Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis

Presented by

Dr Jean Jacques Noubiap Nzeale
Student number: NBPJEA001

Submitted to the University of Cape Town
In fulfilment of the requirement of the degree

MMed (Master in Internal Medicine)

Faculty of Health Sciences
University of Cape Town

Supervised by

Prof Andre Pascal Kengne
Department of Medicine, University of Cape Town
Non-communicable Disease Research Unit,
South African Medical Research Council, Cape Town, South Africa

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I- DECLARATION

I, **Jean Jacques Noubiap Nzeale**, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Signed by candidate

24 February 2019

II- DEDICATION

To my late father Jacques NZEALE who always gave me all the support I needed for my academic fulfilment.

III- ABSTRACT

Background

The burden of dyslipidaemia in Africa remains inadequately characterised. We aimed to estimate the prevalence of dyslipidaemia in African adults from hospital-based and community-based studies.

Methods

In this systematic review and meta-analysis, we searched MEDLINE via PubMed, EMBASE, African Journals Online, and African Index Medicus for studies published between Jan 1, 1980, and July 31, 2017, without language restriction. We assessed methodological quality of all crosssectional studies reporting on the prevalence of elevated concentrations of total cholesterol, LDL cholesterol, or triglycerides, or low concentrations of HDL cholesterol in adults residing in African countries. We excluded reports on Africans living outside Africa, studies of individuals selected on the basis of existing dyslipidaemia or those including children and adolescents, and case series with a small sample size. The most frequently used cutoffs in the included studies were chosen for the subgroup analysis. We used random-effect model meta-analysis to derive the pooled prevalence of elevated total cholesterol, low HDL cholesterol, elevated LDL cholesterol, and elevated triglyceride concentrations. This study is registered with PROSPERO, number CRD42014015376. **Findings**

177 studies (294063 participants) were included in the meta-analysis. The pooled prevalence of dyslipidaemia in the general population from population-based studies was 25·5% (95% CI 20·0–31·4) for elevated concentrations of total cholesterol with a cutoff of at least 5·2 mmol/L, 37·4% (29·4–45·7) for low concentrations of HDL cholesterol with a cutoff of less than 1·0 mmol/L,

28·6% (15·8–43·5) for elevated concentrations of LDL cholesterol with a cutoff of at least 3·3 mmol/L, and 17·0% (11·9–22·7) for elevated concentrations of triglycerides with a cutoff of at least 1·7 mmol/L.

Interpretation

The prevalence of dyslipidaemia is high in the general adult population in Africa. Ongoing efforts to reduce cardiovascular diseases in Africa should integrate effective detection and treatment of dyslipidaemia.

IV- ACKNOWLEDGEMENTS

I would like to acknowledge the following persons for their contribution to this dissertation: Dr Jean Joel Bigna (JJB), Dr Jobert Richie Nansseu (JRN), Dr Ulrich Flore Nyaga (UFN), Dr Eric Vounsia Balti (EVB), Dr Justin Basile Echouffo-Tcheugui (JBET) and Prof Andre Pascal Kengne (APK). Their contributions and mine (JJN) are as follows:

JJN, JBET, and APK conceived the idea of the study and, together with JJB and JRN, developed the protocol. JJN, APK, JBET, and JJB did the literature search. JJN, JJB, and UFN selected the studies and extracted the relevant information. JJB, JJN, and APK synthesised the data. JJN, JRN, and JJB wrote the first draft of the paper. JJN, JJB, JRN, UFN, EVB, JBET, and APK critically revised successive drafts of the paper and approved the final version. APK supervised the overall work and is the guarantor of the review.

V- PUBLISHED ARTICLE

This research work was published as referenced below[1]. After publication, it appeared that there was an oversight in the initial paper. An erratum (please see Chapter VI) along with a corrected version of the article[1] _which is presented below_ were then published.

1- Noubiap JJ, Bigna JJ, Nansseu JR et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health*. 2018;6(9):e998-e1007.

Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis

Jean Jacques Noubiap, Jean Joel Bigna, Jobert Richie Nansseu, Ulrich Flore Nyaga, Eric Vounsia Balti, Justin B Echouffo-Tcheugui, André Pascal Kengne

Summary

Background The burden of dyslipidaemia in Africa remains inadequately characterised. We aimed to estimate the prevalence of dyslipidaemia in African adults from hospital-based and community-based studies.

Methods In this systematic review and meta-analysis, we searched MEDLINE via PubMed, Embase, African Journals Online, and African Index Medicus for studies published between Jan 1, 1980, and July 31, 2017, without language restriction. We assessed methodological quality of all cross-sectional studies reporting on the prevalence of elevated concentrations of total cholesterol, LDL cholesterol, or triglycerides, or low concentrations of HDL cholesterol in adults residing in African countries. We excluded reports on Africans living outside Africa, studies of individuals selected on the basis of existing dyslipidaemia or those including children and adolescents, and case series with a small sample size. The most frequently used cutoffs in the included studies were chosen for the subgroup analysis. We used random-effect model meta-analysis to derive the pooled prevalence of elevated total cholesterol, low HDL cholesterol, elevated LDL cholesterol, and elevated triglyceride concentrations. This study is registered with PROSPERO, number CRD42014015376.

Findings 177 studies (294 063 participants) were included in the meta-analysis. The pooled prevalence of dyslipidaemia in the general population from population-based studies was 25·5% (95% CI 20·0–31·4) for elevated concentrations of total cholesterol with a cutoff of at least 5·2 mmol/L, 37·4% (29·4–45·7) for low concentrations of HDL cholesterol with a cutoff of less than 1·0 mmol/L, 28·6% (15·8–43·5) for elevated concentrations of LDL cholesterol with a cutoff of at least 3·3 mmol/L, and 17·0% (11·9–22·7) for elevated concentrations of triglycerides with a cutoff of at least 1·7 mmol/L.

Interpretation The prevalence of dyslipidaemia is high in the general adult population in Africa. Ongoing efforts to reduce cardiovascular diseases in Africa should integrate effective detection and treatment of dyslipidaemia.

Funding None.

Lancet Glob Health 2018; 6: e998–1007

This online publication has been corrected. The corrected version first appeared at thelancet.com/lancetgh on December 12, 2018

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Department of Medicine, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa (J J Noubiap MD, A P Kengne MD); Faculty of Medicine, University of Paris Sud XI, Le Kremlin-Bicêtre, France (J J Bigna MD); Department of Public Health (J R Nansseu MD) and Department of Internal Medicine and Specialties (U F Nyaga MD), Faculty of Medicine and Biomedical Sciences, University of Yaoundé I, Yaoundé, Cameroon; Diabetes Research Center, Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel, Brussels, Belgium (E V Balti MD); Department of Internal Medicine, Universiteit Ziekenhuis Brussel, Brussels, Belgium (E V Balti); Division of Endocrinology, Diabetes and Hypertension, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA (J B Echouffo-Tcheugui MD); and Non-communicable Disease Research Unit, South African Medical Research Council, Cape Town, South Africa (A P Kengne)

Correspondence to:
Prof André Pascal Kengne, Non-communicable Disease Research Unit, South African Medical Research Council, Cape Town, 7505 Tygerberg, South Africa
andre.kengne@mrc.ac.za

See Online for appendix

Introduction

Substantial changes in population health are occurring in Africa, marked by the rising burden of cardiovascular diseases (CVDs), which are set to overtake infectious diseases as the leading cause of death by 2030.[1] This epidemiological shift is driven by unhealthy lifestyles due to rapid urbanisation and westernisation.[1] In low-income and middle-income countries, the surge in CVD burden is purported to be the consequence of increasing prevalence of cardiovascular risk factors, mostly hypertension, diabetes, and obesity.[1]

Dyslipidaemia is defined as the presence of abnormal blood concentrations of one or more of the following: total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides.[2] Dyslipidaemia is a leading contributor to CVD and mortality globally.[1,3] In 2016, the Global Burden of Disease study reported that high concentrations of total cholesterol caused about 4·4 million deaths and 93·8 million disability-adjusted life-years (DALYs), representing the seventh and eighth leading risk factors in terms of attributable DALYs globally for women and men, respectively.[4,5] Definitive evidence exists that effective treatment of dyslipidaemia markedly reduces CVD morbidity and premature mortality.[3,6–8]

The prevalence of major CVD risk factors in Africa has been estimated at the continental and regional level for diabetes and hypertension,[1] but not for dyslipidaemia. Therefore, we did a systematic review and meta-analysis of the prevalence of dyslipidaemia in African populations at the hospital and community levels to guide prevention, detection, and control strategies.

Methods

Search strategy and selection criteria

This report is in accordance with the Meta-analyses and Systematic reviews of Observational Studies (MOOSE; appendix). The protocol was registered in the PROSPERO International Prospective Register of systematic reviews (number CRD42014015376) and published elsewhere.[9]

We searched MEDLINE via PubMed, Embase, African Journals Online, and African Index Medicus to identify

Research in context

Evidence before this study

Despite the importance of dyslipidaemia as a major cardiovascular risk factor, dyslipidaemia remains inadequately characterised in African populations. WHO has estimated the prevalence of raised concentrations of total cholesterol to be 23·1% in Africans aged 25 years or older in 2008. No other estimation is available on the burden of dyslipidaemia in African populations. We searched PubMed and Embase between Jan 1, 1980, and July 31, 2017, without language restriction, with terms including "dyslipidemia", "hyperlipidemia", "lipid disorder", "hypercholesterolemia", "hypertriglyceridemia", and "Africa" to identify studies summarising epidemiological data on dyslipidaemia in African populations.

