Poor blood pressure control and its associated factors among peoples living with Diabetes Mellitus in sub-Saharan Africa: A Systematic Review and Meta-analysis

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Abstract

Background

Poor blood pressure control among people living with diabetes mellitus (DM) is one of the primary causes of cardiovascular complications and death in sub-Saharan Africa (SSA). However, there is paucity of evidence on the prevalence and associated factors of poor blood pressure control in SSA. Therefore, this review aimed to estimate the prevalence and its associated factors among people living with DM in SSA.

Methods

We systematically searched PubMed, African Journals online, Hinari, Google scholar and direct Google to access observational studies conducted in SSA. Microsoft excel spreadsheet was used to extract the data and then exported into STATA/MP version 16.0 for further analysis. Heterogeneity across studies was checked using Cochrane Q test statistic and I^2 test and small study effect were checked using Funnel plot symmetry and Egger's statistical test at 5% significant level. A random-effects model was used to estimates the pooled prevalence of poor blood pressure control with a 95% confidence interval (CI).

Results

Of the 1,043 articles retrieved, 21 articles with an overall sample size of 6308 were eligible for the meta-analysis. After performing random-effects model, the pooled prevalence of poor blood pressure control was 69.8% (95% CI: 63.43, 76.25%). Poor adherence to antihypertensive treatment (OR = 1.7; 95% CI: 1.03–2.80, I^2 = 0.0%, p = 0.531) and overweight (OR = 2.4, 95% CI: 1.57–3.68, I^2 = 0.00%, p = 0.47) were significantly associated with poor blood pressure control.

Conclusions

Only one third of diabetic patients in SSA had achieved target blood pressure. Hence, there is an urgent need for initiatives to improve and control hypertension, and preventive measures should concentrate on modifiable risk factors.

Systematic Review registrations:

The review protocol has been registered in PROSPERO with protocol number of CRD42020187901.

Background

Hypertension is the worldwide leading cause of cardiovascular diseases (CVD) and deaths (1), and accounts for around 7.5 million yearly deaths (2). Globally, an estimated 1.13 billion people are hypertensive, most (two-thirds) living in low- and middle-income countries (3). The highest prevalence of hypertension in the world is observed in SSA (4, 5). It tends to occur more commonly with diabetes and as many as 70–80% of diabetic patients suffer from hypertension, which worsens and accelerates the progression of both micro- and macrovascular complications of diabetes and results in 7.2-fold increase in the risk of mortality (6–9). Moreover, type 2 diabetes mellitus (T2DM) patients with hypertension have a two to four-fold greater risk of developing cardiovascular sequelae than age-matched normotensive type 2 diabetic controls (10).

Therefore, it is imperative to control cardiovascular disease (CVD) risk and mortality in diabetes patients and the most effective and powerful intervention to reduce it is controlling blood pressure by integrated use of life style modification and appropriate regimen and dose of anti-hypertensive medications (11, 12). The benefits of tight BP control in patients with diabetes exceed the benefits of tight glycemic control and extend to the prevention of macrovascular and microvascular complications (13, 14). Many randomized controlled trials and the United Kingdom Prospective Diabetes Study (UKPDS) showed that strict BP control in patients with hypertension and diabetes reduces the risk of stroke, coronary heart disease, congestive heart failure and other CVD, macrovascular and microvascular complications, and death (13, 15, 16).

A meta-analysis has revealed that a 10 mm Hg reduction in systolic blood pressure reduced the risk of major cardiovascular disease events by 20%, coronary heart disease by 17%, stroke by 27%, heart failure by 28%, and all-cause mortality by 13% (17). Lowering of blood pressure to treatment targets is therefore, a priority in individuals with diabetes to prevent complications (18–20). Even though different guidelines differ in their recommendations on BP targets in diabetic patients (21), many guideline committees had recommended that in patients with DM and hypertension, the target systolic and diastolic BP should be below 130 and 80 mm Hg, respectively (6, 21, 22). However, most hypertensive diabetic patients fail to meet the recommended BP target. A study in USA by Andros et al. reported that poor blood pressure control among individuals with diabetes was still high and remains a major public health concern causing economic burden (23). In a longitudinal cohort study of 30,228 diabetic patients, only 43 and 30% of European American and African American diabetic hypertensive patients, respectively, demonstrated a target blood pressure of 130/80 mmHg (24). In SSA rates of BP control range between 11 and 35% (25, 26) and the cardiovascular complications in this region diabetic individuals are attributed to poor blood pressure control (27). A study carried out in six specialized diabetes care centers of six SSA showed an overall poor BP control in T2DM individuals despite adherence to guidelines (26). This implies the presence of other factors attributed to this poor BP control, including demographic, health literacy, and socio-economic characteristics (28). Moreover, overweight and noncompliance with antihypertensive drugs were strongly associated with uncontrolled hypertension (29, 30).

