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Review

Contribution of diabetes to amputations in sub-Sahara Africa: A systematic review and meta-analysis

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ABSTRACT

Diabetes related amputations remain a major global problem, with devastating complications. We critically appraised relevant literature to quantify the prevalence of diabetes related amputations in sub-Saharan Africa (SSA). An electronic search was performed using the EMBASE and PubMed databases until 2020. Twenty-four out of 834 studies retrieved were included. The pooled prevalence of diabetic-related amputations was 36.9% (95%CI: 32.9%–40.8%). Complications of diabetes related amputations included infection, anaemia, foot deformity and mortality. The study revealed a substantial contribution of diabetes to the burden of amputations in SSA and suggests the need for further studies to assess how to reduce the incidence of diabetes, reduce the incidence of and or delay the progression of macro and microvascular complications of diabetes in SSA.

1. Introduction

Diabetes mellitus (DM) is a growing global health emergency and one of the most challenging health problems in the 21st century [1]. In 2019, it was estimated that 463 million people have diabetes globally, and this number is projected to reach 578 million by 2030, with over four million people estimated to die from diabetes-related causes [2]. DM is one of the most common non-communicable disease, contributing to premature disability and the leading cause of death in most low-and middle-income countries (LMICs) [1,3]. In sub-Saharan Africa (SSA), 15.5 million people were estimated to be living with DM in 2017 [4].

The complications of DM are common and devastating, leading to blindness and organ damage such as renal failure [5,6]. Major complications such as amputations are also high among patients with DM [7,8]. The increased burden of amputations among people living with diabetes is parallel to the exponential increase in the incidence of DM [9]. Diabetes foot and lower extremity amputations (LEAs) are the most prevalent and feared complications [5,6]. A South African study, for instance, reported an alarming burden of LEAs due to DM in the public sector in Cape Town [6]. A report by the Centers for Disease Control and Prevention (CDC) also revealed about 15–40 times higher burden of amputations among DM patients than among non-DM patient [10]. Aside the obvious associated morbidity, diabetes patients with LEA have an increased risk of complications and reduced quality of life [11]. Specifically, 70% of patients who undergo LEA die within their first five years [6]. Even in high-income countries such as the UK, there is high mortality following amputation, ranging from 39% to 80% [12].

The indications for amputations, prevalence of diabetes related amputations and complications of diabetes related amputations in SSA is needed. This information will provide a basis for planning locally appropriate interventions. A few reviews have been done on amputations in Africa: for instance, Thanni and Tade, reviewed the indications and mortality of lower extremity amputations in Nigeria [13] and Limakatso et al. assessed the incidence of phantom limb pain among

Abbreviations: AKA, above knee amputation; BKA, below knee amputation; CDC, centers for disease control and prevention; DM, diabetes mellitus; LEA, lower extremity amputations; LMIC, low- and middle-income countries; NCD, non-communicable disease; NIH, National Institute for Health; SSA, sub-Saharan Africa; UEA, upper extremity amputation.

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amputation population [14]. The critical questions are what is the contribution of diabetes to the burden of amputations in SSA? What are the complications associated with diabetes related amputations? Currently, information on the above questions is either scanty or absent in SSA and have not yet been systematically assessed. Therefore, this systematic review aimed to assess the contributions of diabetes to amputations in SSA and to determine the complications associated with diabetes-related amputations.

2. Methods

This proposed review protocol was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) for protocol extension guidelines [15].

2.1. Search strategy

A customized search strategy containing appropriate words and terms were used to search MEDLINE/PubMed and Embase databases. The search strategy is provided as a Supplemental File A.

2.2. Inclusion and exclusion of studies

We included studies that were done in SSA and were (i) published in English in peer-reviewed journals between 1988–2020, (ii) reported original research on diabetes related amputations in SSA, (iii) conducted in any of these study settings; community, residential care homes, primary care, secondary care, tertiary care and specialized care centers/institutions; or at the regional level using data from primary research, demographic and health surveys, or demographic and health surveillance systems. Papers were primarily from research of quantitative design.