Added value of this study

To our knowledge, this is the first comprehensive overview of published population-based and hospital-based studies on the prevalence of elevated concentrations of total cholesterol, LDL cholesterol, and triglycerides, and low HDL cholesterol concentrations in adults in Africa. Our study suggests high prevalence of dyslipidaemia in African adults, with low HDL cholesterol concentrations being the most common and elevated triglyceride concentrations the less frequent type of dyslipidaemia. The prevalence of dyslipidaemia seems to be higher in urban areas than in rural areas and similar in men and women. High prevalence of dyslipidaemia was also observed in patients with coexisting major cardiovascular risk factors such as diabetes, hypertension, or HIV.

Implications of all the available evidence

Control of dyslipidaemia should be part of strategies to reduce the burden of cardiovascular disease in Africa. Effective interventions for the scaling up of access to tests, building of capacities of health-care professionals in the management of dyslipidaemia, and improvement of access to lipid-modifying therapies, are essential.

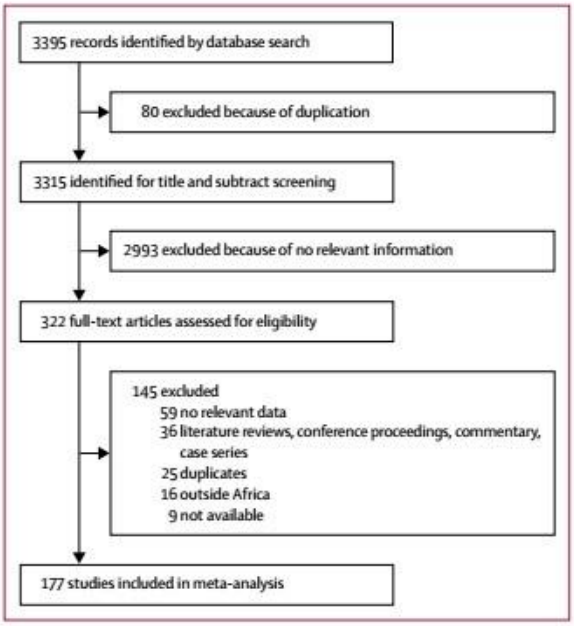

Figure 1: **Study selection**

all relevant articles published between Jan 1, 1980, and July 31, 2017, on the prevalence of dyslipidaemia in adults residing in Africa, without language restriction. We applied a search strategy combining relevant terms and names of each of the 54 African countries and African subregions. Search terms for dyslipidaemia included "dyslipidemia", "hyperlipidemia", "lipid disorder", "hypercholesterolemia", and "hypertriglyceridemia". The main search strategy done in PubMed was adapted to suit other databases and is available in the protocol.[9] We manually searched the reference list of all relevant articles and reviews to identify additional articles.

We included all cross-sectional studies reporting on the prevalence of elevated concentrations of total cholesterol, LDL cholesterol, or triglycerides, or low concentrations of HDL cholesterol in adults residing in African countries, or enough data to compute it. We excluded reports on Africans residing outside Africa, studies of individuals selected on the basis of existing dyslipidaemia (eg, clinical trials or case-control studies), and studies including children and adolescents. Case series with a small sample size (less than 50 patients), commentaries, editorials, letters, reviews, and studies without primary data or explicit description of methods, or both, were also excluded. For studies published in more than one report, the most comprehensive with the largest sample size was considered.

Two investigators independently screened the titles and abstracts of articles retrieved from the literature search, and the full texts of potentially eligible articles were obtained and further assessed for final inclusion (figure 1). Disagreements were resolved through consensus.

Data analysis

Methodological quality of included studies was evaluated with the tool developed by Hoy and colleagues.[10] A score of 1 (yes) or 0 (no) was assigned for each item, and scores were summed across items to generate an overall quality score that ranged from 0 to 10. Studies were then classified as having a low (>8), moderate (6–8), or high (≤5) risk of bias. Two investigators independently assessed the study's methodological quality, with disagreements resolved by consensus.

	Total cholesterol	HDL cholesterol	LDL cholesterol	Triglycerides	All studies
Studies	134	118	83	151	177
Year of publication	1982–2017	1989–2017	1996–2017	1982–2017	1982–2017
Number of participants	181722	145777	119251	207139	304545
Age range, years	28·8–73·7 (106 studies)	20·0–69·0 (107 studies)	28·8–69·0 (76 studies)	20·0–69·0 (130 studies)	20·0–73·7 (178 studies)
Men	0–100%	0–100%	0–85%	0–100%	0–100%
Disease specific					
No	83 (49·7%)	60 (42·3%)	36 (35·6%)	81 (44·7%)	85 (44·7%)
Yes	77 (46·1%)	78 (54·9%)	60 (61·4%)	91 (50·3%)	94 (49·5%)
Yes and no	7 (4·2%)	4 (2·8%)	5 (5·0%)	9 (5·0%)	11 (5·8%)
Areas					
Urban	118 (70·2%)	112 (78·9%)	80 (79·2%)	139 (76·8%)	137 (72·1%)
Rural	20 (11·9%)	17 (12·0%)	15 (4·9%)	22 (12·2%)	20 (10·5%)
Urban and rural	27 (16·1%)	13 (9·1%)	6 (5·9%)	20 (11·0%)	27 (14·2%)
Imprecise	6 (3·8%)	..	..	..	6 (3·2%)
Site					
Hospital based	98 (58·3%)	99 (69·7%)	77 (76·2%)	120 (66·3%)	119 (62·6%)
Population based	69 (41·1%)	43 (30·3%)	24 (23·8%)	61 (33·7%)	70 (36·8%)
Imprecise	1 (0·6%)	..	..	..	1 (0·5%)
Representativeness					
National	15 (8·9%)	3 (2·1%)	0	9 (5·0%)	17 (8·9%)
Subnational	149 (88·7%)	136 (95·8%)	100 (99·0%)	169 (93·4%)	167 (87·9%)
Multinational	4 (2·4%)	3 (2·1%)	1 (1·0%)	3 (1·6%)	6 (3·2%)
Regions					
Central Africa	15 (8·9%)	11 (7·7%)	11 (10·9%)	16 (8·8%)	22 (11·6%)
Eastern Africa	47 (28·0%)	30 (21·1%)	27 (26·7%)	38 (21·0%)	43 (22·6%)
Northern Africa	30 (17·9%)	28 (19·7%)	13 (12·9%)	38 (21·0%)	34 (17·9%)
Southern Africa	27 (16·1%)	27 (19·0%)	19 (18·8%)	33 (18·2%)	37 (19·5%)
Western Africa	48 (28·6%)	45 (31·7%)	29 (28·7%)	55 (30·4%)	53 (27·9%)
Multi-regional	1 (0·6%)	1 (0·7%)	1 (1·0%)	1 (0·6%)	1 (0·5%)
Cutoffs, mmol/L					
Cutoff one	≥3·8 (n=1; 0·6%)	<0·8 (n=1; 0·7%)	≥2·6 (n=20; 19·8%)	≥1·2 (n=1; 0·6%)	..
Cutoff two	≥4·5 (n=6; 3·6%)	<0·9 (n=16; 11·3%)	≥3·3 (n=64; 63·4%)	≥1·4 (n=1; 0·6%)	..
Cutoff three	≥5·2 (n=117; 70·1%)	<1·0 (n=121; 85·2%)	≥4·0 (n=17; 16·8%)	≥1·7 (n=142; 78·5%)	..
Cutoff four	≥6·5 (n=39; 23·3%)	<1·2 (n=2; 1·4%)	..	≥2·2 (n=34; 18·8%)	..
Cutoff five	≥7·0 (n=4; 2·4%)	<1·3 (n=1; 0·7%)	..	≥4·5 (n=2; 1·1%)	..
Cutoff six	Imprecise (n=1; 0·6%)	<1·6 (n=1; 0·7%)	..	≥5·2 (n=1; 0·6%)	..

Table: **Characteristics of included studies**

Two investigators independently extracted relevant data from individual studies using a preconceived and standardised data extraction form. Information extracted included: first author's name, year of publication, country, area (rural *vs* urban), study design, setting (hospital or community based), sample size, mean or median age and age range, proportion of men, any disease specific to the study population, forms of dyslipidaemia investigated (ie, elevated total cholesterol, low HDL cholesterol, elevated LDL cholesterol, or elevated triglyceride concentrations), diagnostic cutoff, and the number of participants with dyslipidaemia. Studies used various cutoffs to define dyslipidaemia, reflecting the evolution of guidelines for the diagnosis and management of dyslipidaemia. Only the most frequently used cutoffs were considered. On the basis of the country of recruitment, a WHO African region was assigned to each study. Disagreements between investigators were resolved through consensus.

