of diabetic retinopathy

Figure 6: Forest plot summarising studies on the prevalence of diabetic foot ulcers

Figure 7: Forest plot summarising studies on the prevalence of diabetic nephropathy

Figure 8: Forest plot summarising studies on the prevalence of diabetic neuropathy

Figure 9: Forest plot summarising studies on the prevalence of peripheral arterial disease

Supplementary figure 1: Funnel plot for studies investigating prevalence of diabetic nephropathy

Supplementary figure 2: Funnel plot for studies investigating prevalence of diabetic neuropathy

Supplementary figure 3: Funnel plot for studies investigating prevalence of peripheral arterial disease

Supplementary figure 4: Funnel plot for studies investigating prevalence of diabetic retinopathy

Supplementary figure 5: Funnel plot for studies investigating prevalence of diabetic foot ulcers

Supplementary figure 6: Funnel plot for studies investigating rate of attainment of an optimal HbA1c goal

Supplementary figure 7: Funnel plot for studies investigating rate of attainment of an optimal BP goal

Supplementary figure 8: Funnel plot for studies investigating rate of attainment of an optimal LDLC goal

Figure 1. PRISMA flow diagram of selection of eligible studies

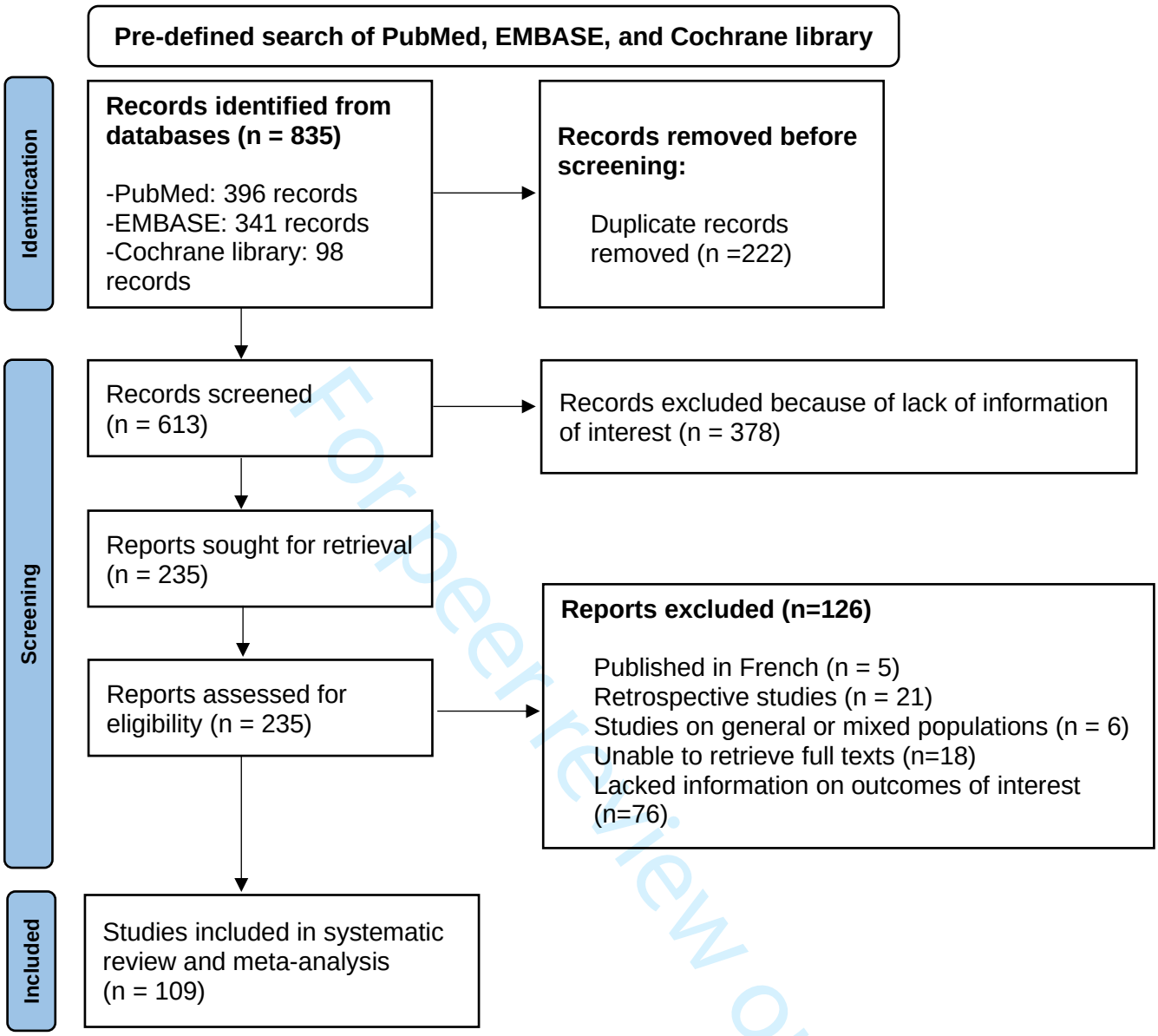
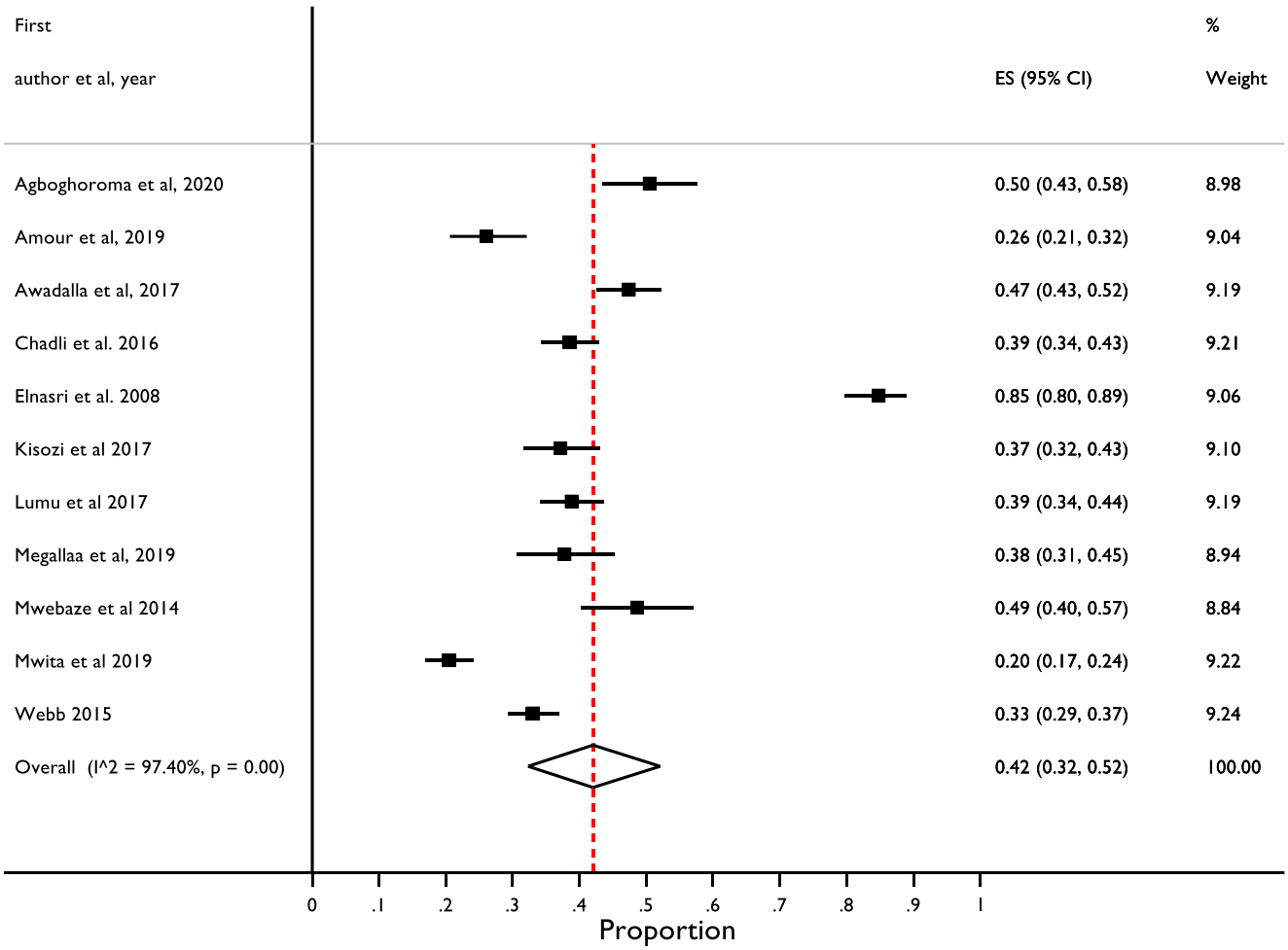
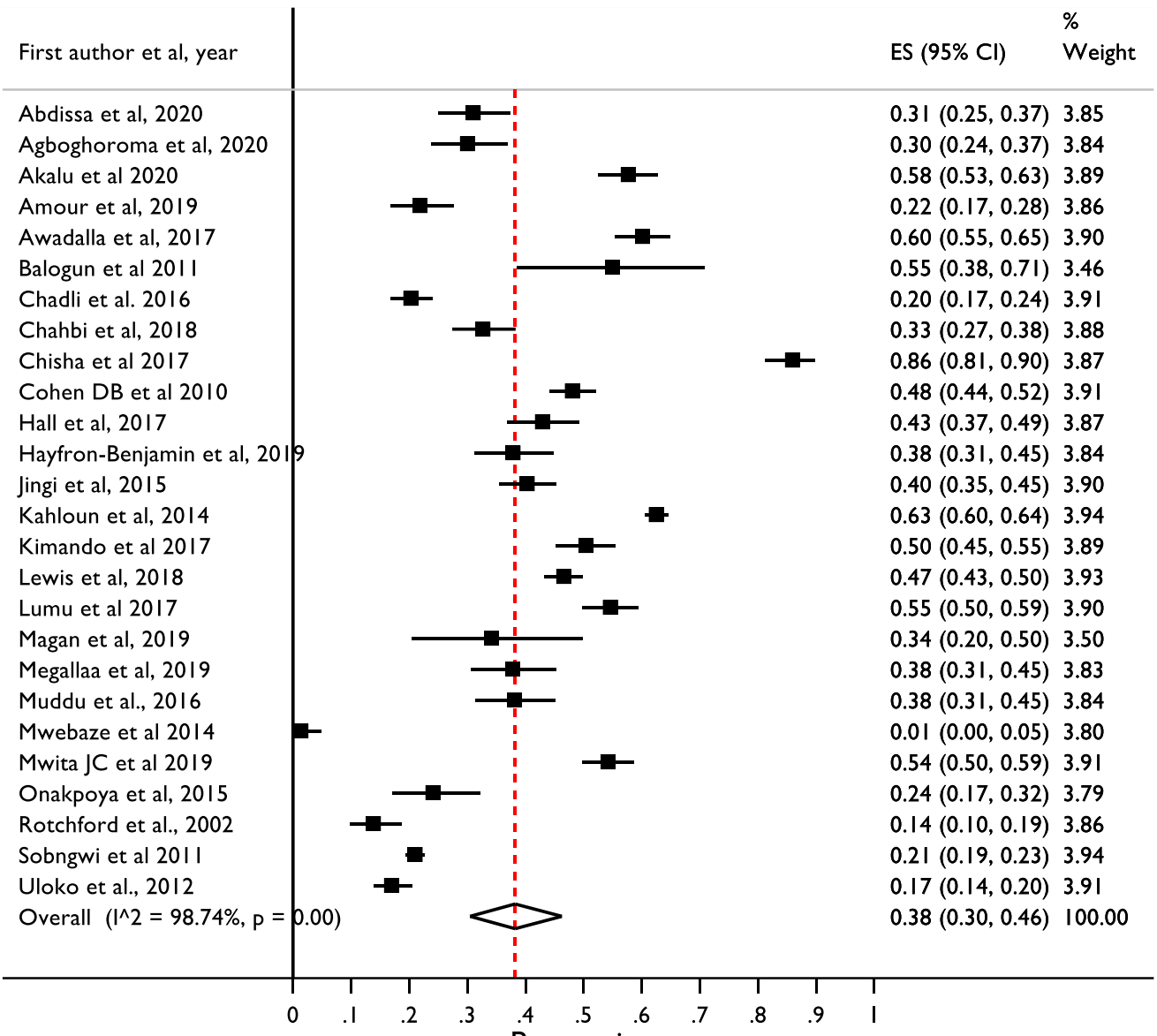