Even though extensive efforts to develop interventional BP control strategies to decrease risk of complications have been made in the past several decades, there is still significant rise in the risk of

complications in diabetic patients with hypertension, and the control of BP is sub-optimal. To solve this problem and meet the blood pressure target, understanding of risk factors of blood pressure control particularly in SSA is important. Therefore this systematic review and meta-analysis aimed to determine the prevalence and associated factors of poor blood pressure control among people living with DM in SSA.

Methods

Search strategies

This systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (S1 Table, PRISMA Checklist) (31). PubMed, African Journals online, Hinari, Google scholar, and direct Google search were used to access relevant studies for this review. Moreover, references list of eligible studies were retrieved to account for the missed studies in the database searching. All studies reporting proportion or prevalence of poor blood pressure control among people living with DM (either T1DM or T2DM) in SSA countries were the target of this review.

A search strategy was established for each database by combining MeSH (Medical Subject Heading) terms. Example of the search strategy for PubMed (search strategies for all data bases attached as supplementary file):

((("uncontrolled hypertension"[Title/Abstract]) OR ("Hypertension control") OR ("blood pressure control") OR ("management of hypertension") OR ("Treatment of Hypertension")) AND ((("Diabetes Mellitus") OR ("Type 2 diabetes mellitus") OR ("Type 1 diabetes mellitus") OR ("Diabetes")) AND ((Angola) OR (Benin) OR (Botswana) OR (Burkina Faso) OR (Burundi) OR (Cameroon) OR (Cape Verde) OR (Central African Republic) OR (Chad) OR (Comoros) OR (Congo) OR (Ivory Coast) OR (Democratic Republic of the Congo) OR (Djibouti) OR (Equatorial Guinea) OR (Eritrea) OR (Ethiopia) OR (Gabon) OR (Gambia) OR (Ghana) OR (Guinea) OR (Guinea-Bissau) OR (Kenya) OR (Lesotho) OR (Liberia) OR (Madagascar) OR (Malawi) OR (Mali) OR (Mauritania) OR (Mauritius) OR (Mayotte) OR (Mozambique) OR (Namibia) OR (Nigeria) OR (Reunion) OR (Rwanda) OR (Saint Helena) OR (Sao tome) OR (Senegal) OR (Seychelles) OR (Sierra Leone) OR (Somalia) OR (South Africa) OR (South Sudan) OR(Niger) OR (Swaziland) OR (Togo) OR (Uganda) OR (Tanzania)OR (Zambia) OR (Zimbabwe)).

Eligibility criteria

We used CoCoPop (Condition, Context, and Population) approach for prevalence studies to declare inclusion and exclusion criteria.

Inclusion criteria and exclusion criteria

We included all studies conducted in SSA countries, written in English language, published as of August 01, 2020 and reported prevalence and/or associated factors of poor blood pressure control among people living with type 1 or type 2 diabetes. All included studies were published. Studies which did not report prevalence of poor blood pressure control, case-reports, case-series, letters to the editors, and studies conducted on specific population were also excluded.

Study selection

All studies retrieved using different electronic databases were exported into endnote version X7. After excluding duplicated articles, titles of all articles were screened and abstracts and their full-texts were independently reviewed by two authors (YA and SAT). Disagreement between reviewers was resolved by further discussion and other reviewers (DAA and MG)

Quality assessment

The quality of included studies were assessed using the validated modified version of a quality assessment tool for prevalence studies (32). Two reviewers (BD and GAT) independently assessed the quality of the included studies and discrepancy in quality appraisal between the two authors was synchronized by the third reviewer (SAT). The quality assessment tool has 9 risk of bias items which has a maximum score of "9" and minimum score of "0". Ranking of risk of bias is labeled as low risk (0-3), moderate risk (4-6), and high risk (7-9) (32).