Data analyses used the meta package of R, version 3.5.1. To minimise the influence from studies with extreme prevalence estimates on the overall estimate, we first stabilised the variance of study-specific prevalence using the Freeman-Tukey double-arcsine transformation[11] before pooling using random effects model meta-analysis.[12] Heterogeneity between studies was assessed with Cochran's Q, I^2, and H statistics.[13] The I^2 statistic estimates the percentage of total variation across studies due to true between-study differences rather than chance. Generally, I^2 values greater than 60–70% indicate the presence of substantial

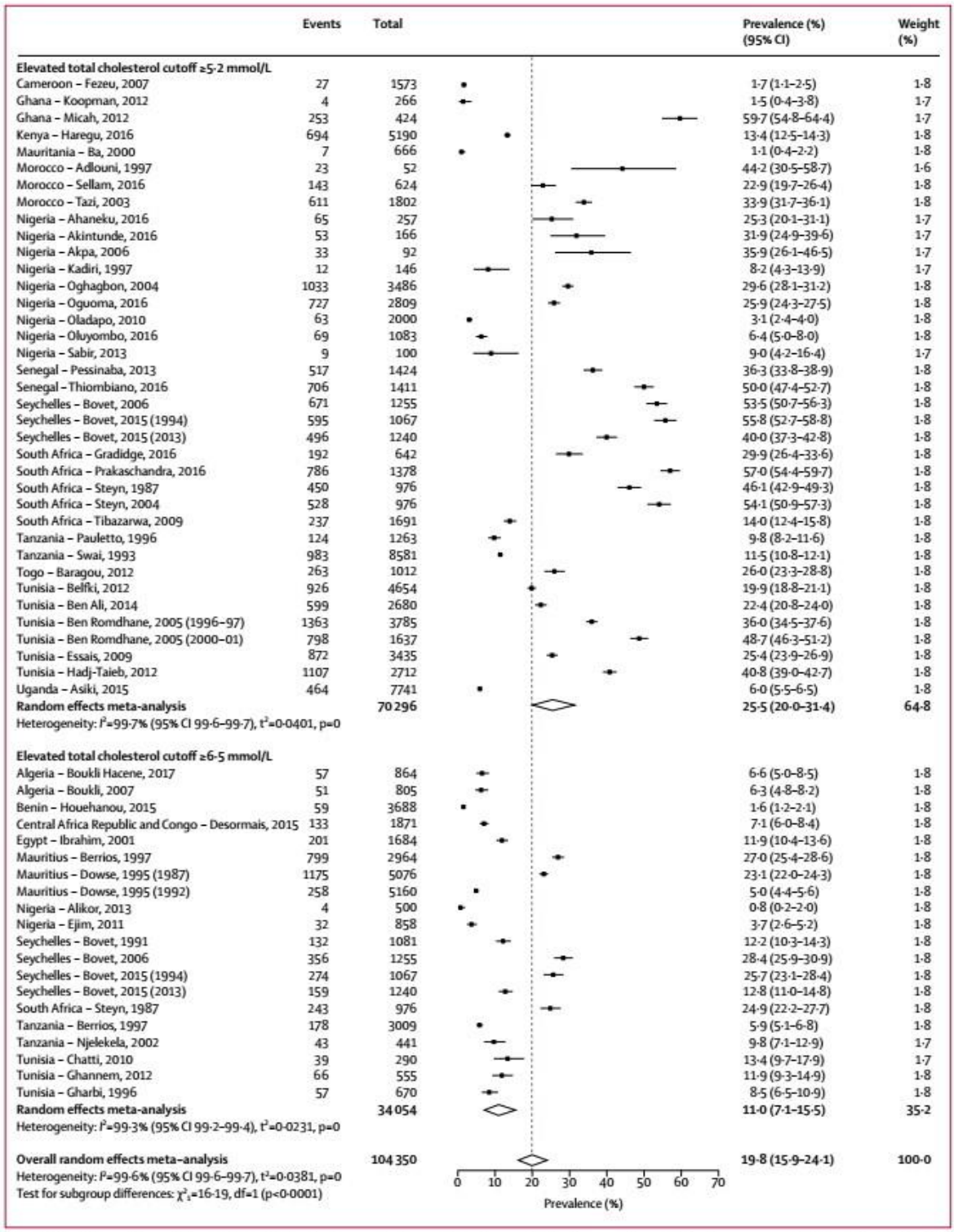

Figure 2: **Pooled prevalence of elevated total cholesterol concentrations with various cutoffs in the general population from community-based studies in Africa**
References are listed alphabetically in the appendix. Df=degrees of freedom.

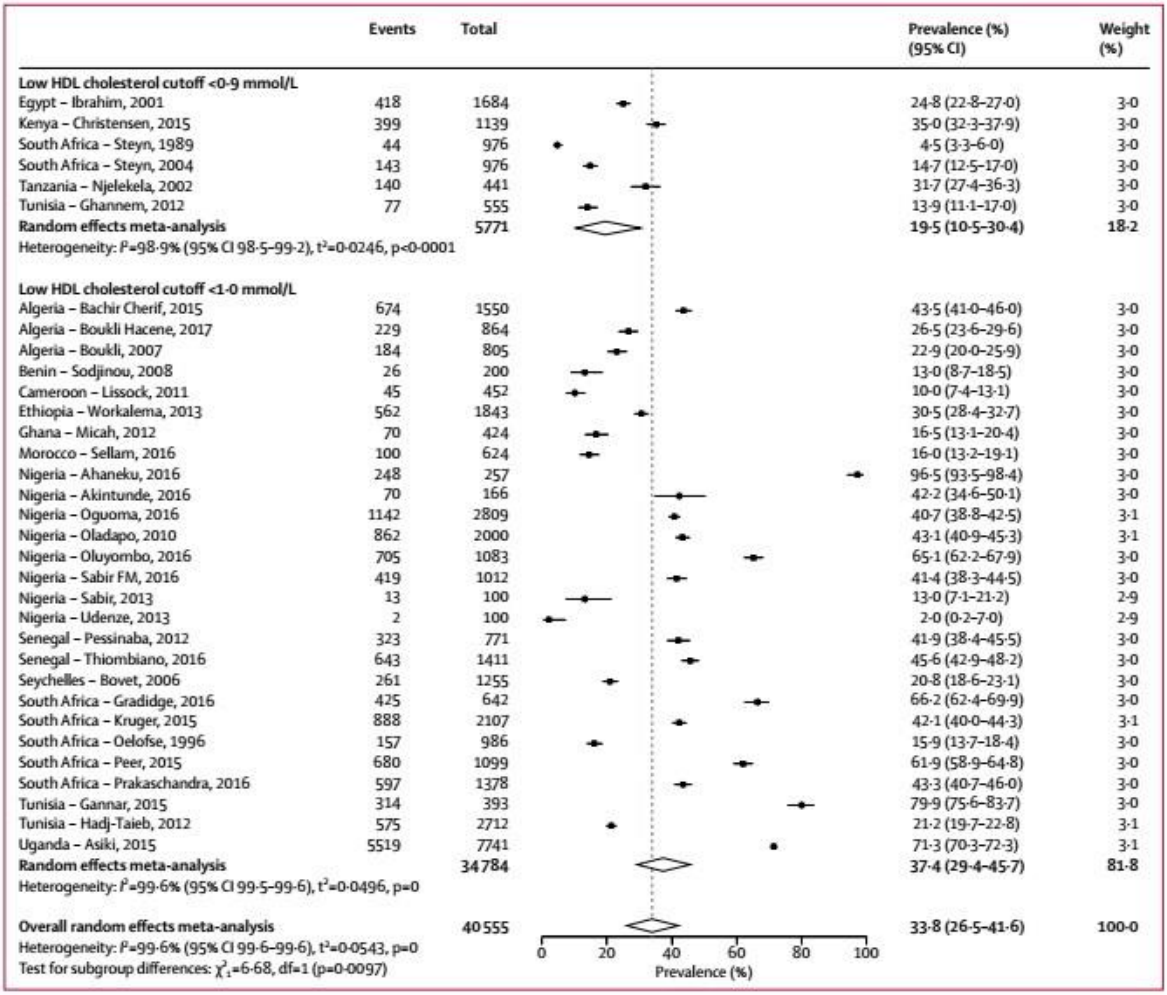

Figure 3: **Pooled prevalence of low HDL cholesterol concentrations with various cutoffs in the general population from community-based studies in Africa**
References are listed alphabetically in the appendix. Df=degrees of freedom.

heterogeneity. For population-based studies of apparently healthy participants, we explored sources of heterogeneity by comparing the prevalence between subgroups defined by several study-level characteristics. The most frequently used cutoffs in the included studies were chosen for the subgroup analysis. For studies reporting on low HDL cholesterol concentrations with a diagnostic cutoff of less than 0·9 mmol/L for men and less than 1·0 mmol/L for women, the overall diagnostic cutoff was reported as less than 1·0 mmol/L for both sexes to facilitate cutoff grouping and statistical analyses. We assessed the presence of publication bias using the Egger test of bias,[14] with p<0·10 indicating significant publication bias. We assessed inter-rater agreement for study inclusion and data extraction using Cohen's kappa coefficient (κ).[15]

Role of the funding source

There was no funding source for this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Of 3395 records identified, 3315 remained after elimination of duplicates. After screening titles and abstracts, we found 2993 records to be irrelevant and excluded them. We assessed full texts of the remaining 322 papers for eligibility, of which 145 were excluded (figure 1). The inter-rater agreement for study selection was high (κ=0·81; appendix). 177 studies were included for meta-analysis of prevalence (appendix pp 28–45), with 134 reporting on total cholesterol, 83 on LDL cholesterol, 118 on HDL cholesterol, and 151 on triglycerides. The most frequently used diagnostic cutoffs were at least 5·2 mmol/L (70·1%) for total cholesterol, less than 1·0 mmol/L (85·2%) for HDL cholesterol, at least 3·3 mmol/L (63·4%) for LDL cholesterol, and at least 1·7 mmol/L (78·5%) for triglyceride concentrations. Of 181 studies, one (0·6%), 68 (37·6%), and