Figure 2. Forest plot summarising studies on the proportion of attainment of an optimal low-density lipoprotein cholesterol goal in percentage



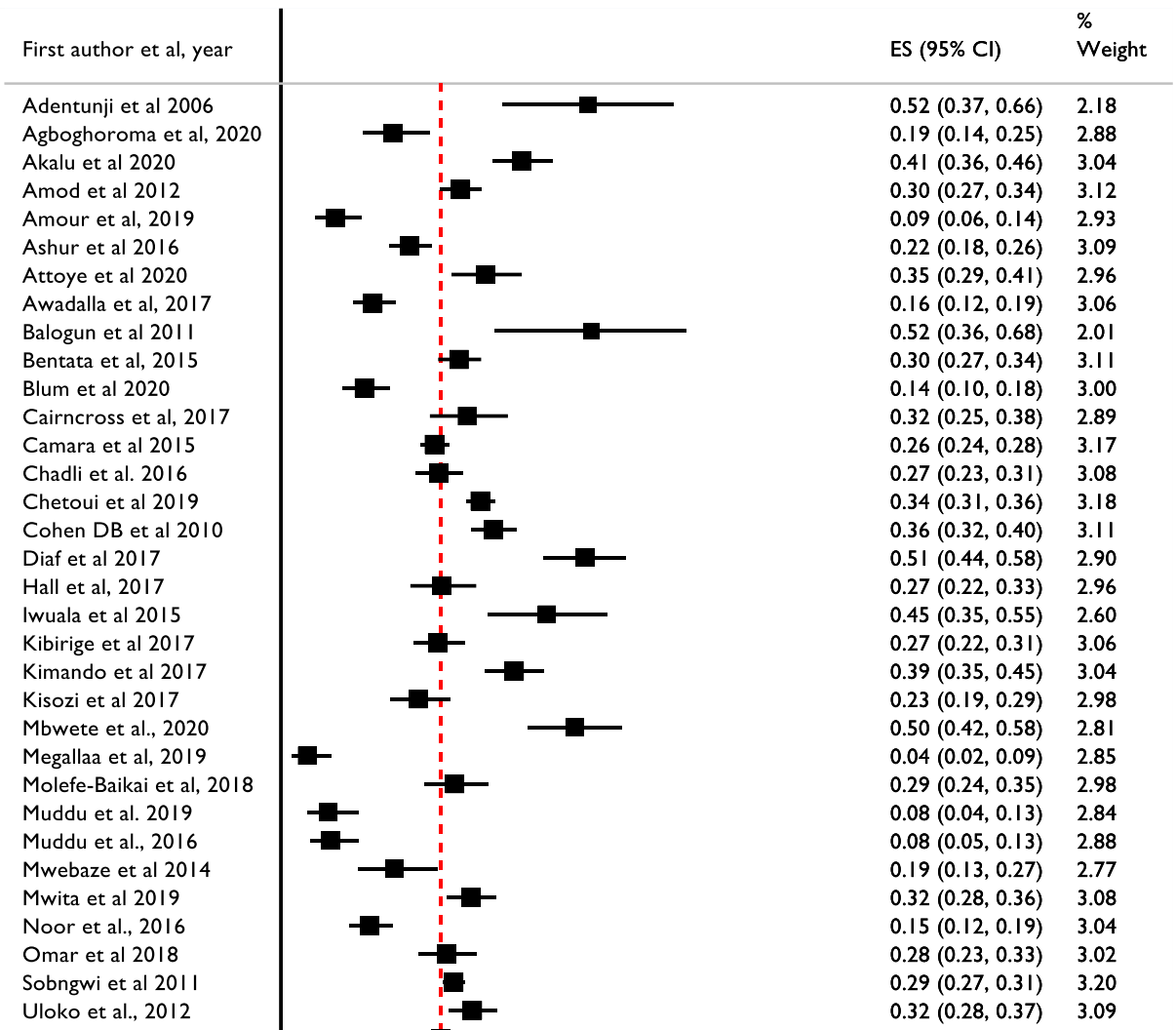
ES= Effect size

Figure 3. Forest plot summarising studies on the proportion of attainment of an optimal blood pressure goal in percentage



