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 are 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 to 30, i²=94.7%), 38% (95% CI 30 to 46, i²=98.7%) and 42% (95% CI 32 to 52, i²=97.4%), respectively. The pooled prevalence of diabetic peripheral neuropathy, retinopathy, diabetic nephropathy, peripheral arterial disease and foot ulcers was 38% (95% CI 31 to 45, i²=98.2%), 32% (95% CI 28 to 36, i²=98%), 31% (95% CI 22 to 41, i²=99.3%), 19% (95% CI 12 to 25, i²=98.1%) and 11% (95% CI 9 to 14, i²=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.

INTRODUCTION

Globally, the burden of diabetes mellitus (DM) continues to exponentially rise to epidemic proportions, disproportionately affecting low-income 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. This will ultimately lead to an immense strain...
the proportion of attainment of optimal HbA1c, BP and LDL-C 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. The PRISMA checklist is available as an online supplemental 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 neuropathy” OR “screening for diabetic peripheral nephropathy” OR “screening for diabetic retinopathy” OR “prevalence of diabetic peripheral neuropathy” 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 Zaïre 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.
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, 52.7 to 57.8 | 101            |
| Smokers (%; 95% CI)                    | 9.9, 0.5 to 55.6 | 44                |
| Participants on OHA (%; 95% CI)        | 65.0, 34.0 to 96.6 | 51              |
| Participants on insulin (%; 95% CI)    | 31.3, 26.3 to 36.2 | 52              |
| Participants on lipid-lowering agents (%; 95% CI) | 25.7, 0.5 to 86.7 | 14              |
| Participants on anti-hypertensive agents (%; 95% CI) | 73.3, 64.1 to 82.5 | 18          |
| BMI in kg/m² (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.

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 antihypertensive 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 mm Hg 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 m² 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 10 g monofilament testing for the presence of diabetic peripheral neuropathy, presence of lesions like soft or hard exudates, cotton wool spots, microaneurysms, neovascularisation and retinal haemorrhages on funduscopy 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...
### Table 2  Indicators of optimal glycated haemoglobin goal

| First author and year | Country(ies) | Region of Africa | No. of study participants | Mean age of participants | % of females | % with optimal HbA1c |
|-----------------------|--------------|------------------|---------------------------|--------------------------|-------------|---------------------|
| Adentunji 2006        | Nigeria      | Western          | 50                        | –                        | –           | 52.0                |
| Agboghoroma 2020      | Nigeria      | Western          | 200                       | –                        | –           | 19.0                |
| Akalu 2020            | Ethiopia     | Eastern          | 378                       | 58.6                     | 38.6        | 40.7                |
| Amo 2012              | South Africa | Southern         | 701                       | 57.4                     | 43.9        | 30.4                |
| Amour 2019            | Tanzania     | Eastern          | 238                       | 57.2                     | 65.7        | 9.2                 |
| Ashur 2016            | Libya        | Northern         | 523                       | 54.4                     | 47.0        | 21.8                |
| Attoye 2020           | Nigeria      | Western          | 260                       | –                        | –           | 34.6                |
| Awadalla 2017         | Sudan        | Northern         | 424                       | –                        | 49.3        | 15.6                |
| Balogun 2011          | Nigeria      | Western          | 40                        | 59.4                     | 62.5        | 52.5                |
| Bentata 2015          | Morocco      | Northern         | 637                       | 58.5                     | 62.3        | 30.1                |
| Blum 2020             | DRC          | Central          | 319                       | –                        | 33.5        | 14.1                |
| Cairncross 2017       | South Africa | Southern         | 203                       | –                        | 72.5        | 31.3                |
| Camara 2015           | Cameroon and Guinea Conakry | Central and Western | 1267                   | 58.0                     | 61.0        | 26.0                |
| Chadli 2016           | Morocco      | Northern         | 498                       | 58.0                     | 62.4        | 26.8                |
| Chamba 2017           | Tanzania     | Eastern          | 119                       | 58.1                     | 49.6        | 39.3                |
| Chetoui 2019          | Morocco      | Northern         | 1456                      | 56.2                     | 73.4        | 33.7                |
| Cohen 2010            | Malawi       | Southern         | 620                       | 52.2                     | 60.1        | 36.0                |
| Diao 2017             | Algeria      | Northern         | 210                       | 55.6                     | 65.0        | 51.4                |
| Hall 2017             | Cameroon     | Central          | 261                       | 56.0                     | 56.3        | 27.2                |
| Iwuala 2015           | Nigeria      | Western          | 100                       | 59.9                     | 62.0        | 45.0                |
| Kibirige 2017         | Uganda       | Eastern          | 425                       | –                        | 67.0        | 26.5                |
| Kimando 2017          | Kenya        | Eastern          | 385                       | 62.1                     | 65.5        | 39.5                |
| Kisozi 2017           | Uganda       | Eastern          | 288                       | 48.5                     | 38.0        | 23.3                |
| Mbwete 2020           | Tanzania     | Eastern          | 161                       | 63.9                     | 67.1        | 49.7                |
| Megalla 2019          | Egypt        | Northern         | 180                       | –                        | 24.4        | 4.4                 |
| Molefe-Baikai 2018    | Botswana     | Southern         | 289                       | 50.7                     | 66.1        | 29.4                |
| Muddu 2019            | Uganda       | Eastern          | 175                       | 46.0                     | 48.6        | 8.1                 |
| Muddu, 2016           | Uganda       | Eastern          | 202                       | 46.0                     | 49.5        | 8.4                 |
| Mwebaze 2014          | Uganda       | Eastern          | 146                       | 53.9                     | 48.6        | 19.2                |
| Mwita 2019            | Botswana     | Southern         | 500                       | 58.9                     | 66.0        | 32.3                |
| Noor, 2016            | Sudan        | Northern         | 387                       | –                        | 49.6        | 15.0                |
| Omar 2018             | Sudan        | Northern         | 339                       | 54.8                     | 69.9        | 28.1                |
| Sobngwi 2011          | Tanzania, Kenya, Cameroon, Ghana, Senegal and Nigeria | Eastern, Western and Central | 2352                   | 53.0                     | 61.1        | 29.2                |
| Uloko 2012            | Nigeria      | Western          | 531                       | 57.1                     | 60.5        | 32.4                |
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 V.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% CIs and mean±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