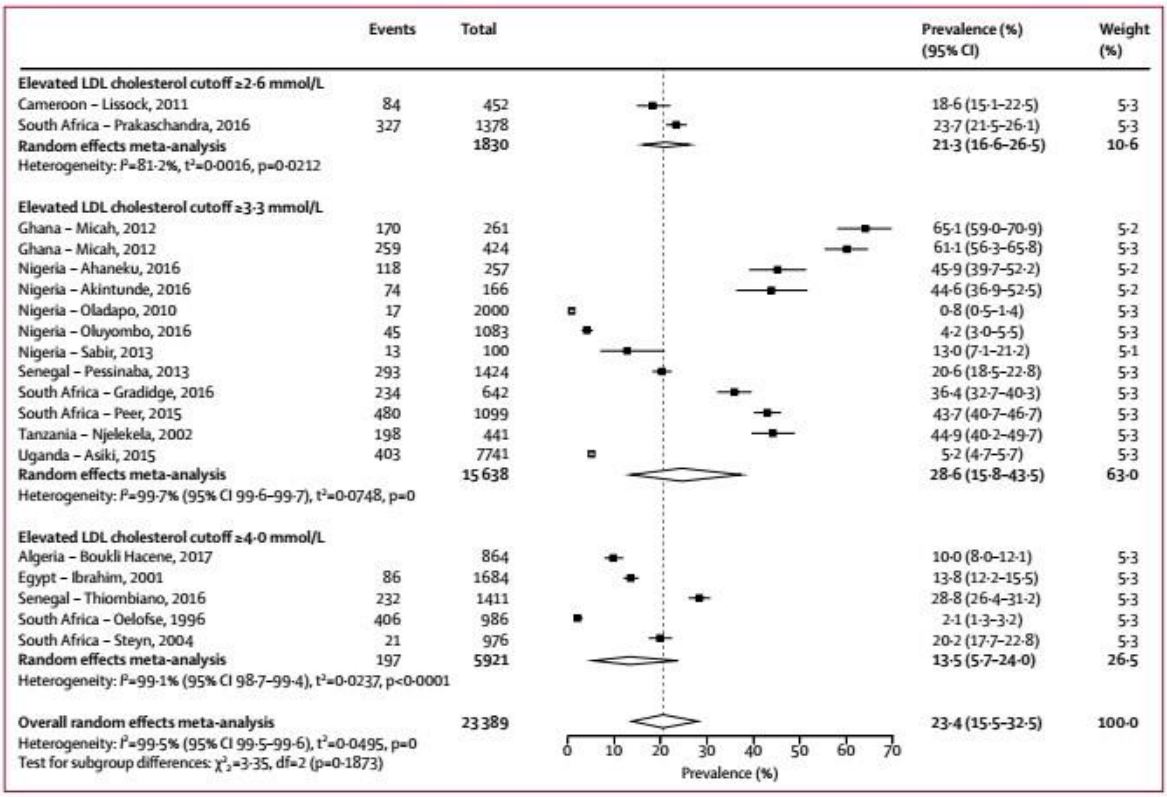

Figure 4: **Pooled prevalence of elevated LDL cholesterol concentrations with various cutoffs in the general population from community-based studies in Africa**
References are listed alphabetically in the appendix. Df=degrees of freedom.

112 (61·9%) were classified as having high, moderate, and low risk of bias, respectively. Overall, most studies were from western Africa, were sub-national surveys or hospital based, were done in urban areas, and were done in people with a specific disease. The age ranged from 20·0 years to 73·7 years. Three to six cutoffs were used to diagnose each type of dyslipidaemia (table).

The overall prevalence of elevated total cholesterol concentrations was 25·5% (95% CI 20·0–31·4) and 11·0% (7·1–15·5) by use of cutoffs of at least 5·2 mmol/L and at least 6·5 mmol/L, respectively (p=0·0003 for difference across criteria; figure 2), with publication bias for the cutoff of at least 5·2 mmol/L (appendix). The prevalence varied widely across regions: it was higher in urban areas than in rural areas, regardless of the cutoff used, and higher in national representative studies than in subnational studies (35·9% *vs* 20·8%, p=0·005), with a cutoff of at least 5·2 mmol/L. No difference occurred in prevalence by sex, publication date, and sample size (appendix).

In the general population from population-based studies, the overall prevalence of low HDL cholesterol concentrations was 19·5% (95% CI 10·5–30·4) and 37·4% (29·4–45·7) by use of cutoffs of less than 0·9 mmol/L and less than 1·0 mmol/L, respectively (p=0·002 for difference across criteria; figure 3), with a publication bias for the cutoff of less than 1·0 mmol/L. By use of a cutoff of less than 1·0 mmol/L, the prevalence was different across regions (p<0·0001), higher in rural areas than in urban areas (61·1% *vs* 33·3%, p<0·0001), and higher in studies published after 2010 than before (45·0% *vs* 18·4%, p<0·0001; appendix).

The overall prevalence of elevated LDL cholesterol concentrations was 21·4% (95% CI 16·6–26·6), 28·6% (15·8–43·5), and 13·5% (5·7–24·0) by use of cutoffs of at least 2·6 mmol/L, 3·3 mmol/L, and 4·0 mmol/L, respectively (p=0·2262 for difference across criteria; figure 4), with a publication bias for the cutoff of at least 3·3 mmol/L. By use of a cutoff of at least 3·3 mmol/L, the prevalence was higher in urban areas than in rural areas (35·0% *vs* 9·4%, p<0·0001), higher in studies published before 2010 than after (44·9% *vs* 24·4%, p=0·008), and higher in studies with a small sample size than a large sample size (44·2% *vs* 11·3%, p=0·03; appendix).

The overall prevalence of elevated triglyceride concentrations was 17·0% (95% CI 11·9–22·7), 11·2% (7·9–15·1), and 5·0% (3·1–7·2) by use of cutoffs of at least 1·7 mmol/L, 2·2 mmol/L, and 5·2 mmol/L, respectively (p<0·0001 for difference across criteria; figure 5), with no publication bias. The prevalence was different across regions (p=0·0005), higher in urban areas than in rural areas (18·8% *vs* 8·3%, p=0·007), and higher in national representative studies than in subnational studies (34·0% *vs* 14·2%, p=0·009). No difference occurred in

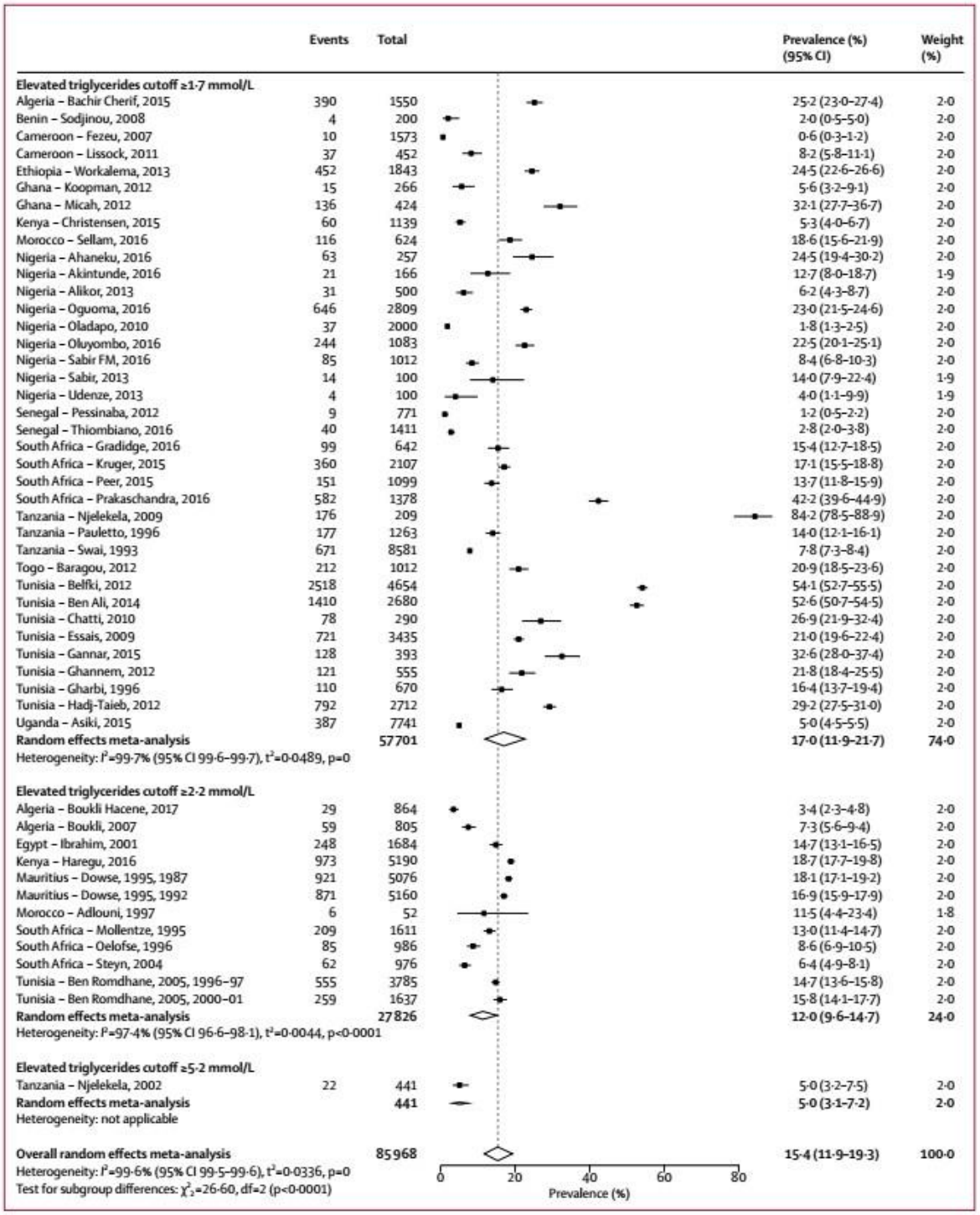

Figure 5: **Pooled prevalence of elevated triglyceride concentrations with various cutoffs in the general population from community-based studies in Africa**
References are listed alphabetically in the appendix. Df=degrees of freedom.

prevalence by sex, publication date, and sample size (appendix).