Studies that were conducted among SSA populations living outside SSA were excluded. Two reviewers (BBA and DB) screened the studies titles and abstract against the pre-defined study inclusion criteria. In case of divergent opinions, DNA and CA were consulted. Full texts were also independently screened by BBA and DB for eligibility. Information was extracted on: authors, year of publication, study design and population, research methods, indications and mortality burden of amputations. Contact was made to authors for full text if the full text was otherwise not available.

2.3. Definition of terms/concepts

Diabetes-related complications are defined as amputations performed because of complications primarily due to uncontrolled diabetes only. Diabetes related amputations refers to clinically diagnosed persons with diabetes who had gone through amputations. Extremity amputations are amputations involving the upper and lower limbs. Upper extremity amputations involve amputations affecting the upper extremities such as the shoulder, elbow and fingers etc., whiles lower extremity amputations involve amputations of the lower limb such as the ankle, thigh, legs and toes. Indications of amputations are the causal factors or the factors contributing to amputations. Infection in this study refers to gangrene. This article focused on gangrene and peripheral arterial disease secondary to diabetes leading to amputations. The SSA region was classified based on the United Nations classification of countries [16].

2.4. Data analysis

Findings from the studies were narratively summarized. Absolute number and prevalence of amputations were included, for both men and women. The indications for amputations were summarized as proportions. The pooled prevalence of diabetes related amputations were estimated using Open Meta (analyst) software, an open-source, cross-platform software for advanced meta-analysis [17]. Heterogeneity test for all the proportions were assessed with recourse to the Cochran's heterogeneity statistic (Q) and degree of inconsistency, I^2, using the random effect model [18]. The robustness of the pooled estimates was assessed by conducting a leave-one-out sensitivity analysis [19]. These assessed the impact of each of the included studies on the pooled estimate [19]. Statistical significance was considered at a P-value of <0.05.

3. Results

3.1. Study characteristics

A total of 830 titles and published studies were identified as per the above-mentioned search criteria (Fig. 1). A total of 743 studies were excluded for being irrelevant to the review question, and 89 full text articles were assessed for inclusion. In addition, 61 articles were excluded due to various reasons such as wrong outcome or exposure and published in other languages other than English. Eventually, 24 full text papers were reviewed as detailed in Fig. 1.

All the included studies involved patients who had undergone extremity amputations. With regards to the outcomes, 18 studies investigated the indications and distribution of amputations. Twelve studies reported on the complications and mortalities post amputations. All studies were conducted in public hospitals, with the exception of one study, which was conducted in a private hospital [20]. All studies were retrospective except three studies; of which one was cross-sectional and two were prospective [11,21,22]. Countries where the studies were conducted also varied; half of the studies were conducted in Nigeria whereas 2 each of the studies were conducted in Ghana, Tanzania and Kenya. La Cote D'Ivoire, Rwanda. All the studies were consistent in defining their inclusion criteria with their outcomes as indications, complications, and the contribution of diabetes to amputations. All studies included at least 44 patients and the total sample size for all included studies was 3478 (Table 1). The age of patients in the studies ranged from 2 months to 96 years.

3.2. Quality assessment

The quality of studies were assessed based on the National Institute of Health (NIH) Quality Assessment Tool for Observation Cohort and Cross-sectional Studies [23]. This assessment tool appraises the reliability, validity and generalization of quantitative studies. Most of the studies were rated to be good or of high quality (n = 17). They described in detail the design and methodology used, the process of recruiting participants, justification and methods of arriving at required sample size, study setting, clear and detailed presentation of findings. Studies that were rated to be of fair or poor quality (n = 7) were papers that failed to describe details of subject recruitment process including inclusion and exclusion criteria and sampling strategies and lacked justification of sample size and other issues that could lead to higher risk of bias and undermine generalizability of the study (Supplementary File B).

3.3. Distribution of amputations

The levels of extremity amputations were reported as upper extremity and lower extremity amputations (Table 2). The lower extremity amputations were further categorized as above knee or below knee amputations. Most (60.9%) of the studies reported on lower extremity amputations. Information on the number of amputees per specific age group was, however, limited in the included studies.