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**Table 3** Indicators of optimal blood pressure (BP) goal

| Author and year | Country(ies) | Region of Africa | No. of study participants | Mean age of participants | % of females | % with optimal BP |
|-----------------|--------------|------------------|---------------------------|-------------------------|--------------|------------------|
| Abdissa et al 202018 | Ethiopia | Eastern | 229 | – | 40.4 | 31.0 |
| Aghboghoroma et al 202030 | Nigeria | Western | 200 | – | – | 30.0 |
| Akalu et al 202030 | Ethiopia | Eastern | 378 | – | 38.6 | 57.7 |
| Amour et al 201921 | Tanzania | Eastern | 238 | 57.2 | 65.7 | 21.7 |
| Awadalla et al 201737 | Sudan | Northern | 424 | – | 49.3 | 60.1 |
| Balogun et al 201154 | Nigeria | Western | 40 | 59.4 | 62.5 | 55.0 |
| Chadli et al 201690 | Morocco | Northern | 498 | 58.0 | 62.4 | 20.2 |
| Chahbi et al 201881 | Morocco | Northern | 300 | – | 93.0 | 32.6 |
| Chisha et al 201734 | Ethiopia | Eastern | 270 | – | 48.9 | 85.9 |
| Cohen et al 2010105 | Malawi | Southern | 620 | 52.2 | 60.1 | 48.0 |
| Hall et al 20175120 | Cameroon | Central | 261 | 56.0 | 56.3 | 43.0 |
| Hayfron-Benjamin et al 201970 | Ghana | Western | 206 | 52.9 | 68.9 | 37.9 |
| Jingi et al 2015121 | Cameroon | Central | 407 | 54.2 | 41.8 | 40.4 |
| Kahloun et al 201436 | Tunisia | Northern | 2320 | 54.5 | 60.2 | 62.5 |
| Kimando et al 201736 | Kenya | Eastern | 385 | 62.1 | 65.5 | 50.4 |
| Lewis et al 2018107 | Zambia | Southern | 921 | 56.0 | 45.0 | 46.6 |
| Lumu et al 201739 | Uganda | Eastern | 425 | 52.2 | 67.0 | 54.7 |
| Magan et al 201941 | Uganda | Eastern | 44 | 50.4 | 63.4 | 34.1 |
| Megallaa et al 201997 | Egypt | Northern | 180 | – | 24.4 | 37.8 |
| Muddu et al 201645 | Uganda | Eastern | 202 | 46.0 | 49.5 | 38.1 |
| Mwebaze et al 201447 | Uganda | Eastern | 146 | 53.9 | 48.6 | 1.5 |
| Mwita et al 2019111 | Botswana | Southern | 500 | 58.9 | 66.0 | 54.2 |
| Onakpoya et al 201577 | Nigeria | Western | 133 | – | 48.1 | 24.1 |
| Rotchford et al 2002113 | South Africa | Southern | 253 | 56.5 | 73.1 | 14.0 |
| Sobngwi et al 20113 | Tanzania, Kenya, Cameroon, Ghana, Senegal and Nigeria | Eastern, Western and Central | 2352 | 53.0 | 61.1 | 21.0 |
| Uloko et al 201267 | Nigeria | Western | 531 | 57.1 | 60.5 | 17.0 |
in forest plots. The DerSimonian and Laird method was used for pooling random effects estimates.\textsuperscript{13}