The overall prevalence of dyslipidaemia was 29·7% (95% CI 12·7–50·1) for elevated total cholesterol concentrations with a cutoff of at least 5·2 mmol/L, 38·6% (29·8–47·8) for low HDL cholesterol concentrations with a cutoff of less than 1·0 mmol/L, 18·5% (6·7–34·2) for elevated LDL cholesterol concentrations with a cutoff of

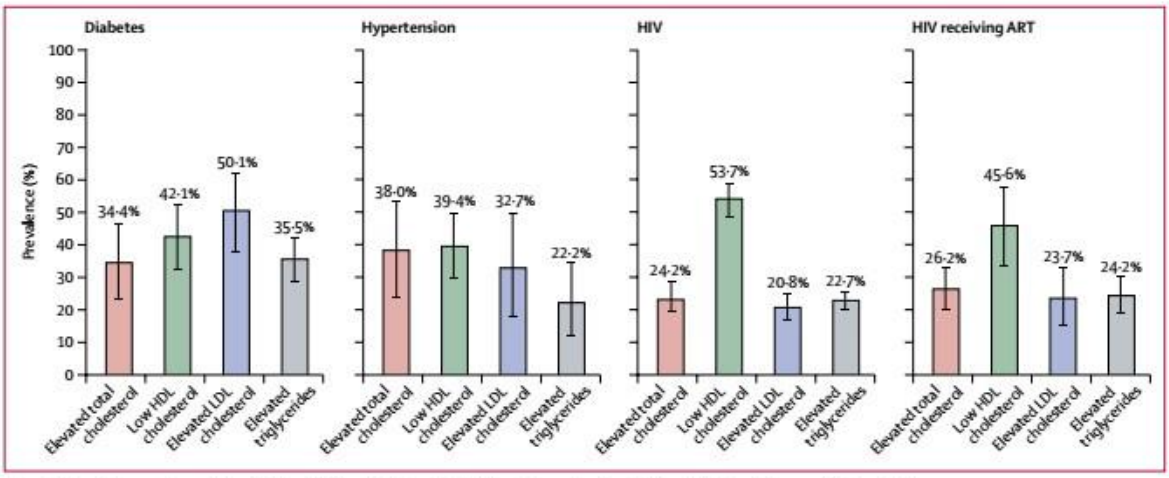

Figure 6: **Pooled prevalence of dyslipidaemia in patients with diabetes, hypertension, HIV, and HIV receiving antiretroviral therapy**
ART=antiretroviral therapy. The cutoff for elevated total cholesterol concentrations was at least 5·2 mmol/L, low HDL cholesterol concentrations was less than 1·0 mmol/L, elevated LDL concentrations was at least 3·3 mmol/L, and elevated triglyceride concentrations was at least 1·7 mmol/L.

at least 3·3 mmol/L, and 26·0% (18·0–34·8) for elevated triglyceride concentrations with a cutoff of at least 1·7 mmol/L (appendix).

In the general population, no significant difference existed in the overall prevalence of elevated total cholesterol (p=0·52, cutoff ≥5·2 mmol/L), low HDL cholesterol (p=0·69, cutoff <1·0 mmol/L), and elevated LDL cholesterol (p=0·44, cutoff ≥3·3 mmol/L) concentrations between the population-based and hospital-based studies; however, higher prevalence was observed in hospital-based studies for elevated triglyceride concentrations (p=0·04, cutoff ≥1·7 mmol/L).

The prevalence of elevated total cholesterol concentrations was 34·4% (95% CI 23·3–46·4) in patients with diabetes and 38·0% (23·8–53·4) in patients with hypertension by use of a cutoff of at least 5·2 mmol/L. The prevalence of low HDL cholesterol concentrations was 39·5% (95% CI 26·7–53·0) in patients with diabetes by use of a cutoff of less than 1·0 mmol/L. The prevalence of elevated triglyceride concentrations was 3·9% (1·2–7·7) in patients with diabetes by use of a cutoff of at least 1·7 mmol/L (appendix).

Figure 6 shows the prevalence of elevated total cholesterol, low HDL cholesterol, elevated LDL cholesterol, and elevated triglyceride concentrations in patients with diabetes, hypertension, HIV, and HIV receiving antiretroviral therapy. For all types of dyslipidaemias, substantial heterogeneity was observed across the contributing studies overall and within subgroups for sex, region, representativeness, date of publication, area, and median sample size, and across cutoff used. Publication bias statistics are reported in the appendix.

Discussion

In this overview of 177 population-based and hospital-based studies of African adults, we observed a high prevalence of dyslipidaemia that varied significantly depending on the cutoff used. Regardless of these cutoffs, at least one in five adults in the general population had dyslipidaemia, with low concentrations of HDL cholesterol being the commonest form. The prevalence of dyslipidaemia did not differ between population-based and hospital-based studies, except for triglyceride concentrations, which were significantly higher in hospital-based studies. Moreover, estimates of dyslipidaemia were much higher in patients with diabetes, hypertension, or HIV than in the general population. Substantial heterogeneities in the estimates were not explained by major study-level characteristics, whereas evidence of publication bias was marginal.

For patient care, the definition of dyslipidaemia is often based on the combination of concentrations of more than one lipid variable.[2] In this study, we reported the prevalence of single components of dyslipidaemia because original studies did not investigate the presence of more than one lipid abnormality. Therefore, our results might not accurately reflect the burden of dyslipidaemia in Africa, especially as some of the cutoffs used are higher than the limits that have been agreed on, which are yet to be validated locally.

Regardless, this study challenges the misbelief that dyslipidaemia is rare in Africa. Our results are consistent with the findings of a meta-analysis on dyslipidaemia among sub-Saharan Africans with established CVD, which found a high prevalence of 38·4% (49·6% for patients with coronary heart disease).[16] Furthermore, our estimates of the frequency of dyslipidaemia—15% to about 50% among African adults—are similar to reports from other parts of the world (33–75%).[17–21] This finding is unsurprising considering the rapid urbanisation and adoption of unhealthy lifestyles occurring across Africa.[1] These estimates are of concern considering the leading contribution of dyslipidaemia to CVD and mortality.[1–3]

Evidence from this study and others suggest that strategies to reduce the risk of CVD in Africa should include effective diagnosis and management of dyslipidaemia in addition to hypertension and diabetes, which are also highly prevalent in the region.[22,23] However, difficulty in the implementation of screening programmes and inadequate access to affordable health care in Africa substantially hinder attainment of these goals. Furthermore, although all guidelines agree that a lipid-lowering medication should be introduced as a pharmacological therapy of dyslipidaemia when indicated,[24] these drugs are unavailable or unaffordable throughout the continent, or both.[25,26] Efforts are needed from local governments, stakeholders, and manufacturers to make these essential medicines available and affordable across Africa.

Other challenges to be considered include low-level knowledge about dyslipidaemia among the public and health-care professionals, along with few experienced and well trained health personnel and the consequential heavy workload.[27,28] Task shifting from physicians to other health workers, nurses, or pharmacists, for instance, has been proposed as a reliable solution by circumventing the shortage of physicians for management of non-communicable diseases in African countries.[29] Additionally, in most countries, no local clinical practice guidelines exist for dyslipidaemia, and where available, uptake of such guidelines is low. Therefore, context-appropriate guidelines should be developed and largely promoted in relevant public health strategies aiming to prevent or control dyslipidaemia throughout Africa.

Unsurprisingly, we observed a high prevalence of dyslipidaemia among patients with HIV. HIV and highly active antiretroviral therapy have been shown to be associated with an increased risk of CVD, dyslipidaemia, and type 2 diabetes; not only among populations of European descent,[30,31] but also among African populations.[32] Therefore, patients with HIV—almost 80% of whom live in sub-Saharan Africa—would benefit from continuous monitoring of dyslipidaemia for timely preventive or corrective measures.[33] Moreover, dyslipidaemia is a correlate of diabetes and hypertension,[34,35] explaining perhaps the higher prevalence observed in these specific populations than in the general population. This finding reinforces the need for an integrated approach to the prevention, detection, and control of non-communicable disease risk factors in Africa.

Our results should be interpreted in the context of some limitations. First, the cutoffs used to define the various patterns of dyslipidaemia were not consistent across studies, partly contributing to the substantial heterogeneity found between studies. Furthermore, these cutoffs have not been validated in African populations. In most of the studies, lipid concentrations were measured only once, leading to possible misdiagnosis. Second, the various subregions of Africa were variably represented and the majority of studies were hospital-based and subnational, which could affect the generalisability of our findings. Third, the studies included in our meta-analyses did not have data on the awareness and treatment of dyslipidaemia. Fourth, almost all studies did not investigate the combination of several parameters, which is sometimes necessary to define dyslipidaemia. For instance, triglyceride concentrations provide relevant information as a predictor of cardiovascular risk mostly when combined with low HDL cholesterol and elevated LDL cholesterol concentrations.[36] Fifth, this paper does not cover important forms of dyslipidaemia, such as elevated non-HDL cholesterol concentrations or apolipoprotein B to apolipoprotein A-I ratio. Lastly, almost all included studies did not provide age-specific or ethnic-specific estimates; therefore, we were unable to derive pooled estimates of dyslipidaemia according to those major characteristics. Some variations in the prevalence of dyslipidaemia are expected across different age groups with the highest prevalence in elderly people, and potentially across ethnic groups within African populations considering racial or ethnic differences in dyslipidaemia patterns observed in American populations (ie, blacks, Asian Americans, Hispanics, and non-Hispanic whites) for instance.[37] However, the huge ethnic diversity in Africa precludes any expectation that comprehensive and reliable ethnic-specific estimates of disease burden or risk factors in Africa could be generated through a study like this one. Strengths of the study include the comprehensive search of multiple databases by use of rigorous and reproducible methodological procedures, and use of robust statistical methods to pool identified studies examining the general population and specific groups.