Data extraction and management

Findings on the prevalence and associated factors of poor blood pressure control among diabetic patients from each study were summarized by two authors (YA & YY) using the data extraction format which was prepared with the assistance of the Joanna Briggs Institute (JBI) data extraction tool for prevalence studies and the extracted data were compared between the two authors (YA and YY). Discrepancies were resolved by consensus after discussion. For each study; name of the first author, year of publication, study design, sample size, blood pressure cut point used (to define poor blood pressure control), the prevalence of poor blood pressure control or number of cases with poor blood pressure control, and associated factor (sex, BMI, adherence) estimates (Odds ratio or the cases in each cell) with their standard error were extracted.

Outcome measurement

Outcome variable of this study was poor blood pressure control among peoples living with diabetes mellitus. In the primary studies, the outcome variable was defined using different blood pressure cut points. Included studies defined poor blood pressure control in diabetes as; 1: systolic blood pressure (SBP) $\geq$ 140mmHg and /or a diastolic blood pressure (DBP) $\geq$ 90 mmHg; 2: SBP $\geq$ 140mmHg and /or a DBP $\geq$ 80 mmHg, and 3: SBP $\geq$ 130mmHg and /or DBP $\geq$ 80. The latest BP cut point to define poor blood pressure control is SBP $\geq$ 130mmHg and /or DBP $\geq$ 80 in DM patients (33-35).

Statistical analysis

The extracted data in the Microsoft excel were exported into STATA version 16.0 software for further analysis. The pooled estimate of poor blood pressure control prevalence and its associated factors were determined by the random-effects model using DerSimonian-Laird weight (36). Statistical heterogeneity was checked by Cochrane Q-test and I^2 statistics (37). To minimize the variance of point estimates between primary studies subgroup analysis was carried out by BP cut point used to define poor BP control, year of publication, income level, type of DM, and sample size. Besides, sensitivity analysis was also conducted to determine the effect of single studies on the pooled estimate. Univariable meta-regression was conducted by publication year, mean age of the respondent from primary studies, sample size and income level using random-effects model.

Publication bias (small study effect) was checked using funnel plot and statistically by Egger's test (38). Odds ratio(OR) and 95% confidence interval was used to identify factors associated with poor blood pressure control in people living with DM.

Systematic Review registration

The review protocol has been registered in PROSPERO with protocol number of CRD42020187901, URL: <https://www.crd.york.ac.uk/PROSPERO/#myprospero>

Results

Description of included studies

We retrieved 1,043 records of journal articles in the electronic database search and 456 duplicates were removed. After scrupulous review of the titles and abstracts, we excluded 561 articles. Five articles were excluded in the full-text review because of difference in population under study (28), full text not found (39, 40), and reviews (21, 41). We used full-text copies of 21 records for further review with an overall sample size of 6, 308 (Figure 1).

Of the 21 studies, 5 were from South Africa (42-46), 5 from Ethiopia (11, 47-50), 3 from Kenya (51-53), 2 from Tanzania (54, 55), 2 from Nigeria (56, 57), and 1 from Cameron (58), Uganda (59), Botswana (60), and Ghana (61). All studies were institution based cross-sectional studies. To define poor blood pressure control, BP cut point of $\geq 140/90$ was used by 11 studies (11, 43, 47, 48, 50, 53, 62-66), $\geq 140/80$ by 3 studies (45, 59, 67) and $\geq 130/80$ by 7 studies (44, 52, 54-56, 58) (Table 1).

Table 1: Characteristics of the included studies and prevalence of poor blood pressure in individual studies