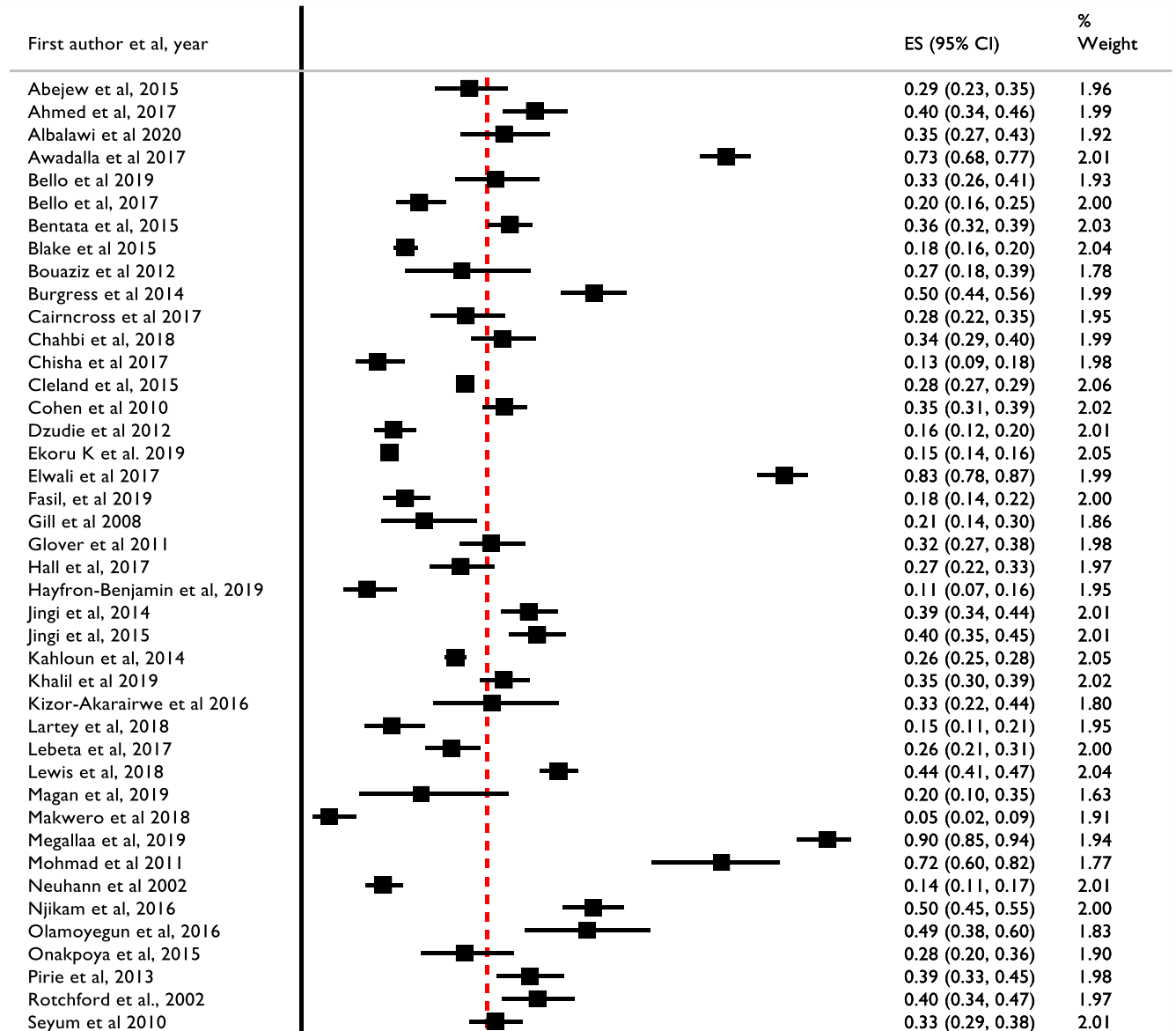
ES= Effect size

Figure 4. Forest plot summarising studies on the proportion of attainment of an optimal glycated haemoglobin in percentage



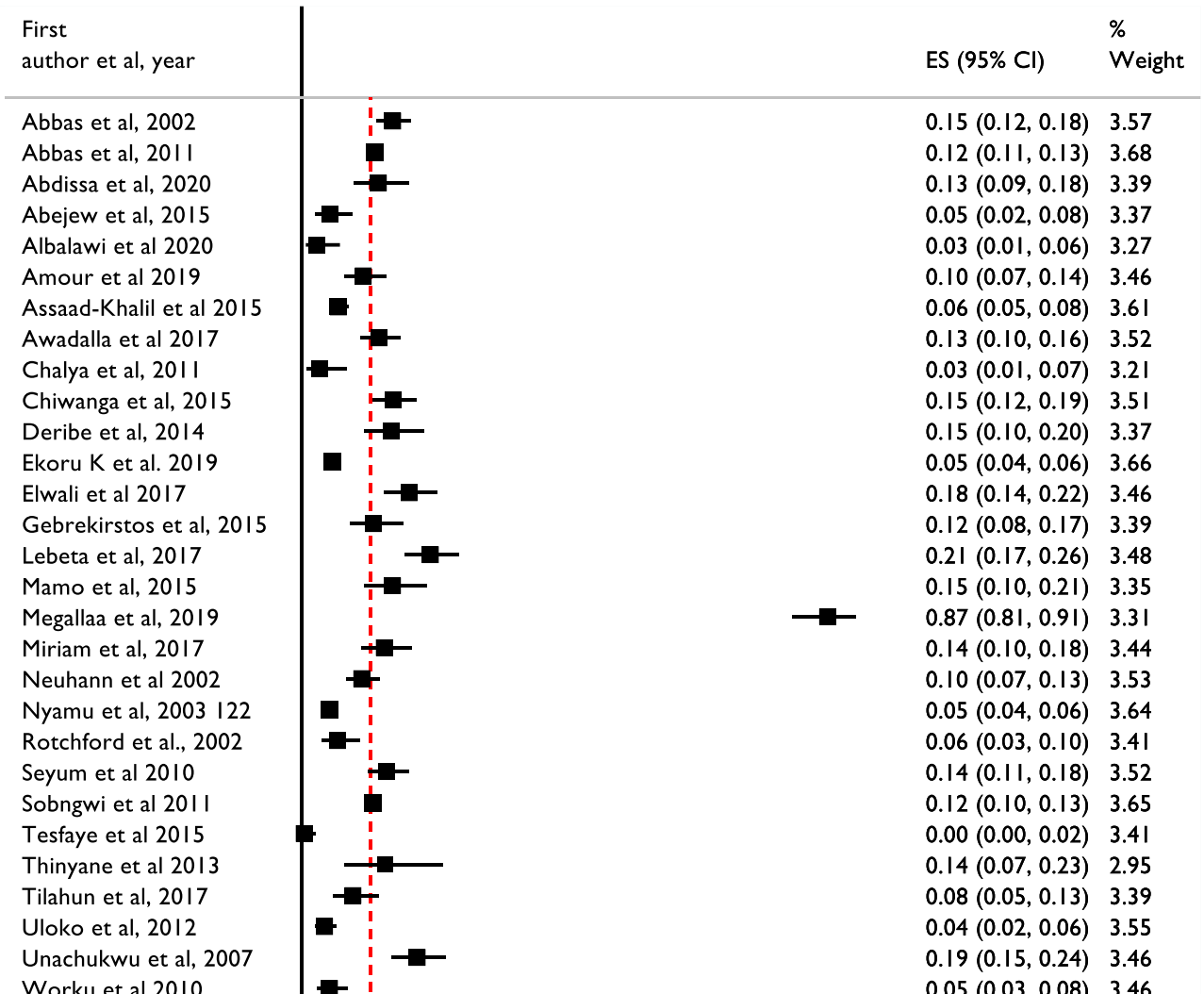
ES= Effect size

Figure 5. Forest plot summarising studies on the prevalence of diabetic retinopathy



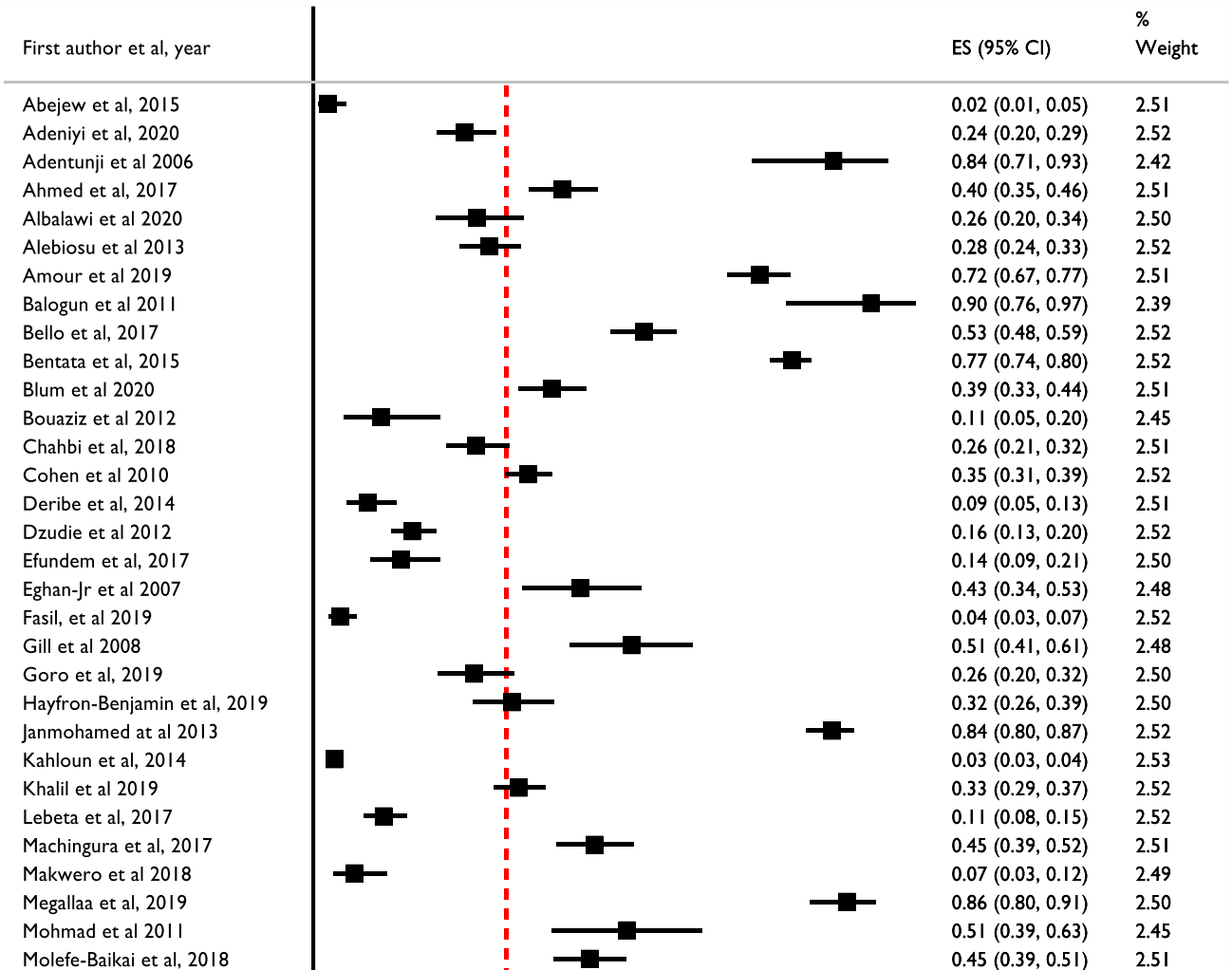
ES= Effect size

Figure 6. Forest plot summarising studies on the prevalence of diabetic foot ulcers