The prevalence of dyslipidaemia is high in the general adult population in Africa, and much higher in patients with coexisting cardiovascular risk factors such as hypertension, diabetes, or HIV. These findings strengthen the case for action to implement the control of dyslipidaemia more effectively to achieve CVD prevention in African populations. Such efforts include the improvement of access to laboratory testing, training of professionals for dyslipidaemia management, and facilitation of access to lipid-modifying therapies.

Contributors

JJN, JBET, and APK conceived the idea of the study and, together with JJB and JRN, developed the protocol. JJN, APK, JBET, and JJB did the literature search. JJN, JJB, and UFN selected the studies and extracted the relevant information. JJB, JJN, and APK synthesised the data. JJN, JRN, and JJB wrote the first draft of the paper. JJN, JJB, JRN, UFN, EVB, JBET, and APK critically revised successive drafts of the paper and approved the final version. APK supervised the overall work and is the guarantor of the review.

Declaration of interests

We declare no competing interests.

References

1 WHO. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization, 2014.

2 Stone NJ, Robinson JG, Lichtenstein AH, et al. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines: *Circulation* 2014; **129** (suppl 2): S1–45.

3 Murphy A, Faria-Neto JR, Al-Rasadi K, et al. World Heart Federation Cholesterol Roadmap. *Glob Heart* 2017; **2**: 179–97.

4 GBD 2016 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; **390**: 1260–344.

5 GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; **390**: 1151–10.

6 Cholesterol Treatment Trialists' (CTT) Collaboration. Efficacy and safety of more intensive lowering of LDL cholesterol: a meta-analysis of data from 170 000 participants in 26 randomised trials. *Lancet* 2010; **376**: 1670–81.

7 Robinson JG, Smith B, Maheshwari N, et al. Pleiotropic effects of statins: benefit beyond cholesterol reduction? *J Am Coll Cardiol* 2005; **46**: 1855–62.

8 Collins R, Reith C, Emberson J, et al. Interpretation of the evidence for the efficacy and safety of statin therapy. *Lancet* 2016; **388**: 2532–61.

9 Noubiap JJ, Nansseu JR, Bigna JJ, Jingi AM, Kengne AP. Prevalence and incidence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis protocol. *BMJ Open* 2015; **5**: e007404.

10 Hoy D, Brooks P, Woolf A, et al. Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. *J Clin Epidemiol* 2012; **65**: 934–39.

11 Barendregt JJ, Doi SA, Lee YY, Norman RE, Vos T. Meta-analysis of prevalence. *J Epidemiol Community Health* 2013; **67**: 974–78.

12 DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials* 1986; **7**: 177–88.

13 Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003; **327**: 557–60.

14 Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997; **315**: 629–34.

15 Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med* 2005; **37**: 360–63.

16 Karaye KM, Habib AG. Dyslipidaemia in patients with established cardiovascular disease in sub-Saharan Africa: a systematic review and meta-analysis. *Eur J Prev Cardiol* 2014; **21**: 682–91.

17 Ambegaonkar BM, Bash LD, Chirovsky DR, et al. Attainment of normal lipid levels among high cardiovascular risk patients: pooled analysis of observational studies from the United Kingdom, Sweden, Spain and Canada. *Eur J Intern Med* 2013; **24**: 656–63.

18 Huang Y, Gao L, Xie X, Tan SC. Epidemiology of dyslipidemia in Chinese adults: meta-analysis of prevalence, awareness, treatment, and control. *Popul Health Metr* 2014; **12**: 28.

19 Huxley RR, Barzi F, Lam TH, et al. Isolated low levels of high-density lipoprotein cholesterol are associated with an increased risk of coronary heart disease clinical perspective: an individual participant data meta-analysis of 23 studies in the Asia-Pacific region. *Circulation* 2011; **124**: 2056–64.

20 Fatema K, Zwar NA, Milton AH, Ali L, Rahman B. Prevalence of risk factors for cardiovascular diseases in Bangladesh: a systematic review and meta-analysis. *PLoS One* 2016; **11**: e0160180.

21 Alabousi M, Abdullah P, Alter DA, et al. Cardiovascular risk factor management performance in Canada and the United States: a systematic review. *Can J Cardiol* 2017; **33**: 393–404.

22 Ataklte F, Erqou S, Kaptoge S, Taye B, Echouffo-Tcheugui JB, Kengne AP. Burden of undiagnosed hypertension in sub-Saharan Africa: a systematic review and meta-analysis. *Hypertension* 2015; **65**: 291–98.

23 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4·4 million participants. *Lancet* 2016; **387**: 1513–30.

24 White CM, Weeda ER, Nguyen E. Should an LDL-cholesterol target-based approach be readopted? *Ann Pharmacother* 2018; **52**: 175–84.

25 Khatib R, McKee M, Shannon H, et al. Availability and affordability of cardiovascular disease medicines and their effect on use in high-income, middle-income, and low-income countries: an analysis of the PURE study data. *Lancet* 2016; **387**: 61–69.

26 Jingi AM, Noubiap JJN, Ewane Onana A, et al. Access to diagnostic tests and essential medicines for cardiovascular diseases and diabetes care: cost, availability and affordability in the West Region of Cameroon. *PLoS One* 2014; **9**: e111812.

27 Jingi AM, Nansseu JRN, Noubiap JJN. Primary care physicians' practice regarding diabetes mellitus diagnosis, evaluation and management in the West Region of Cameroon. *BMC Endocr Disord* 2015; **15**: 18.

28 Noubiap JJN, Jingi AM, Veigne SW, Onana AE, Yonta EW, Kingue S. Approach to hypertension among primary care physicians in the West Region of Cameroon: substantial room for improvement. *Cardiovasc Diagn Ther* 2014; **4**: 357–64.

29 Lekoubou A, Awah P, Fezeu L, Sobngwi E, Kengne AP. Hypertension, diabetes mellitus and task shifting in their management in sub-Saharan Africa. *Int J Environ Res Public Health* 2010; **7**: 353–63.

30 De Wit S, Sabin CA, Weber R, et al. Incidence and risk factors for new-onset diabetes in HIV-infected patients: the Data Collection on Adverse Events of Anti-HIV Drugs (D:A:D) study. *Diabetes Care* 2008; **31**: 1224–29.

31 Tsiodras S, Mantzoros C, Hammer S, Samore M. Effects of protease inhibitors on hyperglycemia, hyperlipidemia, and lipodystrophy: a 5-year cohort study. *Arch Intern Med* 2000; **160**: 2050–56.

32 Dillon DG, Gurdasani D, Riha J, et al. Association of HIV and ART with cardiometabolic traits in sub-Saharan Africa: a systematic review and meta-analysis. *Int J Epidemiol* 2013; **42**: 1754–71.

33 Maggi P, Di Biagio A, Rusconi S, et al. Cardiovascular risk and dyslipidemia among persons living with HIV: a review. *BMC Infect Dis* 2017; **17**: 551.

34 Fukui M, Tanaka M, Toda H, et al. Risk factors for development of diabetes mellitus, hypertension and dyslipidemia. *Diabetes Res Clin Pract* 2011; **94**: e15–18.

35 Otsuka T, Takada H, Nishiyama Y, et al. Dyslipidemia and the risk of developing hypertension in a working-age male population. *J Am Heart Assoc* 2016; **5**: e003053.

36 Miller M, Stone NJ, Ballantyne C, et al. Triglycerides and cardiovascular disease: a scientific statement from the American Heart Association. *Circulation* 2011; **123**: 2292–333.

37 Frank AT, Zhao B, Jose PO, Azar KM, Fortmann SP, Palaniappan LP. Racial/ethnic differences in dyslipidemia patterns. *Circulation* 2014; **129**: 570–79.

VI- POST-PUBLICATION CORRESPONDENCES

The article initially published in The Lancet Global Health had few errors. A corrected version[1] was therefore published along with an erratum[2]. Furthermore, a correspondence[3] by Dr Newton regarding our article was published accompanied by an authors' reply[4]. The erratum and the post-publication correspondences are presented below.

1- Noubiap JJ, Bigna JJ, Nansseu JR et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health*. 2018;6(9):e998-e1007.

2- [No authors listed]. Correction to Lancet Glob Health 2018; 6: e998-1007. Lancet Glob Health. 2019 Mar;7(3):e312.

3- Newton R. Dyslipidaemia in Africa-comment on a recent systematic review. Lancet Glob Health. 2019 Mar;7(3):e307.

4- Noubiap JJ, Balti EV, Bigna JJ, Echouffo-Tcheugui JB, Kengne AP. Dyslipidaemia in Africacomment on a recent systematic review - Authors' reply. Lancet Glob Health. 2019 Mar;7(3):e308e309.