S.no	Author	Publication Year	Country	Sample size	BP cut point used	Prevalence of Poor BP control	Quality score
1	Simeon Pierre et.al (58)	2007	Cameroon	210	130/80	89.8	2(low risk)
2	Akalu et.al (48)	2020	Ethiopia	378	140/90	74.4	2(low risk)
3	Hailu A et. al. (67)	2017	Ethiopia	484	140/80	63.6	1(low risk)
4	Anakwue RC et a (56)	2012	Nigeria	420	130/80	88	0(low risk)
5	E. O. Okoro et al (62)	2004	Nigeria	115	140/90	89	3(low risk)
6	Y Pinchevsky e al (44)	2013	South Africa	666	130/80	54.2	0(low risk)
7	AM Klisiewicz et al (42)	2009	South Africa	150	130/80	82	2(low risk)
8	Yacob Pinchevsky et al (45)	2016	South Africa	261	140/80	58	3(low risk)
9	N.S. Levitt et al (43)	1997	South Africa	300	140/90	61.5	2(low risk)
10	Mwita JC et al (54)	2012	Tanzania	150	130/80	66	2(low risk)
11	Kibirige et al. (59)	2014	Uganda	250	140/80	44	2(low risk)
12	Sintayehu Muleta et al (11)	2017	Ethiopia	131	140/90	56.5	3(low risk)
13	Julius Chacha Mwita et al (66)	2019	Botswana	500	140/90	45.8	1(low risk)
14	Tariku Shimels et al (50)	2018	Ethiopia	361	140/90	80.6	2(low risk)
15	Emmanuel M Mwengi et al (53)	2019	Kenya	237	140/90	69.2	2(low risk)
16	B. W. NDEGE et al (52)	2014	Kenya	218	130/80	79	2(low risk)
17	Oladele Vincent A. et al (65)	2016	South Africa	265	140/90	75.5	3(low risk)
18	Semvua B1.	2017	Tanzania	295	130/80	84.5	2(low

	Kilonzo et al (55)						risk)
19	Hailu Abera et al (47)	2016	Ethiopia	382	140/90	85	2(low risk)
20	Mercy W. Kimando1(64)	2017	Kenya	385	140/90	76.6	2(low risk)
21	James Osei- Yeboah et al(63)	2018	Ghana	150	140/90	41.33	3(low risk)

Pooled estimate of Poor Blood Pressure control among people living with DM in Sub-Saharan Africa

The pooled prevalence of poor blood pressure control in 21 studies in sub-Saharan Africa was 69.8% (95% CI: 63.43, 76.25%) and considerable heterogeneity was observed among studies ($I^2 = 97.3\%$, $p < 0.001$) (Figure 2). The funnel plot shows symmetric distribution and the egger's test was not significant (estimated bias coefficient=10.5 with a standard error of 3.4, and $p = 0.180$), indicating no publication bias (Figure 3).

Handling Heterogeneity

The extent of heterogeneity among the included studies was high in the random-effects model pooled estimate. To handle this, sensitivity, subgroup and, meta-regression analyses were performed. In the sensitivity analysis, no influential study was found (Figure 4). We further did and report estimates from a sub group analysis considering other possible sources of variations including the cut point used to diagnosis poor BP control, type of DM, sample size, income, and year of publication. However, heterogeneity was not handled. A pooled prevalence from sub-group analysis showed, studies which used BP cut point of 130/80 mmHg systolic and diastolic blood pressure, respectively, had the highest prevalence of poor BP control (77.7%) (Supplementary figure (S.Figure 1)), and the least pooled prevalence (55.3%) was observed in the subgroup of studies those used 140/80 mmHg as a BP cut point. Pooled prevalence of poor BP control was higher (71%) in studies whose study population was both (type 1 and/or 2) types of DM than studies with study population of type 2 DM only (68.8%) (S.Figure). Higher pooled prevalence of poor blood pressure control (70.0%) was found in studies with sample greater than or equal to 296 than the counter parts (S.Figure 3). Studies published from 2005-2012 had the highest pooled prevalence of poor blood pressure control (82.0%) (S. Figure 4). Sub group analysis by income was also done and the highest pooled prevalence was found in lower middle income SSA countries (Ghana, Nigeria, Cameron) (77.3%) followed by low income SSA countries (Ethiopia, Kenya, Uganda, Tanzania) (71.1%) (S.Figure 5) (Table 2).