3.4. Indications of amputations in sub-Saharan Africa

Table 2 shows results of the indications of amputations among the included studies. The reported indications of amputations included trauma, tumours, infections, diabetes, gangrene and complications of

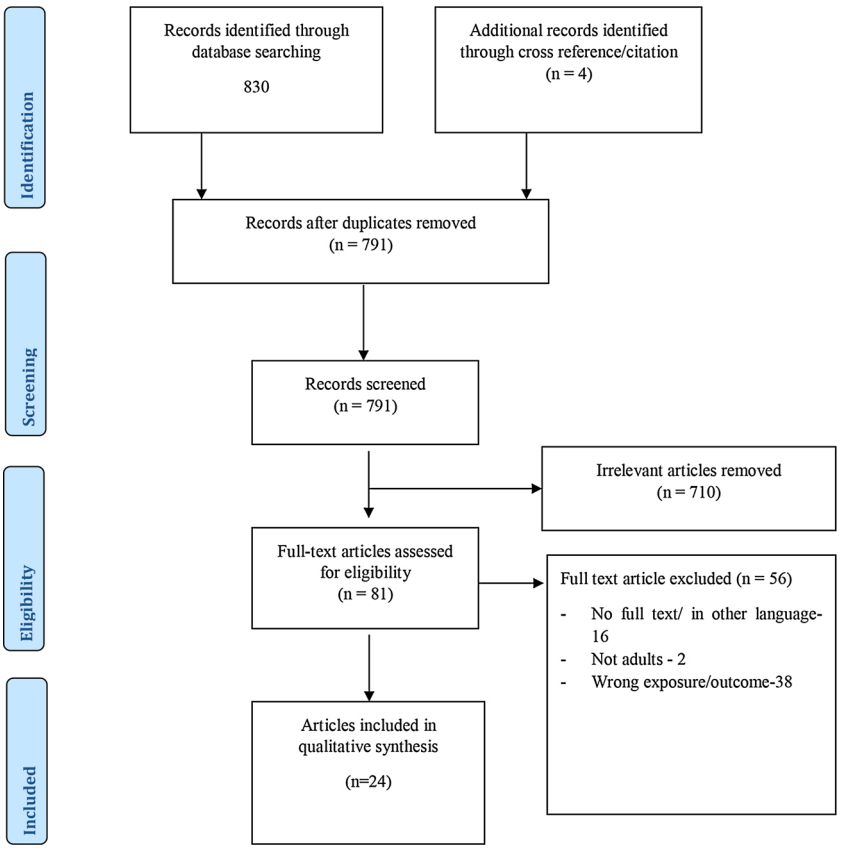

Fig. 1. Flow chart for study inclusion and exclusion steps.
The flowchart illustrates the process of arriving at final articles included in the study, from identification of records (n = 834) to final inclusion in meta-analysis (n = 24).

bone setting. In Nigeria, the six most common indications of amputation were trauma, malignant tumours, diabetic gangrene, infections, peripheral artery disease and burns. Specifically, a hospital-based study by Ogundele (2015) identified trauma and diabetes as the leading causes of amputations [24]. Studies from the southern and northern parts of Nigeria showed that complications of traditional bone setting and trauma were the leading causes of amputations [25,26]. Murwanashyaka et al. in Rwanda also identified traumatic gangrene and other trauma-related limb conditions as the leading indications for amputation [27]. Essoh et al., in their study among adults in Ivorian Teaching hospital found trauma, diabetic foot, and peripheral artery disease as the leading causes of amputations [28].

The data revealed a significant contribution of diabetes to the burden of amputations in SSA. Specifically, the overall pooled prevalence of diabetes related amputations was 36.8% (95% CI: 32.9%–40.1%) as shown in Fig. 2. A leave-one-out sensitivity analysis revealed that the pooled prevalence was most impacted by prevalence data from Sarfo-Kantanka et al. [9] and Manickum et al. [29] (Supplemental Fig. E.1). However, there was no significant difference in the pooled prevalence when these studies were left out, indicating that the pooled estimate was not driven by these studies.