Correction to *Lancet Glob Health* 2018; 6: e998–1007

Published Online
December 12, 2018
http://dx.doi.org/10.1016/S2214-109X(18)30519-9

Noubiap JJ, Bigna JJ, Nansseu JR, et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. Lancet Glob Health *2018;* **6:** *e998–1007*—Seven studies were included in the meta-analysis which were duplicates of three studies. Four of the duplicate studies were removed and the analyses were redone (R version has been updated). The data for studies included, elevated concentrations of total cholesterol with a cutoff of at least 5·2 mmol/L, low concentrations of HDL cholesterol with a cutoff of less than 1·0 mmol/L, elevated concentrations of LDL cholesterol with a cutoff of at least 3·3 mmol/L, elevated concentrations of triglycerides with a cutoff of at least 1·7 mmol/L, and overall random effects meta-analysis have been updated to reflect this in the Summary, in the table, on pages e1002, e1003, and e1005, and in figures 2–5. These changes have been made to the online version as of Dec 12, 2018.

Dyslipidaemia in Africa—comment on a recent systematic review

Published Online
December 12, 2018
http://dx.doi.org/10.1016/S2214-109X(18)30511-4

The publication of the systematic review by Jean Jacques Noubiap and colleagues[1] in *The Lancet Global Health* highlights two important issues. The first issue is the trend to systematically review data according to well established formula, but in the absence of a thorough understanding of the field and expertise. Many systematic reviews are produced by professional reviewers with little topic-specific knowledge. In Noubiap and colleagues'[1] systematic review, data are presented including three studies from Uganda; however, these three articles cover the same study, although the focus of each article was different.

The second issue is the desire to summarise Africa. Currently, the UN recognises 54 countries on what is the second largest (and arguably the most diverse) continent in the world, both in terms of land area and population. With such wide heterogeneity of results across the studies included in Noubiap and colleagues'[1] review, a summary estimate should not have been calculated. There is little value in saying that the prevalence of low HDL in Africa is 41%, when the range is from 2% to 96% (the lowest and highest prevalence estimates were from studies conducted in the same country). Systematic reviews can be valuable, but they can also be misleading.

I declare no competing interests.

Robert Newton
robert.newton@york.ac.uk

Department of Health Sciences, University of York, York, UK; Medical Research Council/Uganda Virus Research Institute and London School of Hygiene and Tropical Medicine Uganda Research Unit, Entebbe, Uganda

1 Noubiap JJ, Bigna JJ, Nansseu JR, et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health* 2018; **6:** e998–1007

Dyslipidaemia in Africa—comment on a recent systematic review

Authors' reply

We thank Robert Newton for his Correspondence, which has provided us with the opportunity to correct an oversight. We agree that our review[1] mistakenly included three articles from the same study done in Uganda.[3–4] After further cross-checking of the 181 studies initially included in the review, we identified two additional duplicates.[5–8] We conducted new analyses including only data reported in the articles with highest sample size among the duplicates identified (table). The pooled prevalence of dyslipidaemia in the general population from population-based studies was 25·5% (95% CI 20·0–31·4; corrected from 23·6%, 18·4–29·6) for elevated concentrations of total cholesterol with a cutoff of at least 5·2 mmol/L, 37·4% (29·4–45·7; corrected from 41·1%; 33·0–49·2) for low concentrations of HDL cholesterol with a cutoff of less than 1·0 mmol/L, 28.6% (15·8–43·5; corrected from 25·7%, 16·2–36·6) for elevated concentrations of LDL cholesterol with a cutoff of at least 3·3 mmol/L, and 17·0% (11·9–22·7; corrected from 16·5%, 11·8–21·6) for elevated concentrations of triglycerides with a cutoff of at least 1·7 mmol/L (table). The new results are not different from those in the main manuscript[1] in terms of magnitude of prevalence estimates; thus, the message of our article is unchanged.

Newton also says he considers that a wide heterogeneity precludes pooled estimates from meta-analyses. In general, heterogeneity is inevitable in meta-analyses of observational studies and prevalence studies, particularly in Africa. This heterogeneity is also reflected in meta-analyses of African studies done by Newton and colleagues.[9,10] It is improbable that several studies carried out in different populations by different investigators, with variable methodological approaches, will provide consistent results. The decision to pool estimates should be taken a priori, provided data are from studies fulfilling well predefined inclusion criteria. The high heterogeneity described in our meta-analysis does not invalidate its findings. When high heterogeneity is found, potential sources should be investigated. In our study, the substantial heterogeneity in the estimates was not explained by major study-level characteristics. In addition to presenting estimates at the continental level, we did various subgroup analyses, including at the regional level. Moreover, in the forest plots depicting pooled estimates, data are presented by country.

In the context of these limitations, our findings are not overemphasised. The observed high prevalence in the general adult populations at the continental and country levels highlight the need for effective detection and treatment of dyslipidaemia in Africa. The data provided for each country can be used by local health authorities to design country-specific interventions for dyslipidaemia.

We declare no competing interests.

*Jean Jacques Noubiap, Eric Vounsia Balti, Jean Joel Bigna, Justin B Echouffo-Tcheugui, *André Pascal Kengne*

andre.kengne@mrc.ac.za

Department of Medicine, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa (JJM, APK); Diabetes Research Center, Faculty of Medicine and Pharmacy, Vrije Universiteit Brussel, Brussels, Belgium (EVB); Department of Internal Medicine, Universiteit Ziekenhuis Brussel, Brussels, Belgium (EVB); Faculty of Medicine, University of Paris Sud XI, Le Kremlin-Bicêtre, France (JJB); Division of Endocrinology, Diabetes and Hypertension, Department of Medicine, Brigham and Women's Hospital and Harvard Medical School, Boston, MA, USA (JBE-T); Non-communicable Disease Research Unit, South African Medical Research Council, Cape Town, South Africa (APK)

Published Online December 12, 2018 http://dx.doi.org/10.1016/S2214-109X(18)30517-5

	Prevalence	Studies	Participants	I^2	H	$p_{heterogeneity}$	$p_{Egger\ test}$	$p_{difference}$
Total cholesterol								
5·2 mmol/L	25·5% (20·0–31·4)	37	70 296	99·7 (99·6–99·7)	17·2 (16·5–17·9)	<0·0001	0·070	<0·0001
6·5 mmol/L	11·0% (7·1–15·5)	20	30 054	99·3 (99·2–99·4)	12·4 (11·5–13·3)	<0·0001	0·943	..
HDL cholesterol								
0·9 mmol/L	19·5% (10·5–30·6)	6	5771	98·9 (98·5–99·2)	9·6 (8·2–11·3)	<0·0001	0·801	0·01
1·0 mmol/L	37·4% (29·4–45·7)	27	34 784	99·6 (99·5–99·6)	15·6 (14·9–16·4)	<0·0001	0·039	..
LDL cholesterol								
2·6 mmol/L	21·3% (16·7–26·5)	2	1830	81·2 (19·9–95·6)	2·3	0·021	NA	0·187
3·3 mmol/L	28·6% (15·8–43·5)	12	15 638	99·7 (99·6–99·7)	17·5 (16·3–18·8)	<0·0001	0·009	..
4·0 mmol/L	13·5% (5·7–24·0)	5	5921	99·1 (98·7–99·4)	10·6 (8·9–12·5)	<0·0001	0·484	..
Triglycerides								
1·7 mmol/L	17·0% (11·9–22·7)	37	57 701	99·7 (99·6–99·7)	17·1 (16·5–17·9)	<0·0001	0·762	<0·0001
2·2 mmol/L	12·0% (9·6–14·7)	12	27 826	97·4 (96·6–98·1)	6·3 (5·4–7·2)	<0·0001	0·007	..
5·2 mmol/L	5·0% (3·1–7·2)	1	441	NA	NA	NA	NA	..

Data are % (95% CI), N, I^2 (95% CI), or H (95% CI).

Table: **Pooled prevalence of dyslipidaemia with various cutoffs in the general population from community-based studies in Africa**

1 Noubiap JJ, Bigna JJ, Nansseu JR, et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health* 2018; **6:** e998–1007.

2 Wekesa C, Asiki G, Kasamba I, et al. Atherogenic risk assessment among persons living in rural Uganda. *J Trop Med* 2016; **2016:** 7073894.

3 Asiki G, Murphy GA, Baisley K, et al. Prevalence of dyslipidaemia and associated risk factors in a rural population in south-western Uganda: a community based survey. *PLoS One* 2015; **10:** e0126166.

4 Murphy GA, Asiki G, Ekoru K, et al. Sociodemographic distribution of non-communicable disease risk factors in rural Uganda: a cross-sectional study. *Int J Epidemiol* 2013; **42:** 1740–53.

5 Olamoyegun MA, Oluyombo R, Asaolu SO. Evaluation of dyslipidemia, lipid ratios, and atherogenic index as cardiovascular risk factors among semi-urban dwellers in Nigeria. *Ann Afr Med* 2016; **15:** 194–99.

6 Oluyombo R, Akinwusi PO, Olamoyegun MO, et al. Clustering of cardiovascular risk factors in semi-urban communities in south-western Nigeria. *Cardiovasc J Afr* 2016; **27:** 322–27.

7 Nwose EU, Oguoma VM, Bwititi PT, Richards RS. Metabolic syndrome and prediabetes in Ndokwa community of Nigeria: preliminary study. *N Am J Med Sci* 2015; **7:** 53–58.

8 Oguoma VM, Nwose EU, Ulasi II, et al. Maximum accuracy obesity indices for screening metabolic syndrome in Nigeria: a consolidated analysis of four cross-sectional studies. *Diabetes Metab Syndr* 2016; **10:** 121–27.