The heterogeneity of studies was assessed using the $I^2$ value and corresponding 95\% CIs. 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.\textsuperscript{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, that is, 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 metaregression. 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.\textsuperscript{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\%).\textsuperscript{5,6} The proportion of studies conducted in Western, Northern, Southern and Central Africa was 22\% (n=24 studies),\textsuperscript{3,5,9} 15.6\% (n=17 studies)\textsuperscript{101–106} and 8.3\% (n=9 studies),\textsuperscript{3,5,9,117–123} respectively. Three studies were...
conducted in more than one region of Africa (Western, Central and Eastern). 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%–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, LDL-C 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 antihypertensives was reported in about 65% (95% CI 34 to 96.6), 31.3% (95% CI 26.3 to 36.2), 25.7% (95% CI 0.5 to 86.7) and 73.3% (95% CI 64.1 to 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 online Table 4.

**Table 4**

| Author and year | Country (es) | Region of Africa | No. of study participants | Mean age of participants | % of females | % with optimal LDL-C |
|-----------------|--------------|------------------|---------------------------|-------------------------|-------------|---------------------|
| Agbogboroma 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 |
| Elansri et al 2008 | Sudan | Southern | 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 |
| Megalla et al 2019 | Egypt | Northern | 180 | – | 24.4 | 37.8 |
| Mwebaze et al 2014 | Uganda | Eastern | 146 | 53.9 | 48.6 | 48.6 |
| Mvita et al 2019 | Botswana | Southern | 500 | 58.9 | 66.0 | 20.4 |

LDLC, low-density lipoprotein cholesterol.
Table 5  Prevalence of diabetic nephropathy

Prevalence of diabetic nephropathy (n=40 studies): pooled prevalence=31% (95% CI 22 to 41, $I^2=99.3$% 95% CI 99.2 to 99.4) and $I^2$ after meta-regression: 95.6%.

Prevalence of diabetic nephropathy per region: Central: 22% (95% CI 9 to 39), Eastern: 25% (95% CI 10 to 43), Southern: 28% (95% CI 18 to 40), Northern: 38% (95% CI 14 to 65) and Western: 47% (95% CI 25 to 69).

| Author and 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 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 et al 2013    | 369                       | Tanzania      | Eastern           | 54.0                     | 53.4         | 83.7                       |
| Kahloun et al 2014       | 2320                      | Tunisia       | Northern          | –                        | 60.2         | 3.4                        |
| Khalili 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                       |
| Makweru et al 2018       | 150                       | Lesotho       | Southern          | 58.2                     | 80.7         | 6.7                        |
| Megalla 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                       |
| Neuhan 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,     | Eastern, Western  | 53.0                     | 61.1         | 2.4                        |
|                          |                           | Kenya,        | and Central       |                           |              |                             |
|                          |                           | Cameroon,     |                   |                           |              |                             |
|                          |                           | Ghana,        |                   |                           |              |                             |
|                          |                           | Senegal       |                   |                           |              |                             |
|                          |                           | and Nigeria   |                   |                           |              |                             |
| Tesfaye et al 2015       | 247                       | Ethiopia      | Eastern           | –                        | 40.5         | 6.5                        |

Continued
supplemental table 2 and online supplemental 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% (n=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.

Extent of attainment of optimal HbA1c, BP and LDLC goals

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

Data on attainment of optimal HbA1c, BP and LDLC goals were reported in 34 studies. 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.