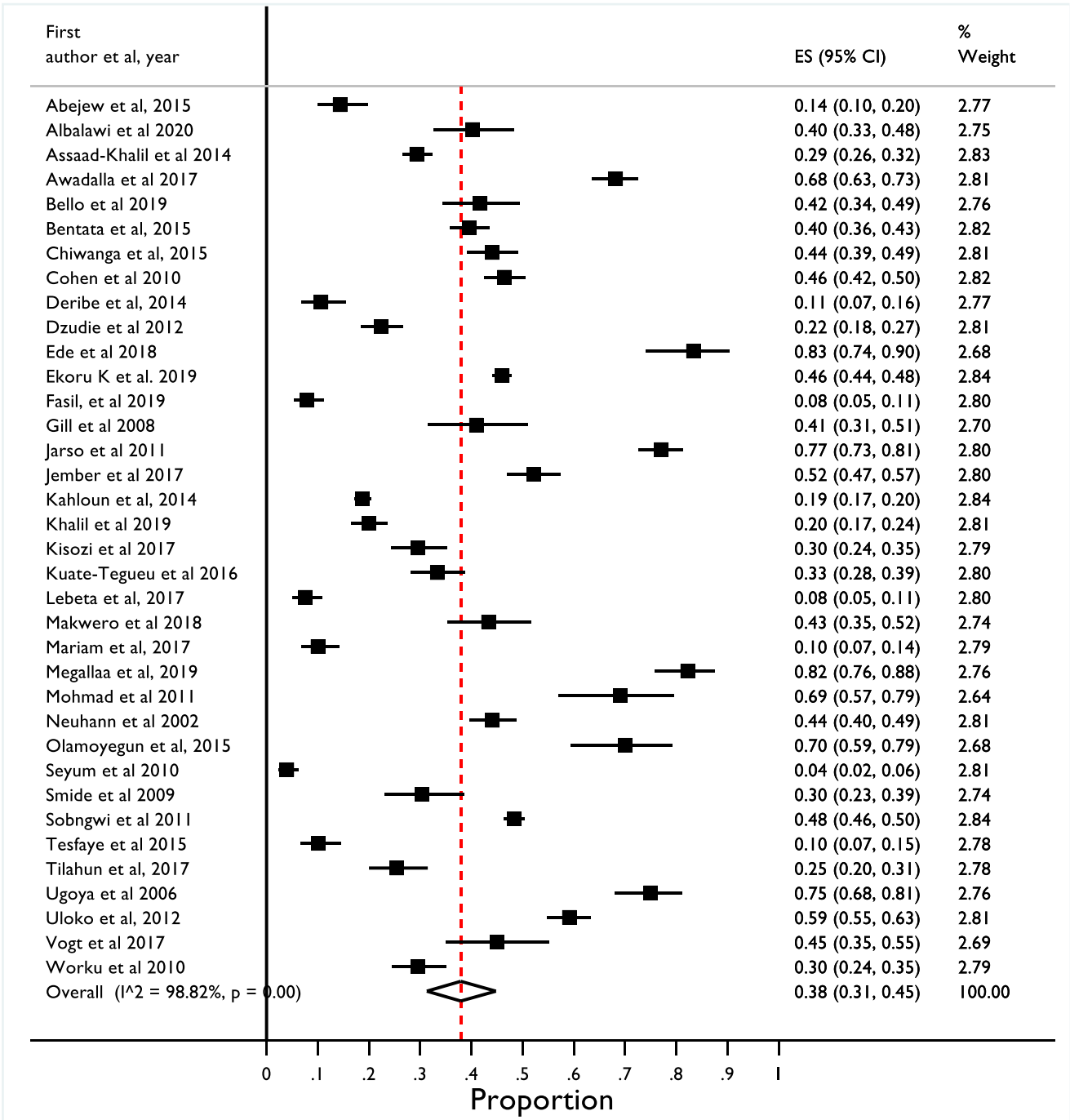
ES= Effect size

Figure 7. Forest plot summarising studies on the prevalence of diabetic nephropathy



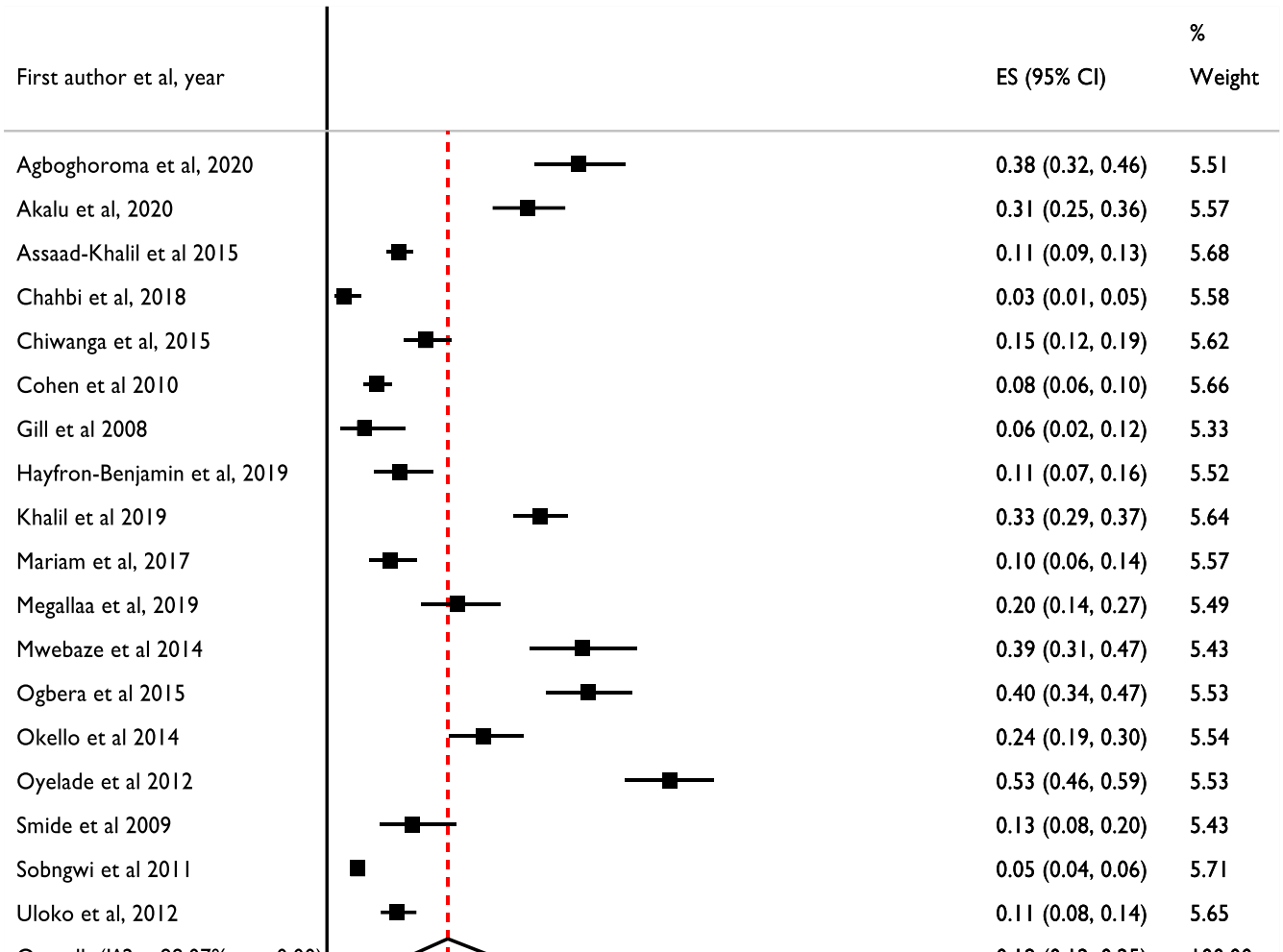
ES= Effect size

Figure 8. Forest plot summarising studies on the prevalence of diabetic peripheral neuropathy