The estimated overall prevalence for other indications of amputations were trauma: 39.1% (95% CI: 30.4%–47.7%) (Supplemental Fig. A), tumour 14.5% (95% CI: 9.8%–19.2%) (Supplemental Fig. B), infections 4.1% (95% CI: 2.2%–5.9%) (Supplemental Fig. C) and peripheral vascular disease (PVD) 8.8% (95% CI: 5.6%–14.4%) (Supplemental Fig. D). The results of the leave-one-out sensitivity analyses for the pooled prevalence are presented as Supplemental Fig. E (1–5). The leave-one-out analyses showed no marked difference in results, suggesting that they were not driven by one single study.

3.5. Complications of diabetes related amputations

Fourteen included studies reported on the complications associated with amputations, which included infection, foot deformity and mortality. Two of the studies reported mortality rates, without indicating the proportions attributed to diabetes. There was marked variation in the overall burden of post-operative complications in SSA with mortality associated with amputations ranging from 4.7% in a study conducted in Rwanda to 62.5% in a study conducted in La Cote D'Ivoire [28]. In a study by Dakbana and Nyaku in Nigeria, complicated diabetes accounted for 57% of indications [25]. Foot deformity was 16.7% in a study conducted in Ghana by Atosona [11].

4. Discussion

4.1. Key findings

The review revealed a substantial contribution of diabetes to amputations in SSA. Other indications of amputations include trauma, tumours, infection, gangrene, and complications of bone setting with much variability among countries, regions, and particular health institutions. Complications of amputations identified in the review included infections, gangrene and mortality with diabetes contributing substantially to mortalities among post operation amputations.

4.2. Discussion of key findings

4.2.1. Contribution of diabetes to amputations

The significant contribution of diabetes to the burden of amputations in SSA corroborates the results of a systematic review that compared the incidence of lower extremity amputations in the diabetic compared with

Table 1
Characteristics of included studies.

Study and year Country	Study design Data source Age of participants	Data collection instrument Study setting	Sample size	Sex distribution Male %	 Female %
Akiode et al. (2015) [55] Nigeria	Retrospective study Hospital records 1998–2003 10 months–80 years	Case notes of all major amputations Olabisi Onabanjo Hospital in Sagamu, Nigeria	69	75.4	24.6
Awori and Atinga (2007) [64] Kenya	Retrospective study from Hospital records 2003–2004 7 months–96 years	Questionnaires Kenyatta National Hospital, Kenya	74	59.0	41.0
Chayla et al. (2012) [65] Tanzania	Retrospective study Hospital records March 2008–February 2010 2 months–70 years	Questionnaire Buganda Medical Centre	167	71.0	29.0
Agu and Ojiaku (2016) [20] Nigeria	Retrospective study Hospital records 2007–2015 9 months–89 years	Data Extraction form South-western hospital in Nigeria	67	91.0	9.0
Dabkana et al. (2018) [25] Nigeria	Retrospective Hospital records 2010–2016. 2 months–70 years	Data Extraction form University of Maiduguri Teaching Hospital in Nigeria	163	75.0	25.0
Kidmas et al. (2004) [66] Nigeria	Retrospective study. Hospital data 1992–1997. 3–83 years	Amputation data sheet University of Jos Teaching Hospital, Nigeria	87	57.0	43.0
Nwosu et al. (2017) [26] Nigeria	Retrospective design Hospital records 2008–2014 3–89 years	Case notes on amputations between 2008–2014 Federal Medical Centre, Benin Kebbi, Kebbi State, Nigeria	116	67.0	33.0
Ogengo et al. 2009 [67] Nigeria	Retrospective study Hospital records 99–200 10–90 years	Case notes on amputations Kikuyu Hospital, Kenya	120	72.0	28.0
Odatuwa-Omagbemi and Vadiki (2012) [68] Nigeria	Retrospective study Hospital records 2009–2011 8–88 years	Case notes on age, sex, Central Warri Hospital, Nigeria	44	61.0	39.0
Edonwonyi and Onuminya, (2016) [69] Nigeria	Retrospective study Hospital records 2005–2010 14–86 years	Case notes on amputations Irrua Specialist University Teaching Hospital, Irrua, Edo state, Nigeria	53	68.0	32.0
Loro and Francschi (1999) [70] Tanzania	Retrospective, quantitative study, Hospital records 1983–1992 9–89 years	Case papers Dodoma Hospital, Tanzania	241	71.4	28.6
Berhe et al. (2017) [71] Ethiopia	Retrospective review Hospital records January 2011–December 2013 3–95 years	A pretested questionnaire Ayder referral hospital, Mekelle, Ethiopia	87	78.0	22.0
Omoke et al. (2012) [72] Nigeria	Retrospective study Hospital data 2001–2010 7–90 years	Data extraction sheet Ebonyi State University Teaching Hospital, Nigeria	58	77.0	23.0
Ogundele et al. (2015) [24] Nigeria	Retrospective study Hospital records 2006–2013. 1–91 years.	A questionnaire Nigerian teaching hospital, Nigeria	158	70.0	30.0
Olasisinde et al. (2002) [73] Nigeria	Retrospective study Hospital records 1987–1999 2–85 years	Case notes Nigerian teaching hospital	82	83.0	17.0
Atosona and Larbie (2019) [11] Ghana	Cross sectional study Surveyed information from diabetic patients from June to July 2015 18–80	Questionnaires and Biomedical information sheet KBTH, KATH and TTH	100	69.0	31.0
Alegbeleye (2020) [21] Nigeria	Retrospective study Surveyed information from patients 2006−2010 18–90 years	Data collected sheet National Othorpaedic Centre, Kano, Nigeria	132	79.0	21.0
Baidoo and Debrah (2016) [54] Ghana	Retrospective study Medical records on amputations 2010–2013 Not given	Information sheet St. Joseph's Orthopedic hospital, Ghana	94	61.0	39.0
Essoh et al. (2009) [28] La Cote D'voire.	Retrospective study Patients records 1998–1999 15–85 years	Data extracted sheet Yopougon Teaching Hospital, Abidjan	156	69.0	31.0
Manickum et al. (2019) [74] South Africa	Retrospective study Hospital records 2010–2014 10–90 years	Information sheet Four public sector hospitals in South Africa	941	71.0	29.0
Ndukwu and Muoneme (2015) [75] Nigeria	Retrospective study Case notes of patients 2011–2012	Case notes NAUTH, Nigeria	90	60.0	40.0