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

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 to 23) and Western regions (37%, 95% CI 29 to 46), respectively. For the attainment of an optimal BP control, the Western region had the least proportion (31%, 95% CI 20 to 43), while the Northern region had the highest (42%, 95% CI 24 to 61). An optimal LDLC target was least achieved in the Southern region (27%, 95% CI 24 to 30) and most achieved in the Northern region (53%, 95% CI 32 to 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 5–9 and as forest plots in figures 5–9.

The prevalence of diabetic retinopathy, nephropathy, peripheral neuropathy, foot ulcers and peripheral arterial disease was reported in 51 studies. Among studies with a pooled prevalence of 38% (95% CI 31 to 45, I²=98.2%) and 32% (95% CI 28 to 36, I²=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 to 83.3% in a study conducted in Nigeria. A study by Makwero and colleagues conducted in Lesotho reported the lowest prevalence of diabetic retinopathy of 4.7%, while the study by Megalla and colleagues conducted in Egypt reported the highest (90%).

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 to 27) and Western regions (61%, 95% CI 45 to 75), respectively. Studies conducted in the Eastern region reported the lowest prevalence of diabetic neuropathy (23%, 95% CI
## Table 6    Prevalence of diabetic peripheral neuropathy

Prevalence of diabetic peripheral neuropathy (n=36 studies): pooled prevalence=38% (95% CI 31 to 45, I²=98.2% 95% CI 98.7 to 99.0) and I² after meta-regression=88%.
Prevalence of diabetic peripheral neuropathy per region: Central: 22% (95% CI 18 to 27), Eastern: 26% (95% CI 16 to 38), Northern: 45% (95% CI 30 to 61), Southern: 46% (95% CI 42 to 49) and Western: 61% (95% CI 45 to 75).

| Author and 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 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                        |
| Kisozzi 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 and 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, I²=98% 95% CI 97.8 to 98.3) and I² after meta-regression-88.5%.

Prevalence of diabetic retinopathy per region: Eastern: 23% (95% CI 19 to 28), Western: 27% (95% CI 19 to 36), Southern: 30% (95% CI 23 to 37), Central: 34% (95% CI 22 to 47) and Northern: 51% (95% CI 37 to 65).

| Author and 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 2014 | 73 | Tunisia | Northern | 59.3 | – | 27.0 |
| 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 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 2015 | 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-Akaraine 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 |
| Magalla et al 2010 | 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 |
| Olamoyege et al 2015 | 90 | Nigeria | Western | 62.5 | 50.0 | 48.9 |
| Onakpoya et al 2015 | 133 | Nigeria | Western | 48.1 | 27.8 | 48.9 |
| Pirie et al 2014 | 292 | South Africa | Southern | 59.2 | 79.0 | 39.0 |
Prevalence of diabetic retinopathy per region: Eastern: 23% (95% CI 19 to 28), Western: 27% (95% CI 19 to 36), Southern: 30% (95% CI 23 to 37), Central: 34% (95% CI 22 to 47) and Northern: 51% (95% CI 37 to 65).

Table 7  Continued

| Author and year | No. of study participants | Country (ies) | Region of Africa | Mean age of participants | % of females | Prevalence of retinopathy, % |
|-----------------|---------------------------|---------------|------------------|--------------------------|--------------|----------------------------|
| 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 Africa | 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 |

19 to 28) while studies conducted in the Northern region reported the highest prevalence (51%, 95% CI 37 to 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 to 41, I²=99.3%), 19% (95% CI 12 to 25, I²=98.1%) and 11% (95% CI 9 to 14, I²=97.4%), respectively.

The prevalence of diabetic nephropathy and peripheral arterial disease ranged from 2.2% in Ethiopia to 90% in Nigeria and 2.7% in a study performed in Morocco to 52.5% in a study performed in Nigeria. 56

Regarding the burden of diabetic foot ulcers, there was also an observed heterogeneity, with prevalence ranging from 0.4% in Ethiopia to 86.7% in Egypt. 55

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 to 10) and Western (29%, 95% CI 13 to 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 to 12, I²=92.9%), 20% (95% CI 13 to 28, I²=98.4%), 31% (95% CI 21 to 42, I²=99.4%), 33% (95% CI 28 to 37, I²=98.2%) and 40% (95% CI 32 to 48, I²=99%), respectively. The pooled proportion of attainment of optimal HbA1c, BP and LDLC treatment goal was 27% (95% CI 23 to 30, I²=94.5%), 37% (95% CI 29 to 46, I²=99.0%) and 43% (95% CI 31 to 55, I²=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%).
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, health-care systems and knowledge-practice gaps among health-care 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-income and middle-income countries. 