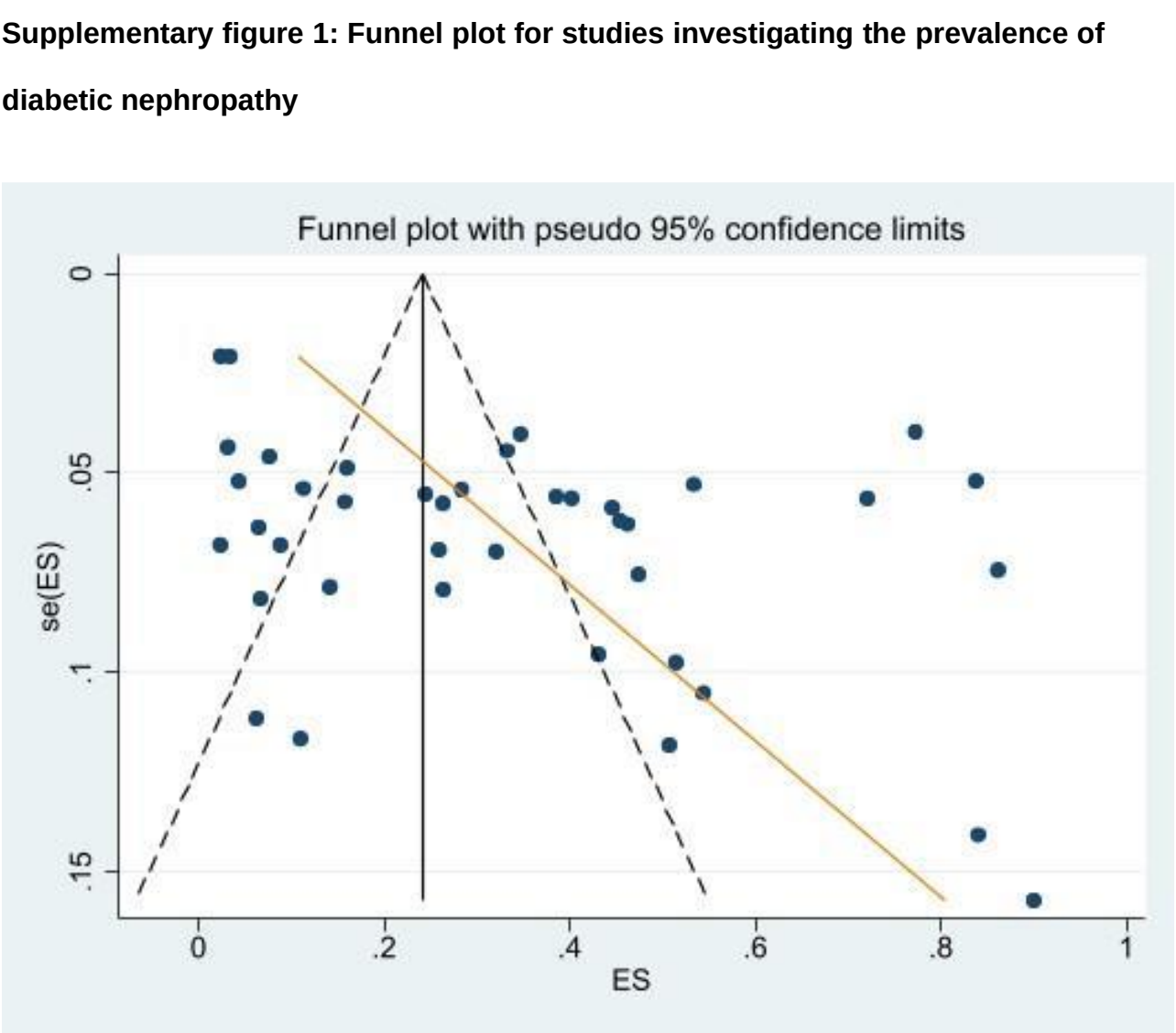
ES= Effect size

Figure 9. Forest plot summarising studies on the prevalence of peripheral arterial disease

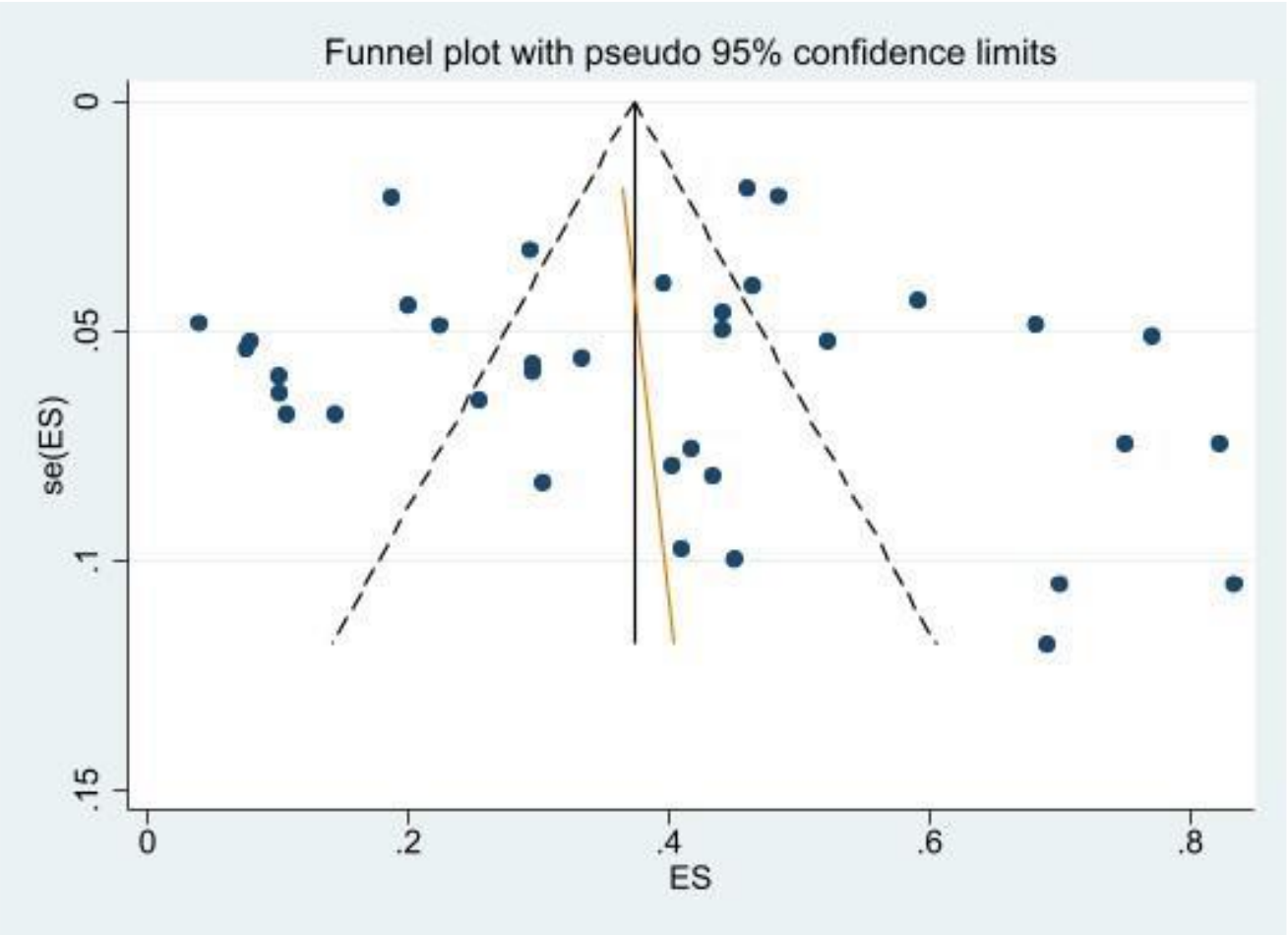


ES= Effect size

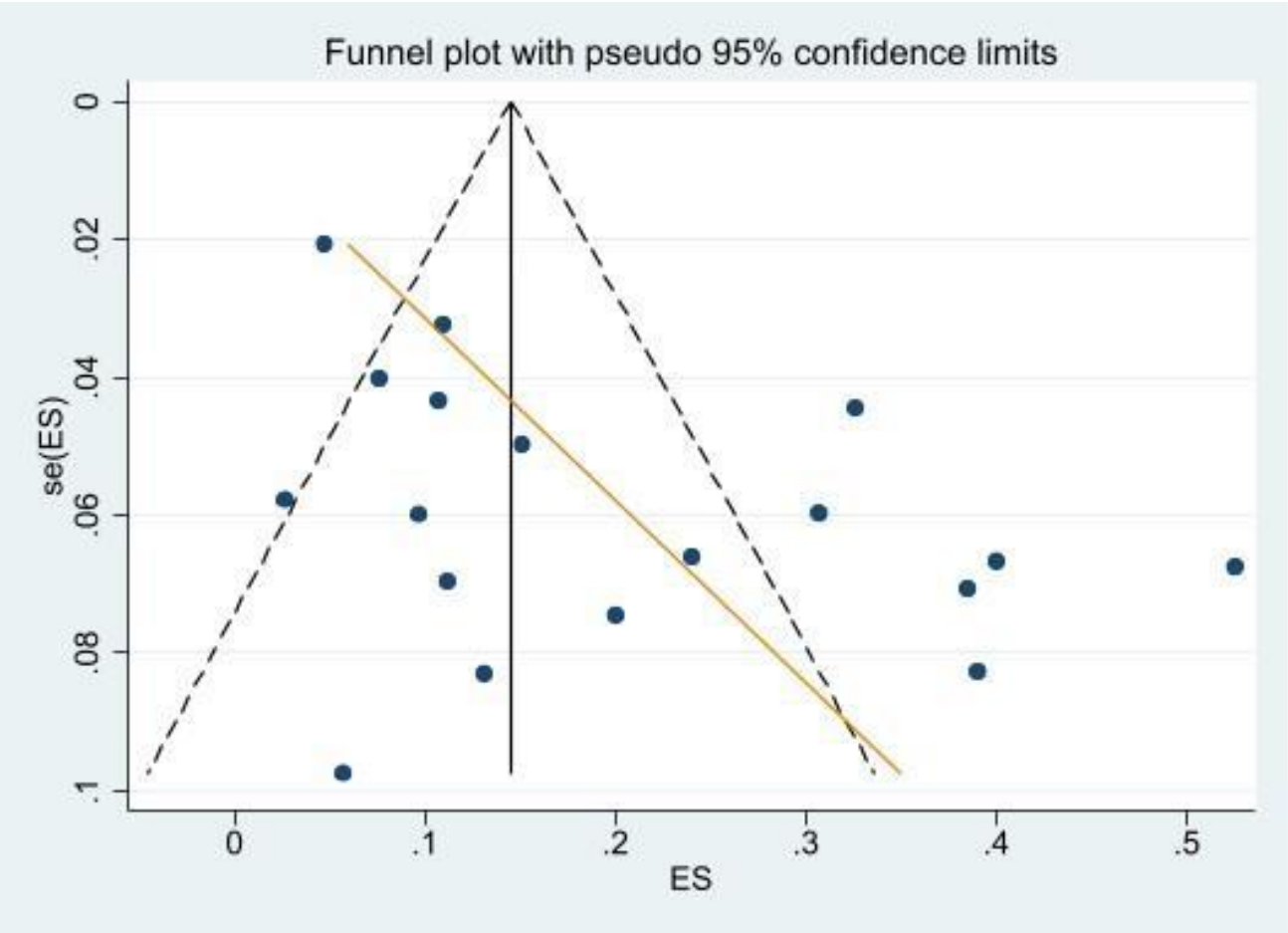
Supplementary figure 1: Funnel plot for studies investigating the prevalence of diabetic nephropathy