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Table 1 (*continued*)

Study and year Country	Study design Data source Age of participants	Data collection instrument Study setting	Sample size	Sex distribution Male %	 Female %
Murwananshyaka et al. (2013) [27] Rwanda	17–89 years Retrospective study Medical records 2009–2012 1–93 years, median age: 44 years	Questionnaire University Teaching Hospital in Butare, Rwanda	107	70.1	29.9
Ahmed (2009) [22] Sudan	Prospective analytic Hospital based study, 2002–2003 35–92 years	Questionnaire Khartoum Teaching Hospital and JADC	100	Not stated	Not stated
Alegbeleye (2020) [21] Cameroun	Observational prospective Hospital-based study 2018–2019 1–84 years.	Pretested proforma St Elizabeth Catholic General Hospital, Shisong, Northwestern region, Cameroon.	172	72.4	27.6

KBTH = Korle-Bu Teaching Hospital; KATH = Komfo Anokye Teaching Hospital; TTH = Tamale Teaching Hospital; NAUTH = Nnamdi Azikiwe University Teachng Hospital; JADC = Jabir Abu El Iz diabetes center.

the non-diabetic population, where the proportion of LEA among diabetic persons ranged from 27% to 75.5% [30]. A study among the Caribbean population in Barbados, also revealed a high contribution of diabetes to amputations [31]. With SSA predicted to be one of the regions of the world with the highest burden of diabetes, its contribution to the burden of amputations cannot be overemphasized. The Global Lower Extremity Amputation Study demonstrated high levels of association between diabetes and amputation worldwide [32]. In the USA, diabetes accounts for 65% of non-traumatic lower-extremity amputations performed [33]. In the UK, almost one in three (33%) amputees has diabetes [34], whilst almost half of all Australian amputees are affected by diabetes [35].