Table 2 Subgroup analysis of pooled prevalence of poor BP control among diabetic population in sub-Saharan Africa countries, 2020 (n = 21)

Subgroup analysis by		Included studies	Sample size	Prevalence (95% CI)	Heterogeneity (I ² , p-value)
BP cut point used	130/80	7	2,525	77.7% (66.92, 88.39)	97.5%, <0.001
	140/80	3	995	55.3% (43.92, 66.71)	92.4%, <0.001
	140/90	11	2788	68.8% (60.21, 77.47)	97.3%, <0.001
Type of DM	Type 2 DM	11	3,754	68.8% (59.49, 78.02)	97.3%, <0.001
	Both Type 1 and 2	10	2554	71% (61.83, 80.24)	96.9%, <0.001
Sample size	≤296	12	2432	69.7% (60.74, 70.61)	96.6%, <0.001
	>296	9	3876	70.0% (60.19, 79.88)	98.1%, <0.001
Publication Year	1997-2004	2	415	75.2% (48.68, 101.7)	97.7%, <0.001
	2005-2012	4	930	82.3 % (74.04, 90.01)	90.8%, <0.001
	2013-2020	15	4,963	66.0% (58.59, 73.44)	97.2%, <0.001
Income level	Low income	11	3271	71.1% (64.35, 77.82)	95.3%, <0.001
	Lower middle income	4	895	77.3% (61.81, 92.77)	97.7%, <0.001
	Upper middle income	6	2142	62.7 (52.15, 73.32)	96.3%, <0.001

Meta-regression

To handle heterogeneity, we further fitted meta-regression on the aggregated study level variables using the random effects model. The univariable meta-regression analysis revealed that mean age, publication year, sample size and income level were not significantly associated with poor blood pressure control (Table 3).

Table 3: Univariable meta-regression analysis results for the prevalence of poor blood pressure control among diabetics in sub-Saharan Africa

Study level variables	Standard error		
	Adjusted R ²	Coefficients (95% CI)	
Mean age	0.00	0.94	0.35(-1.49 - 2.19)
Publication year	0.00	0.60	-0.62(-1.80, 0.54)
Sample size	4.40	0.02	-0.02(-0.06, 0.03)
Income level	17.72	3.38	-4.56(-11.18, 2.06)

Factors associated with poor blood pressure control among people living with diabetes mellitus in sub-Saharan Africa

In the random effect model of meta-analysis of identified associated factors, the pooled effect of four studies (11, 50, 55, 65) showed, poor adherence to antihypertensive treatments (POR =1.7; 95% CI: 1.03, 2.80, $I^2=0.0\%$, $p=0.531$) was significantly associated with poor blood pressure control among peoples living with diabetes mellitus (Figure 5). The pooled effect of other three studies (52, 53, 55) also showed that body mass index (BMI) of $\geq 25\text{kg/m}^2$ (POR =2.4, 95% CI: 1.57, 3.68), $I^2=0.00\%$, $p=0.47$) was significantly associated with poor blood pressure control (Figure 06). On the other hand the pooled effect of eight studies (11, 50, 52, 53, 55, 64-66) showed that sex (POR=0.7, 95% CI, 0.49 - 1.12, $I^2= 74.1\%$, $p=0.001$) was not significantly associated with poor blood pressure control (Figure 07). The odds of poor blood pressure control among diabetic peoples with poor adherence to antihypertensive treatment was 1.7 times higher than the counter parts. Body mass index of $\geq 25\text{ kg/m}^2$ was associated with a 2.4 times more likelihood of having poor blood pressure control (Table 4).

Table 4: Summary of the pooled effects of factors associated with poor blood pressure control among diabetics in sub-Saharan countries

Variables			OR (95% CI)	Heterogeneity (I ² , P-value)	Egger's P-value	Total studies	Sample size
Sex	Male	1					
	Female	0.7(0.49 - 1.12)	74.1%, <0.001	0.16	9	2,619	
Poor adherence to antihypertensive treatments	Yes	1.7(1.03, 2.80) *	0.0%, <0.53	0.42	4	1,052	
	No	1					
BMI (kg/m ²)	<25	1					
	≥25 kg/m ²	2.4(1.57, 3.68)*	0.0%, <0.47	0.632	3	750	

Discussion

In peoples living with diabetes, the risk of developing CVD and life-threatening complications is determined by the degree of control of hypertension. However, the rate of control of hypertension is often inadequate and the cardiovascular complications in SSA diabetic individuals are attributed to poor blood pressure control (14, 27, 68). This systematic review and meta-analysis estimated the pooled prevalence and associated factors of poor blood pressure control among peoples living with diabetes mellitus in sub-Saharan Africa.