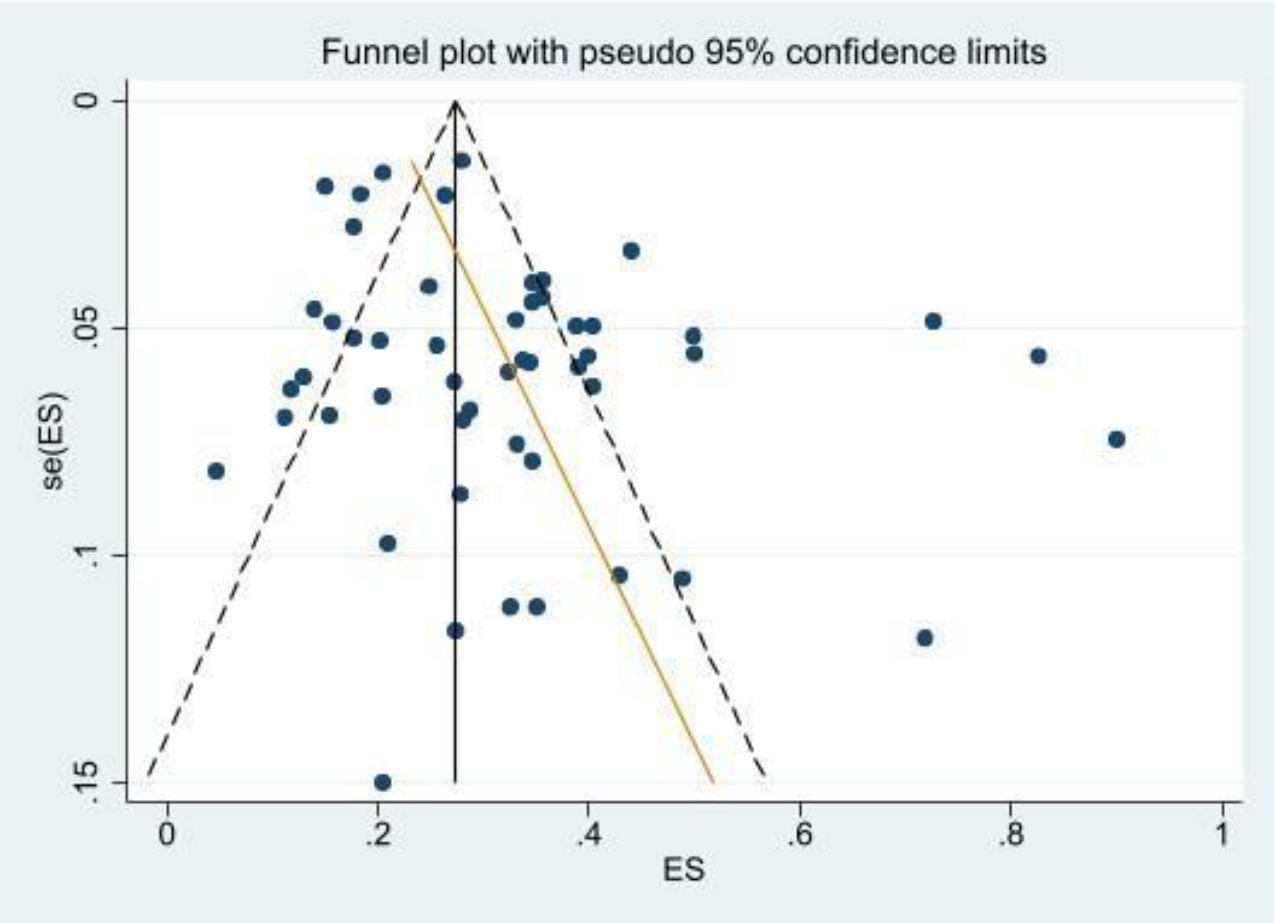
Supplementary figure 2: Funnel plot for studies investigating the prevalence of diabetic neuropathy



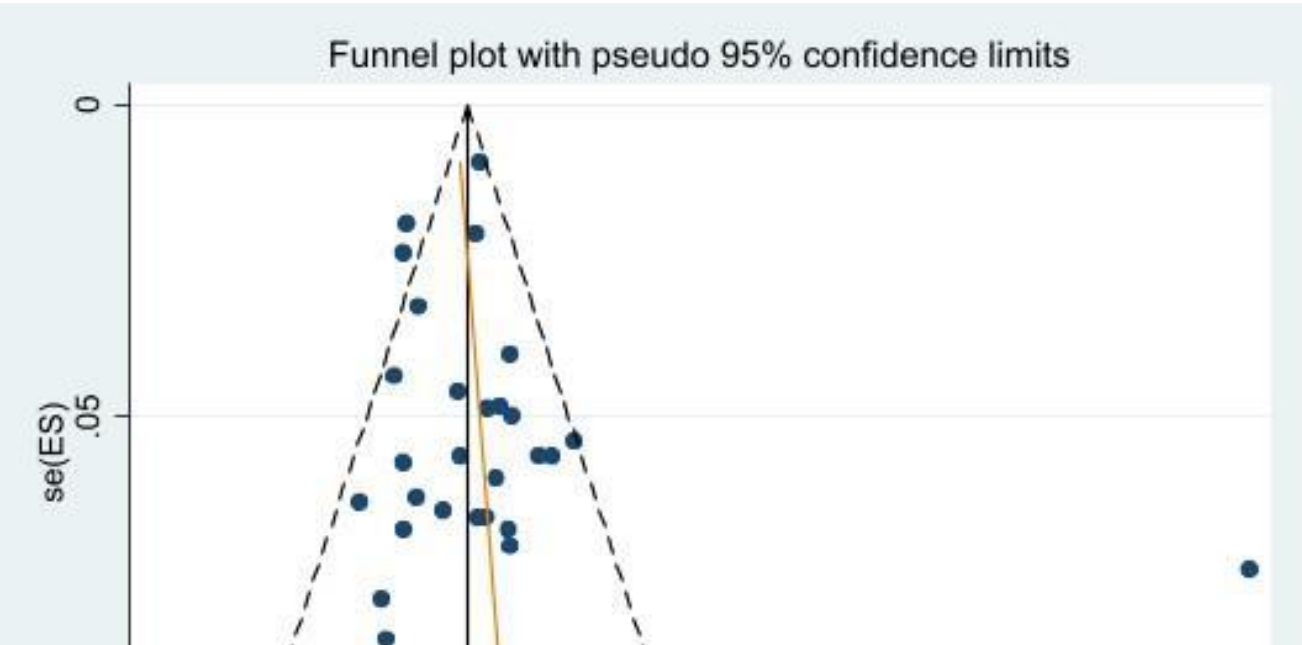
Supplementary figure 3: Funnel plot for studies investigating the prevalence of peripheral arterial disease