Diabetes foot disorders is one of the most prevalent diabetes related complications [36]. With a significantly higher risk of LEA and mortality [37]. LEA in diabetes patients often arise as a result of poorly managed diabetes (poor glycemic control) and/or peripheral neuropathy, infection and peripheral arterial disease [37]. The reasons for the increase burden of diabetes related amputations in SSA could be attributed to sub-optimal diabetes care, control and management [37,38]. Clinical outcomes of diabetic foot ulcers could be improved through prompt referral for specialized assessment and treatment [39]. A recent systematic review and meta-analysis found a positive impact of structured diabetic foot care services on preventing overall and major LEA [40]. Also, in SSA, health systems are more focused on infectious diseases and are not well equipped to provide care for NCDs such as diabetes. Further, the general lack of access to foot screening services and specialist podiatrist within the public health space could account for the problem of diabetes related amputations in SSA [41]. Many other factors including limited resource allocation, lack of training among health professionals and low health literacy contribute to the high rates of complications of diabetes foot and amputations in SSA [42]. For instance in Ghana, as in most other countries in SSA with a rising trend of diabetes-related, lack of resources, high patient load, absence of suitable facilities and trained personnel have been identified as major contributors [43]. Furthermore, illiteracy, poverty, shortage of nursing staff, lack of diabetes policies/guidelines, and inadequate medical resources impede the management of diabetes in the sub-region [44].

The increased burden of diabetes related amputations could also be due to late presentations at the health facilities. Several studies from SSA indicated that people living with diabetes report late to hospital or only after the onset of gangrene or late sepsis that might be resistant to antibiotics, fluids and insulin, culminating in systemic infection, which increases the risk of amputation [45–47].

Contrary to the finding of this review, a decline in incidence of LEA has been reported in many high-income countries over the past three decades [48,49]. For example, in the UK, the rate of amputations has been reducing significantly over the past decade [50]. These achievements were mostly through a campaign of increased screening, widespread adoption of multidisciplinary foot management clinics, stringent vascular risk factor management and improved patient education [51].

This review provides evidence of the increased burden of diabetes coupled with LEA and serve to reinforce that diabetes and its complications pose an ever-present danger to both current and future generations. Of critical importance is the religious and cultural belief of what diabetes is, its cause cure etc. which leads to late presentation in SSA [52,53].

4.2.2. *Complications of diabetes related amputations*

Our systematic review also showed an increase mortality rate among diabetes related amputations [25,54,55]. High mortality rate from diabetes related amputations is almost universal. A study in the UK for instance revealed that, up to 80% of diabetes patients die of LEA within 5 years [37]. Gunney et al. found that 18% of major amputations result in mortality within the first 90 days post operatively [56]. Other evidence shows that patients with diabetes who undergo LEA have a high mortality rate [57]. Although this rate of postoperative mortality is substantial, it is consistent with other diabetes literature from a systematic review of mortality after LEA [58]. However most of these mortalities are hardly reported in SSA due to lack of access to healthcare [41]. Even though co-morbidities of cardiovascular and renal complications may account for mortality in diabetes related amputations, there is no published work on this.

4.2.3. *Other indications of amputations*

This study identified gangrene aside diabetes as one of the leading causes of amputations. The occurrence of gangrene in some of the patients who sustained trauma could be attributed to initial mismanagement by traditional bonesetters, which alludes to their inadequacies with majority of them in LMIC's [59,60]. The role of diabetes in foot gangrene cannot also be over emphasized as foot gangrene is reported to be 50 times more common in diabetes patients over the age of 40 than in non-diabetes patients of the same age [61]. Access, culture and poverty could contribute to the patronage of traditional medications especially in the management of diabetes in some countries in SSA [62], resulting in later presentation at the health facility. There is an undeniable role of medical plurality in diabetes self-management in some countries in SSA for instance among the Swahili of Lamu town, Kenya and in Guinea, diabetes patients use herbal and traditional management approach in addition to orthodox [63].

Table 2
Outcome of assessment of included studies.