The pooled prevalence of poor blood control in diabetes patients among 21 studies in SSA was 69.8% (95% CI: 63.43, 76.25%). But due to the difference in blood pressure cut point used to diagnose poor BP control by these studies, subgroup analysis was done by BP cut point. Accordingly, the pooled prevalence of poor blood control among diabetes patients in seven SSA studies that use 130/80 mmHg as cut point was 77.7% (95% CI: 66.92, 88.39) which is in line with a LEADER trail study among type 2 diabetes patients in 32 countries (74%) (69), a large scale study in Malaysia (76.5%) (70), and a systematic review and meta-analysis of 44 studies (88%) that use the same BP cut point to diagnose poor blood pressure control (71). The high prevalence of poor BP control in people with diabetes might be due to different factors, like the likelihood that a more emphasis on glucose control and under emphasis of treatment for associated risk factors such as hypertension (71). In addition, inadequate access to follow-up care and prescription medications, inappropriate or ineffective treatments, poor adherence to prescription medication and lifestyle modifications or a combination of these factors may be responsible (72, 73). Low compliance is the main reason for poor control of blood pressure in SSA (74). This high prevalence of poor blood pressure control among diabetes suggests urgent need for initiatives to improve and control of hypertension.

However, the prevalence of poor BP control in this review is higher than the finding of a review of 16 studies (64.8%) (75), a nationwide study in Korea (60.1%) (76), a study in Malaysia (52.8%) (77), and other large scale cohort studies (59.7%) (78) and (60%) (79). This inconsistency could be explained by the fact that patients in SSA countries have low socioeconomic status and poor wealth index that are attributed to the weak health systems resulting in poor access to medications and healthier life style (80, 81). They have low access to quality healthcare services, are more likely to have low healthier lifestyle and to be non-adherent to their medications due to barriers in accessing medical care, unaffordable health care costs, lack of transport money to visit the hospital and other reasons, leading to poor blood pressure control (82, 83). A great proportion of populations in SSA countries have no access to more than one blood pressure lowering drugs and, when they are available, they are not affordable (84). Poor dietary quality and practice such as, high saturated- and trans-fatty acid intake, and low fruit and vegetable consumption and physical inactivity are increasingly becoming prevalent in low and middle income countries (LMICs) (81, 85–87). The mean salt intake in most of the LMICs is also beyond the

recommended maximum intake (88). These all factors might contribute to the higher prevalence of poor BP control in SSA.

On the contrary, the prevalence of poor BP control among peoples living with diabetes in this review is lower than the prevalence of poor blood pressure control in Spain (90.2%) (89). This variation may possibly due to difference in; proportion of overweight and obesity, magnitude of co-morbidity, age of study participants, and patient, physician and sociocultural factors, which are hypothesized to have impact on BP control (90, 91).

On the other nine studies of this review which used BP cut point of 140/90, the pooled prevalence of poor blood pressure control was 70.0% (95% CI: 61.9%, 78.08). A similar study that uses the same BP cut point to diagnose poor blood pressure control in Saudi Arabia among 1178 diabetic reported a consistent finding (71.8%) (92). In this systematic review and meta-analysis, the lowest pooled prevalence of poor blood pressure control (55.3%) was found in three studies that uses BP cut point of 140/80. This finding is lower than any of the above prevalence reports, which is clearly due to the BP cut point used to diagnose poor BP control.

In this review, diabetes patients with poor adherence to antihypertensive medications were more likely to have poor blood pressure control. This finding is in agreement with existing literature showing higher prevalence of poor blood pressure control among patients with poor adherence (70, 76, 93, 94). This is due to the fact that adherence to antihypertensive therapies is a primary determinant of treatment success and poor medication adherence is the primary cause for poor control of BP (95). Poor adherence attenuates effectiveness of antihypertensive drugs. Moreover, it is noticeable that poorly adherent patients are less likely to undertake a healthier life style, contributing to poor BP control (94). Therefore, this review indicates the need of counseling and encouraging patients to adhere to antihypertensive medications, as adherence to antihypertensive medications is a key to achieving an optimal BP.