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, health-care systems and knowledge-practice gaps among health-care practitioners.

Table 8  Prevalence of diabetic foot ulcers

| Author and 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 | 11,866                   | 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 | 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                         |
| Lebta 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                         |
| Megalla 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 and 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                          |
33.4%–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.126

Similarly, a low proportion of achievement of an optimal HbA1c target was also reported by a large international, multicentre observational study of 2704 multiracial 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.128

In the Japan Epidemiology Collaboration on Occupational Health study, which enrolled 3070 adult employees of large manufacturing companies, optimal HbA1c, BP and LDLC goals as recommended by the ADA were noted in 44.9%, 76.6% and 27.1% of participants, respectively. Only 11.2% of participants attained all three treatment goals.129

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 al132 reported a pooled prevalence of diabetic foot ulcers of 13%, a finding close to what we observed (11%). In another systematic review and meta-analysis on the prevalence of diabetic peripheral neuropathy in African populations with DM, Shiferaw et al133 reported a slightly higher overall prevalence of 46% compared with what we found in our study (38%) while including fewer studies (n=23).

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 al134 and Achigbu et al135 reported a wide disparity in the prevalence of diabetic retinopathy

| Author and year | No. of study participants | Country(ies) | Region of Africa | Mean age of participants | % of females | Prevalence of PAD, % |
|-----------------|---------------------------|--------------|------------------|-------------------------|-------------|---------------------|
| Agboghoroma et al 202061 | 200 | Nigeria | Western | – | – | 38.5 |
| Akalu et al 202070 | 280 | Ethiopia | Eastern | – | 38.6 | 30.7 |
| Assaad-Khalil et al 201485 | 958 | Egypt | Northern | 57.3 | 50.0 | 11.0 |
| Chahbi et al 201881 | 300 | Morocco | Northern | – | 93.0 | 2.7 |
| Chiwanga et al 201525 | 404 | Tanzania | Eastern | 53.6 | 55.4 | 15.0 |
| Cohen et al 2010105 | 620 | Malawi | Southern | 52.2 | 60.1 | 7.6 |
| Gill et al 200830 | 105 | Ethiopia | Eastern | 41.0 | 30.0 | 6.0 |
| Hayfron-Benjamin et al 201970 | 206 | Ghana | Western | 52.9 | 68.9 | 11.2 |
| Khalil et al 201996 | 506 | Egypt | Northern | – | – | 32.6 |
| Mariam et al 201743 | 279 | Ethiopia | Eastern | 48.8 | 44.8 | 9.7 |
| Megallaa et al 201997 | 180 | Egypt | Northern | – | 24.4 | 20.0 |
| Mwebaze et al 201447 | 146 | Uganda | Eastern | 53.9 | 48.6 | 39.0 |
| Ogbera et al 201555 | 225 | Nigeria | Western | 61.4 | 57.0 | 40.0 |
| Okello et al 201450 | 229 | Uganda | Eastern | 60.0 | 63.7 | 24.0 |
| Oyelade et al 201278 | 219 | Nigeria | Western | – | 58.9 | 52.5 |
| Smide et al 200852 | 145 | Tanzania | Eastern | 46.0 | 48.0 | 13.0 |
| Sobngwi et al 20113 | 2352 | Tanzania, Kenya, Cameroon, Ghana, Senegal and Nigeria | Eastern, Western and Central | 53.0 | 61.1 | 4.7 |
| Uloko et al 201267 | 531 | Nigeria | Western | 57.1 | 60.5 | 10.7 |

Table 9 Prevalence of peripheral arterial disease

Prevalence of peripheral arterial disease (PAD) (n=18 studies): Pooled prevalence=19% (95% CI 12 to 25, I²=98.1% 95% CI 97.6 to 98.4) and I² after meta-regression: 70.9%.

Prevalence of PAD per region: Southern: 8% (95% CI 6 to 10), Northern: 15% (95% CI 4 to 29), Eastern: 18% (95% CI 11 to 27) and Western: 29% (95% CI 13 to 48).
in the included studies of 7%–62.4%, and 13%–82.6%, respectively. Noubiap 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% and 83.7%. Johnston et al in a systematic review that aimed to assess the epidemiological and clinical reports regarding Peripheral arterial disease (PAD) in Sub-Saharan Africa (SSA) documented the prevalence of PAD in patients with diabetes as reported by three studies to range from 39% to 52%.