Study and year	Indications for amputations						Levels of amputations				Complications %
Country	DM, %	Trauma %	Tumours (Cancer) %	Infections %	PVD %	Others %	UEA %	LEA/ AKA %	BKA %	Others %	
Akiode et al. (2005) [55] Nigeria	14.1	76.1	8.5	Not given	Not given	1.4	31	Not given	42	28.9	Mortality rate was 7.2% 50% due to diabetes.
Awori and Atinga (2007) [64] Kenya	17.5	18.9	24.4	1.4	37.8	Not given	Not given	55	31	14	Not given
Chalya et al. (2012) [65] Tanzania	41.9	38.4	7.4	Not given	8.6	3.7	13.6	39.5	46.3	0.6	Mortality rate was 16%, 42.0% was due to diabetes.
Agu and Ojiaku (2016) [20] Nigeria	22.3	70	Not given	Not given	Not given	Not given	Not given	43.3	37.2	19.4	Mortality was 9%; 50% was due to diabetes
Dabkana et al. (2018) [25] Nigeria	57	13.3	7.3	4.3	5.5	17.6	Not given	Not given	76	Not given	Mortality rate was 55.6% 22% was due to peripheral artery disease. Complicated diabetes accounted for 57% of indications
Kidmas et al. (2004) [66] Nigeria	26.4	29.9	23	Not given	9.2	11.3	Not given	49.9	37.2	13.9	Mortality rate was 12.6%, 34% due to diabetes.
Ogeng'o et al. 2009 [67] Kenya	11.4	35.7	12.9	14.3	Not given	25.7	24	31	45	Not given	Not given
Odatuwa-Omagbemi and Vadiki (2012) [68] Nigeria	63.6	20.5	Not given	Not given	Not given	Not given	9	37.5	62.5	17.4	Mortality rate was 6.5%
Edonwonyi and Onuminya (2016) [69] Nigeria	40.6	35.9	6.3	Not given	7.8	9.4	6.3	32.1	53.1	9.4	Not given
Loro and Franceschi (1999) [70] Tanzania	Not given	15	40	10	20	15	Not given	Not given	Not given	Not given	Not given
Gebreslassie et al. (2018) [71] Ethiopia	8	37.7	24.1	9.8	20.7	Not given	Not given	23	36.5	Not given	Not given
Ogundele et al. (2015) [24] Nigeria	30.4	48.1	2.5	Not given	3.8	Not given	24	31	45	Not given	Mortality rate was 0.2%
Nwosu et al. (2017) [26] Nigeria	Diabetic foot -23.2	24.1	19.6	8.9[a]	8.0	Sequel of tradition bone setter (16.1)	24.2	45.5	39.3		Not given
Olasinde et al. (2002) [73] Nigeria	13.4	65.9	8.7	Not given	Not given	9.8	15	Not given	42.9	37	Not given
Atosona and Larbie (2019) [11] Ghana	23.2	51	19.6	Not given	Not given	46	Not given	Not given	Not given	Not given	Foot deformity: present vrs absent – 16.7% vrs 2.1%; p = 0.043
Omoke et al. (2012) [72] Nigeria	Not given	Not given	Not given	Not given	Not given	Not given	Not given	Not given	Not given	Not given	Not given
Ajibade et al. (2013) [76] Nigeria	4.5	42.4	12.1	3.8	Not given	Gangrene 31.8	27.8	31.1	36.4	6.8	Mortality rate was 2.3%
Baidoo and Debrah (2016) [54] Ghana	27.4	46.3	27.4	11	Not given	Congenital malformation, 3	21.7	45	55	Not given	Mortality rate was 6.4% 53.8% due to diabetesto diabetes
Essoh et al. (2009) [28] La Cote D'Ivoire	31.4	49.9	3.2	Not given	13	2.5	27.4	11.9	46.9	11	Mortality rate was 16.5%, 62.5% to due to diabetes and Septicemia

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Table 2 (*continued*)

Study and year Country	Indications for amputations						Levels of amputations				Complications %
	DM, %	Trauma %	Tumours (Cancer) %	Infections %	PVD %	Others %	UEA %	LEA/ AKA %	BKA %	Others %	
Manickum et al. (2019) [29] South Africa	55	Not given	Not given	Not given	Not given	Not given	Not given	Not given	37.3	Not given	Not given
Murwananshyaka et al. (2013) [27] Rwanda	1.9	13.1	29	2.8	0.9	Gangrene, 43.9	14	35.5	37.4	8.3	Mortality due to diabetes was 4.7%.
Ahmed (2009) [22] Sudan	70	Not given	Not given	Not given	Not given	Not given	Not given	Not given	18 patients (26%) had trans femoral amputation	(74) had transtibial amputation	Mortality rate due to diabetes was 20%.
Alegbeleye (2020) [21] Cameroun	22.9	60.4	2.6	3.49	Not given	12.21	42.3	Not given	(57.7)	Not given	Mortality due to DM was 9.30%.