In the current review, BMI of 25 kg/m² or greater was associated with poor blood pressure control. Consistently, other studies reported that being obese is associated with poor blood pressure control (70, 76, 96–100). In obesity there is an increased production of leptin, a polypeptide produced from adipocyte which stimulate sympathetic activity leading to renal water retention, increased heart rate and peripheral vascular resistance, and finally worsening of hypertension (101). Besides, obesity decreases sensitivity of peripheral tissues to insulin (causing insulin resistance) resulting compensatory hyperinsulinemia. This increased insulin has a primary effect on activation of sympathetic nervous system, endothelial dysfunction, and failure of peripheral vasodilation (102). Insulin or leptin induced activation of sympathetic nervous system is also associated with tubular sodium reabsorption and volume expansion, and consequent increased blood pressure (103). Moreover, an increase in BMI results in increased renin and plasma angiotensin-converting enzyme activity, angiotensin level, and plasma aldosterone (104), thereby causing poor blood pressure control.

Findings from the current review might be helpful for clinicians, programmers, and policymakers to design a strategy and take prompt interventions which would prevent complications and death due to uncontrolled hypertension in peoples living with diabetes and hypertension comorbidity.

Limitations

Though sensitivity, subgroup, and meta-regression analyses were conducted to minimize the effect of heterogeneity, the extent of heterogeneity among the included studies was high, which might be due to the difference in the study area, methodology, study period, blood pressure cut point used, and other unexplained variations. Use of different BP cut points by primary studies to define poor blood pressure control in DM patients was the other possible limitation of this review. Hence, clinicians and policymakers should consider these during the interpretations of results.

Conclusion

The pooled prevalence of poor blood pressure control among peoples with diabetes was high. Only one third of diabetic patients had achieved target blood pressure. This high prevalence of poor BP in hypertensive diabetic peoples highlights the urgency for primary health care re-engineering and an urgent need for initiatives to improve and control of hypertension. BMI of 25 kg/m² or greater and poor adherence to antihypertensive treatments were significantly associated with poor blood pressure control. Preventive measures should concentrate on overweight patients and patients with poor adherence to antihypertensive medications.

Abbreviations

BP: Blood Pressure; BMI: Body Mass Index; DBP: Diastolic Blood Pressure (DBP); DM: Diabetes Mellitus; LMICs: Low and Middle Income Countries; SBP: Systolic Blood Pressure; SSA: sub Saharan African Countries; T2DM: Type 2 Diabetes Mellitus

Declarations

Ethics approval and consent to participate

Not Applicable

Consent for publication.

Not applicable.

Availability of data and materials

All the materials and data are presented within the manuscript.

Competing interests

All authors declared that there is no competing interest.

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Authors' contribution

YA, YY, GAT, BD: conceived the design; MG and SAT develop the search strategy;

YA, YY, GAT, DAA, ABT: searched, screened, and appraised the studies, and extract the data: SAT analyzed the data; GAT, YA, BD, ABT, MG: drafted the manuscript. All authors read and approved the final manuscript for publication.

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Figures

Figure 1

PRISMA flow diagram for a systematic review and meta-analysis of poor blood pressure control among people living with diabetes in sub-Saharan African countries

Figure 1

PRISMA flow diagram for a systematic review and meta-analysis of poor blood pressure control among people living with diabetes in sub-Saharan African countries

Figure 2

Forest plot for meta-analysis of poor blood pressure control among DM patients in sub-Saharan Africa countries (N = 21)

Figure 2

Forest plot for meta-analysis of poor blood pressure control among DM patients in sub-Saharan Africa countries (N = 21)

Figure 3

Funnel plot testing publication bias (random, N = 21)

Figure 3

Funnel plot testing publication bias (random, N = 21)

Figure 4

Sensitivity analysis between studies included in a meta-analysis

Figure 4

Sensitivity analysis between studies included in a meta-analysis

Figure 5

Forest plot for the association between poor adherence to antihypertensive drugs and poor blood pressure control among diabetic peoples in sub-Saharan countries

Figure 5

Forest plot for the association between poor adherence to antihypertensive drugs and poor blood pressure control among diabetic peoples in sub-Saharan countries

Figure 6

Forest plot for the association between BMI and poor blood pressure control among diabetic peoples in sub-Saharan countries.

Figure 6

Forest plot for the association between BMI and poor blood pressure control among diabetic peoples in sub-Saharan countries.

Figure 7

Forest plot for the association between sex (being female) and poor blood pressure control among diabetic peoples in sub-Saharan countries.

Figure 7

Forest plot for the association between sex (being female) and poor blood pressure control among diabetic peoples in sub-Saharan countries.

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