Compared with 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 programme that undertook comprehensive risk assessments of 3687 adult patients with type 2 DM recruited from seven Asian countries reported a prevalence of peripheral arterial disease, diabetic neuropathy, macroalbuminuria and microalbuminuria and diabetic retinopathy of 3.1%, 15%, 18.8% and 20.4%, respectively.\textsuperscript{138}

The National Health and Nutrition Examination Survey conducted from 1988 to 1994 and 1999–2018 in USA in 1486 non-pregnant 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% and 18.7%, respectively.\textsuperscript{139}

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 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.\textsuperscript{140–144}

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.\textsuperscript{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.\textsuperscript{2}

Healthcare systems in most African countries remain poorly structured to optimally manage most NCDs 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.\textsuperscript{145}

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 lower tier hospitals or private vs public hospitals), patient characteristics (age, duration of diabetes, coexisting 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.

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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             | 1      | Identify the report as a systematic review.                                    | 1                           |
| ABSTRACT          | 2      | See the PRISMA 2020 for Abstracts checklist.                                   | 3                           |
| INTRODUCTION      | 3      | Describe the rationale for the review in the context of existing knowledge.    | 5-6                         |
|                   | 4      | Provide an explicit statement of the objective(s) or question(s) the review addresses. | 6                           |
| METHODS           | 5      | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | 8                           |
|                   | 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                           |
|                   | 7      | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | 6-7                         |
|                   | 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                         |
|                   | 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                           |
|                   | 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                        |
|                   | 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                          |
|                   | 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

| Study details (Author et al, year) | Selection | Comparability | Outcome |
|-----------------------------------|-----------|---------------|---------|
| | 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 |
| Chefout et al., 2020 | * | * | * | * | * | 8 |
| Diaf et al, 2017 | * | * | * | * | * | 8 |
| Elwall 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 |
| Authors, Year | Rating | Country | Reference | Meeting | Notes |
|--------------|--------|---------|-----------|---------|-------|
| 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 |
| Khalili et al., 2019 | * | * | * | ** | * | 8 |
| Awadalla et al., 2017 | * | * | * | ** | * | 8 |
| Bentata et al., 2015 | * | * | * | ** | * | 8 |
| Bouaziz et al., 2012 | * | * | * | ** | * | 8 |
| Jingi et al., 2015 | * | * | * | ** | * | 8 |
| Study                     | Year     | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | Supplemental material | BMJ Open | 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| Study                  | Year | Risk of Bias 1 | Risk of Bias 2 | Risk of Bias 3 | Risk of Bias 4 | Risk of Bias 5 | Risk of Bias 6 |
|------------------------|------|----------------|----------------|----------------|----------------|----------------|----------------|
| Chiwanga et al., 2015  | *    | -              |              | *              | *              | *              | *              |
| Lumu et al., 2017      | *    | -              |              | *              | **             | *              | *              |
| Balogu et al., 2011    | *    | -              |              | *              | **             | *              | *              |
| Megallaa et al., 2019  | *    | *              |              | *              | -              | *              | *              |
| Eghan et al., 2007     | *    | *              |              | *              | **             | *              | *              |
| Unachukwu et al., 2007 | *    | -              |              | *              | **             | *              | *              |
| Abejew et al., 2015    | *    | *              |              | -              | *              | *              | *              |
| Nyamu et al., 2003     | *    | -              |              | *              |              | *              | *              |
| Gulam-Abbas et al., 2002 | *   | -              | *            |              |              | *              | *              |
| Abbas et al., 2011     | *    | *              |              | *              |              | *              |              |
| Gill et al, 2008       | *    | *              |              | *              |              | *              |              |
| Cairncross et al., 2017 | -   | *              |              |              |              | *              |              |
| Amod et al., 2012      | *    | *              |              | *              |              | *              |              |
| Vogt et al, 2017       | *    | -              |              |              |              | *              |              |
| Worku et al, 2010      | *    | *              |              | -              |              | *              |              |
| Gebrekirstos et al., 2015 | *   | -              |              | *              |              | *              |              |
| Magan et al, 2019      | -    | -              |              |              |              | *              |              |
| Woodward et al, 2020   | -    | -              |              |              |              | *              |              |
| Larney et al., 2018    | -    | -              | -            |              |              | *              |              |
| Tesfatsion et al, 2015 | -    | -              | *            | -              | *              |              |              |
| Neuhann et al, 2001    | -    | -              | -            |              |              | *              |              |