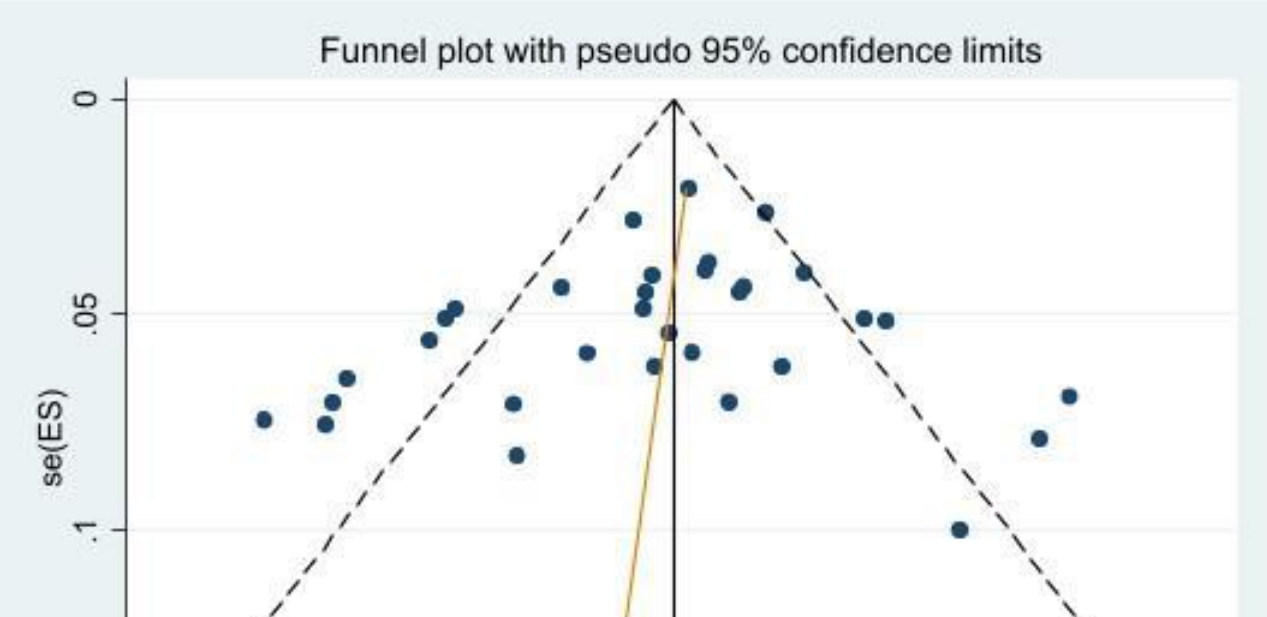
Supplementary figure 4: Funnel plot for studies investigating the prevalence of diabetic retinopathy



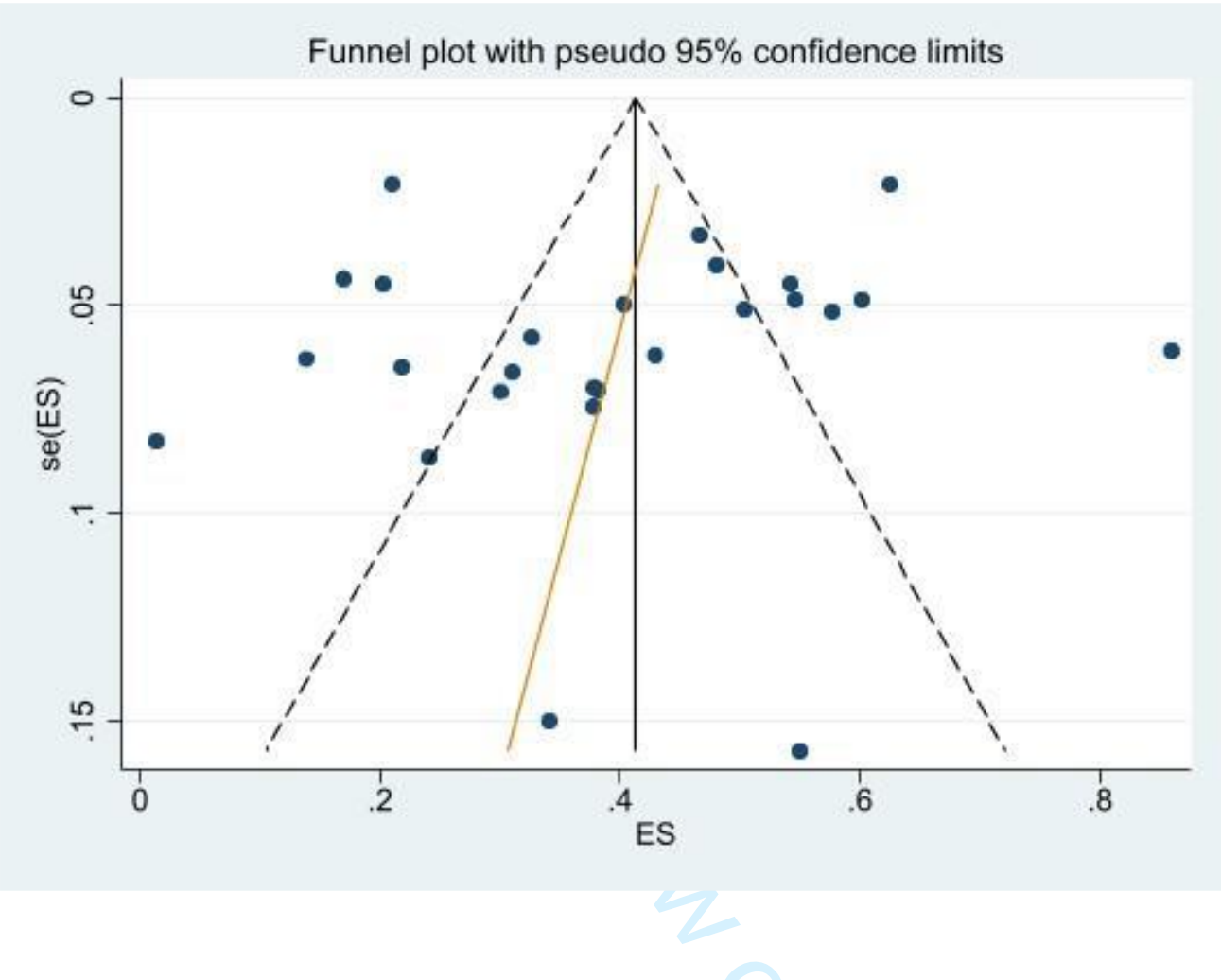
Supplementary figure 5: Funnel plot for studies investigating the prevalence of diabetic foot ulcers



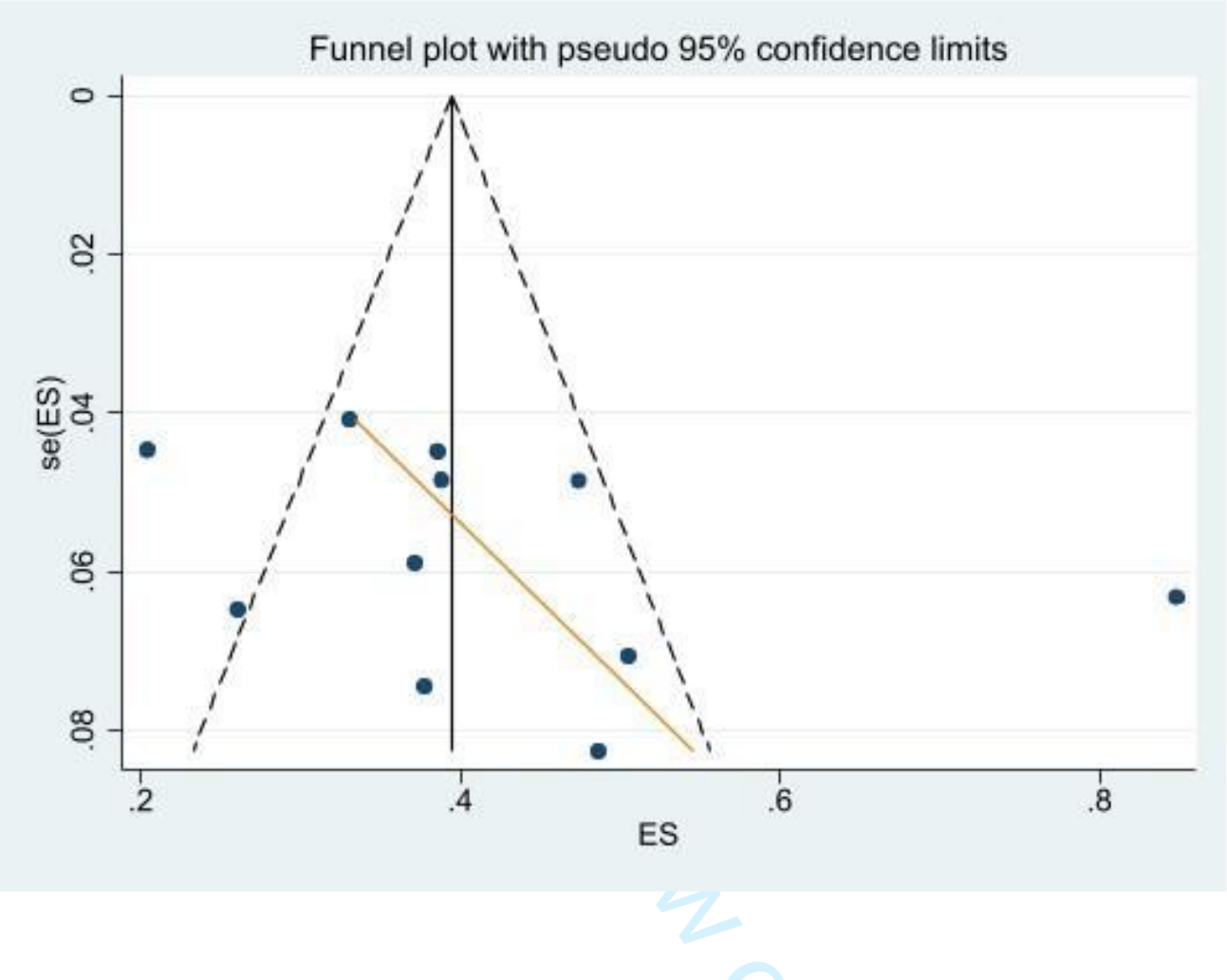
Supplementary figure 6: Funnel plot for studies investigating the rate of attainment of an optimal HbA1c goal