PVD = peripheral vascular disease; DM = diabetes mellitus; UEA = upper extremity amputations; LEA = lower extremity amputations; AKA = above knee amputations; BKA = below knee amputations; DFG = diabetic foot gangrene.

[a] Post infective gangrene.

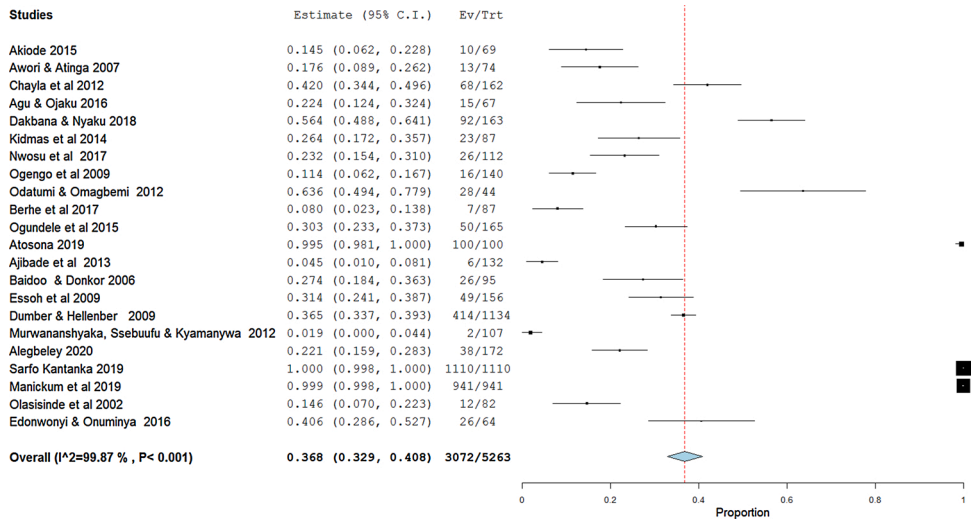

Fig. 2. Forest plot of the pooled prevalence of diabetic-related amputations in sub-Saharan Africa.
The forest plot shows the prevalence and 95% CI as well as the pooled prevalence from meta-analysis of 22 included studies that reported on the prevalence of diabetes related amputations.

4.3. Strengths and limitations

The strength of this review is the fact that it is the first review that assesses the contributions of diabetes to amputations in SSA and to determine the complications associated with diabetes-related amputations. Unfortunately, we were unable to include other studies conducted in other languages due to language barriers. English as an inclusion criterion might have excluded some advanced research result from other countries. Our study was limited to only some few African countries and therefore does not represent all the countries in SSA.

5. Conclusion

The review findings demonstrate a substantial contribution of diabetes to the burden of amputations in SSA with its associated complications of infections and high mortality rates. However, the factors responsible for this contribution in SSA are not very clear. This suggests the need for further studies to assess how to reduce the incidence of diabetes, reduce the incidence of and or delay the progression of macrovascular and microvascular complications of diabetes in SSA. In addition, there is the need for countries to invest in planning and implementation of strategies to ameliorate the increasing incidence and complications of diabetes and its related amputations. Furthermore, enhanced health education and special diabetes care (foot care) must be given to the individuals living with diabetes to reduce the complications and the mortalities associated with diabetes.

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Conflict of interest

None declared.

Author contributions

Bernard Bless Ayellah: Conceptualization, Original draft preparation. **Daniel Boateng**: Methodology, Formal analysis, Reviewing and editing. **David Nana Adjei**: Supervision, Reviewing and editing. **Prof Charles Agyemang**: Supervision, Reviewing and editing.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.pcd.2022.01.011.

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