Supplementary figure 7: Funnel plot for studies investigating the rate of attainment of an optimal BP goal



Supplementary figure 8: Funnel plot for studies investigating the rate of attainment of an optimal LDLC goal



Supplementary table 1. PRISMA checklist for the systematic review and meta-analysis

Section and Topic	Item #	Checklist item	Page where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	5-6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	8
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6-7
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	7-8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	9-10
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	9-10
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	10
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	10
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	10-11

Section and Topic	Item #	Checklist item	Page where item is reported
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	10-11
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	10
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	10-11
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	10-11
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	11
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	11
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	11
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	11-12
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	12
Study characteristics	17	Cite each included study and present its characteristics.	12
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	13-14
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	14-17
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	13-14
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	14-17
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	12
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	17
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	13
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	13
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	17-21
	23b	Discuss any limitations of the evidence included in the review.	21

Section and Topic	Item #	Checklist item	Page where item is reported
	23c	Discuss any limitations of the review processes used.	21
	23d	Discuss implications of the results for practice, policy, and future research.	22
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	A protocol was not prepared
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Search period was changed from September 2020 to December 2020
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	22-23
Competing interests	26	Declare any competing interests of review authors.	23
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	23

Supplementary table 2. Criteria for the adapted Newcastle-Ottawa Scale regarding star allocation to assess quality of included studies

	Selection				Comparability	Outcome		
Study details (Author et al, year)	**Representativeness of sample (⋆)**	**Sample size (⋆)**	**Non respondents (⋆)**	**Ascertainment of exposure (*)**	**(⋆⋆)**	**Assessment of outcome (⋆)**	**Statistical test (⋆)**	**Total (8*)**
Mariam et al, 2017	*	*	*	*	**	*	*	8
Okello et al, 2014	*	*	*	*	**	*	*	8
Amour et al, 2019	*	*	*	*	**	*	*	8
Abdissa et al, 2019	*	*	*	*	**	*	*	8
Fasil et al, 2019	*	*	*	*	**	*	*	8
Jember et al,2017	*	*	*	*	**	*	*	8
Chisha et al, 2017	*	*	*	*	**	*	*	8
Deribe et al, 2014	*	*	*	*	**	*	*	8
Seyum et al, 2008	*	*	*	*	**	*	*	8
Muddu et al,2019	*	*	*	*	**	*	*	8
Mamo et al., 2015	*	*	*	*	**	*	*	8
Muddu et al., 2019	*	*	*	*	**	*	*	8
Blake et al., 2015	*	*	*	*	**	*	*	8
Bello et al., 2019	*	*	*	*	**	*	*	8
Elnasri et al., 2008	*	*	*	*	**	*	*	8
Iwuala et al., 2015	*	*	*	*	**	*	*	8
Chadli et al., 2016	*	*	*	*	**	*	*	8
Jingi et al., 2014	*	*	*	*	**	*	*	8
Hall et al., 2017	*	*	*	*	**	*	*	8
Efundem et al., 2017	*	*	*	*	**	*	*	8
Attoye et al., 2020	*	*	*	*	**	*	*	8
Chetoui et al., 2020	*	*	*	*	**	*	*	8
Diaf et al., 2017	*	*	*	*	**	*	*	8
Elwali et al., 2017	*	*	*	*	**	*	*	8
Kahloun et al., 2014	*	*	*	*	**	*	*	8
Noor et al., 2017	*	*	*	*	**	*	*	8
Bello et al., 2017	*	*	*	*	**	*	*	8
Uloko et al., 2012	*	*	*	*	**	*	*	8
Ede et al., 2018	*	*	*	*	**	*	*	8

Hayfron-Benjamin et al., 2019	*	*	*	*	**	*	8
Kizor-Akaraiwe et al., 2016	*	*	*	*	**	*	8
Ogbera et al., 2015	*	*	*	*	**	*	8
Olamoyegun et al., 2015	*	*	*	*	**	*	8
Oyelade et al., 2012	*	*	*	*	**	*	8
Ugoya et al., 2006	*	*	*	*	**	*	8
Ahmed et al., 2017	*	*	*	*	**	*	8
Albalawi et al., 2020	*	*	*	*	**	*	8
Ashur et al., 2016	*	*	*	*	**	*	8
Blum et al., 2020	*	*	*	*	**	*	8
Burgess et al., 2014	*	*	*	*	**	*	8
Glover et al., 2012	*	*	*	*	**	*	8
Lewis et al., 2018	*	*	*	*	**	*	8
Machingura et al., 2017	*	*	*	*	**	*	8
Molefe-Baikai et al., 2018	*	*	*	*	**	*	8
Mwita et al., 2019	*	*	*	*	**	*	8
Pirie et al., 2014	*	*	*	*	**	*	8
Rotchford et al., 2002	*	*	*	*	**	*	8
Thomas et al., 2013	*	*	*	*	**	*	8
Webb et al., 2015	*	*	*	*	**	*	8
Omar et al., 2018	*	*	*	*	**	*	8
Adeniyi et al., 2020	*	*	*	*	**	*	8
Assaad-Khalil et al., 2015	*	*	*	*	**	*	8
Khalil et al., 2019	*	*	*	*	**	*	8
Awadalla et al., 2017	*	*	*	*	**	*	8
Bentata et al., 2015	*	*	*	*	**	*	8
Bouaziz et al., 2012	*	*	*	*	**	*	8
Jingi et al., 2015	*	*	*	*	**	*	8

Chahbi et al., 2018	*	*	*	*	**	*	*	8
Adetunji et al., 2006	*	*	*	*	**	*	*	8
Jarso et al., 2011	*	*	*	*	**	*	*	8
Janmohamed et al, 2013	*	*	*	*	*	*	*	7
Chalya et al, 2011	*	*	*	*	*	*	*	7
Goro et al, 2019	*	*	*	*	*	*	*	7
Muddu et al, 2016	*	*	-	*	**	*	*	7
Kisozi et al, 2017	*	*	*	*	*	*	*	7
Akalu et al, 2020	*	*	*	*	*	*	*	7
Lumu et al, 2017	*	*	*	*	*	*	*	7
Chamba et al, 2017	*	*	-	*	**	*	*	7
Smide et al, 2008	*	-	*	*	**	*	*	7
Sobngwi et al 2011	*	-	*	*	**	*	*	7
Camara et al, 2014	*	-	*	*	**	*	*	7
Ekoru et al,2019	*	-	*	*	**	*	*	7
Mwebaze et al, 2014	*	*	*	*	*	*	*	7
Agboghoroma et al,2020	*	*	*	*	*	*	*	7
Kimando et al, 2017	*	*	-	*	**	*	*	7
Clealand et al, 2015	*	*	*	*	*	*	*	7
Njikam et al., 2016	*	*	-	*	**	*	*	7
Dzudie et al., 2012	*	*	*	-	**	*	-	7
Alebiosu et al., 2003	*	*	-	*	**	*	*	7
Kuate-Tegueu et al., 2015	*	*	-	*	**	*	*	7
Mohmad et al., 2011	*	*	-	*	**	*	*	7
Cohen et al., 2010	*	*	-	*	**	*	*	7
Makwero et al., 2018	*	*	-	*	**	*	*	7
Onakpoya et al., 2016	*	-	-	*	**	*	*	7
Lebeta et al, 2016	*	*	*	*	-	*	*	6
Kibirige et al, 2017	*	-	-	*	**	*	*	6
Mbwete et al, 2020	*	-	*	*	*	*	*	6
Tiahun et al,2017	*	*	*	*	-	*	*	6

Chiwanga et al, 2015	*	-	*	*	*	*	*	6
Lumu et al, 2017	*	-		*	**	*	*	6
Balogu et al., 2011	*	-	-	*	**	*	*	6
Megallaa et al., 2019	*	*	*	*	-	*	*	6
Eghan et al., 2007	*	*	-	-	**	*	*	6
Unachukwu et al., 2007	*	-	-	*	**	*	*	6
Abejew et al, 2015	*	*	-	*	-	*	*	5
Nyamu et al, 2003	*	-	*	*	-	*	*	5
Gulam-Abbas et al, 2002	*	-	*	*	-	*	*	5
Abbas et al, 2011	*	*	*	*	-	*	-	5
Gill et al, 2008	*	*	*	*	-	*	-	5
Cairncross et al., 2017	-	-	-	*	**	*	*	5
Amod et al., 2012	*	*	*	-	-	*	*	5
Vogt et al, 2017	*	-	-	*	-	*	*	4
Worku et al, 2010	*	*	*	-	-	*	-	4
Gebrekirstos et al, 2015	*	-	*	*	-	*	-	4
Magan et al, 2019	-	-	-	*	-	*	*	3
Woodward et al, 2020	-	-	-	*	-	*	*	3
Lartey et al., 2018	-	-	-	*	-	*	*	3
Tesfatsion et al, 2015	-	-	-	*	-	*	-	2
Neuhann et al, 2001	-	-	-	*	-	*	-	2