9 Namale G, Kamacooko O, Kinengyere A, et al. Risk factors for hemorrhagic and ischemic stroke in sub-Saharan Africa. *J Trop Med* 2018; **2018:** 4650851.

10 Fox JM, Mutalima N, Molyneux E, et al. Seroprevalence of HTLV-1 and HTLV-2 amongst mothers and children in Malawi within the context of a systematic review and meta-analysis of HTLV seroprevalence in Africa. *Trop Med Int Health* 2016; **21:** 312–24.

VII- APPENDIX

This appendix which accompanies the publication in The Lancet Global Health has been slightly modified for the purpose of this dissertation: the table of contents has been removed and the numbering is linked to the whole document.

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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Noubiap JJ, Bigna JJ, Nansseu JR, et al. Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis. *Lancet Glob Health* 2018; **6:** e998–1007.

Prevalence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis

Jean Jacques **Noubiap**, MD, Jean Joel **Bigna**, MD, MPH, Jobert Richie **Nansseu**, MD,

Ulrich Flore **Nyaga**, MD, Eric Vounsia **Balti**, MD, PhD, Justin B. **Echouffo-Tcheugui**, MD, PhD,

Prof André Pascal **Kengne**, MD, PhD

Supplementary Table 1. Summary and comparison statistics for dyslipidaemia based on total cholesterol

Groups	Subgroups	Cut-off, mmol/L	N studies	N participants	% (95% CI)	I^2 (95% CI)	H (95% CI)	P heterogeneity	P Egger test	P-diff criteria	P-diff subgroups
COMMUNITY-BASED NON-DISEASE SPECIFIC											
All		Imprecise	1	452	25.2 (21.3-29.3)	NA	NA	NA	NA	< 0.0001	NA
		5.2	41	85440	23.6 (18.4-29.2)	99.7 (99.7-99.7)	18.5 (17.4-19.2)	<0.0001	0.019		
		6.5	20	34054	11.0 (7.1-15.5)	99.3 (99.2-99.4)	12.4 (11.5-13.3)	<0.0001	0.943		
By Sex	**Males**	5.2	21	22184	25.2 (17.3-34.1)	99.5 (99.4-99.6)	14.1 (13.2-15.0)	<0.0001	0.011	0.003	0.370
	Females	5.2	24	31053	30.5 (23.1-38.6)	99. 5 (99.5-99.6)	14.6 (13.8-15.5)	<0.0001	0.006	0.0003	
	Males	6.5	16	14004	10.9 (6.3-16.5)	98.9 (98.7-99.1)	9.6 (8.7-10.5)	<0.0001	0.951		0.492
	Females	6.5	16	16584	13.5 (8.7-19.0)	98.9 (98.7-99.)	9.7 (8.8-0.6)	<0.0001	0.403		
By Region	**Central**	5.2	1	1573	1.7 (1.1-2.4)	NA	NA	NA	NA	<0.0001	<0.0001
	Eastern	5.2	9	40711	19.3 (11.6-28.5)	99.8 (99.8-99.8)	21.6 (20.1-23.2)	<0.0001	0.007	0.510	
	Northern	5.2	9	21381	31.9 (25.4-38.8)	99.1 (98.8-99.3)	10.3 (9.1-11.7)	<0.0001	0.516	<0.0001	
	Southern	5.2	6	6746	32.6 (15.2-52.9)	99.7 (99.6-99.7)	17.2 (15.4-19.1)	<0.0001	0.695	0.424	
	Western	5.2	16	15029	20.3 (12.2-29.8)	99.4 (99.3-99.5)	13.1 (12.1-14.1)	<0.0001	0.652	<0.0001	
	Central	6.5	1	1871	7.1 (6.0-8.3)	NA	NA	NA	NA		<0.0001
	Eastern	6.5	9	21293	15.6 (9.2-23.4)	99.5 (99.4-99.6)	14.1 (12.8-15.6)	<0.0001	0.653		
	Northern	6.5	6	4868	9.5 (7.2-12.1)	87.5 (75.1-93.7)	2.8 (2.0-4.0)	<0.0001	0.917		
	Southern	6.5	1	976	24.9 (22.2-27.7)	NA	NA	NA	NA		
	Western	6.5	3	5046	1.9 (0.7-3.5)	88.1 (66.7-95.7)	2.9 (1.7-4.8)	0.0002	0.853		
By Setting	**Urban**	5.2	21	26724	28.7 (21.2-36.7)	99.5 (99.4-99.5)	13.8 (12.9-14.7)	<0.0001	0.707	0.0003	<0.0001
	Rural	5.2	15	33654	9.7 (5.7-14.6)	99.4 (99.3-99.5)	13.1 (12.1-14.4)	<0.0001	0.588	0.003	
	Urban	6.5	8	5124	9.9 (4.8-16.7)	98.0 (97.3-98.6)	7.2 (6.1-8.5)	<0.0001	0.544		0.012
	Rural	6.5	5	4523	3.0 (1.5-5.1)	90.3 (80.3-95.2)	3.2 (2.3-4.6)	<0.0001	0.242		
By Representativeness	**National**	5.2	8	18845	35.9 (27.2-45.1)	99.4 (99.2-99.5)	12.9 (11.5-14.4)	<0.0001	0.006	0.002	0.005

	Subnational	5.2	33	66595	20.8 (15.4-26.8)	99.7 (99.7-99.7)	18.0 (17.3-18.8)	<0.0001	0.051	0.005	
	National	6.5	7	18567	13.8 (6.1-24.2)	99.7 (99.6-99.7)	17.7 (16.1-19.5)	<0.0001	0.465		0.428
	Subnational	6.5	12	13616	9.8 (5.4-15.2)	98.9 (98.6-99.1)	9.4 (8.6-10.6)	<0.0001	0.300		
By Publication date	**Published <2010**	5.2	16	31416	25.4 (17.2-34.7)	99.7 (99.6-99.7)	17.4 (16.4-18.5)	<0.0001	0.488	0.022	0.588
	Published ≥2010	5.2	25	54024	22.4 (16.0-29.0)	99.7 (99.7-99.7)	18.7 (17.9-19.6)	<0.0001	0.021	0.001	
	Published <2010	6.5	12	23676	13.6 (8.5-19.6)	99.3 (99.2-99.5)	12.3 (11.2-13.5)	<0.0001	0.954		0.129
	Published ≥2010	6.5	8	10378	7.5 (3.0-13.7)	99.0 (98.7-99.2)	10.1 (8.8-11.5)	<0.0001	0.314		
By Median sample size	**Lower (<1263)**	5.2	20	11814	26.2 (16.9-36.7)	99.3 (99.2-99.4)	12.3 (11.4-13.2)	<0.0001	0.355	0.003	0.400
	Higher (≥1263)	5.2	21	73626	21.2 (15.1-28.1)	99.8 (99.8-99.8)	22.0 (21.0-23.0)	<0.0001	0.003	0.056	
	Lower (<1074)	6.5	10	7026	9.9 (5.1-159)	98.3 (97.8-98.7)	7.7 (6.7-8.8)	<0.0001	0.309		0.612
	Higher (≥1074)	6.5	10	27028	12.1 (6.4-19.2)	99.6 (99.5-99.7)	16.2 (14.9-17.7)	<0.0001	0.648		
Groups	**Subgroups**	**Cut-off, mmol/L**	**N studies**	**N participants**	**% (95% CI)**	**I^2 (95% CI)**	**H (95% CI)**	**P heterogeneity**	**P Egger test**	**P-diff criteria**	**P-diff subgroups**
HOSPITAL-BASED NON-DISEASE SPECIFIC											
All		4.5	4	2185	55.4 (39.4-70.8)	95.5 (91.4-97.7)	4.7 (3.4-6.5)	<0.0001	0.071	<0.0001	
		5.2	12	5967	29.7 (12.7-50.1)	99.3 (99.1-99.4)	11.6 (10.6-12.8)	<0.0001	0.003		
		6.5	8	2663	10.6 (7.1-14.7)	88.7 (80.1-93.6)	3.0 (2.2-4.0)	<0.0001	0.932		
		7.0	1	172	2.3 (0.5-5.2)	NA	NA	NA	NA		
HOSPITAL-BASED DISEASE SPECIFIC											
Diabetes mellitus		5.2	9	2100	34.4 (23.3-46.4)	96.8 (95.4-97.8)	5.6 (4.7-6.7)	<0.0001	0.694	0.746	
Diabetes mellitus		6.5	2	470	37.8 (22.3-54.7)	92.9 (76.2-97.9)	3.8	0.0002	NA		
Diabetic nephropathy		5.2	1	72	62.5 (51.0-73.4)	NA	NA	NA	NA		

HIV		5.2	29	29372	24.2 (19.7-28.9)	98.5 (98.3-98.7)	8.2 (7.6-8.8)	<0.0001	0.012	0.007	
HIV		6.5	2	6785	7.7 (1.6-17.8)	97.3 (93.1-98.9)	6.1	<0.0001	NA		
Hypertension		5.2	7	2136	38.0 (23.8-53.4	97.9 (96.9-98.5)	6.9 (5.7-8.3)	<0.0001	0.946	0.032	
Hypertension		6.5	2	283	15.8 (3.4-34.8)	92.8 (76.0-97.9)	3.7	0.0002	NA		
MI/CHD/HF		5.2	2	6992	37.7 (0.2-90.8)	99.3 (98.6-99.6)	11.6	<0.0001	NA	0.568	
MI/CHD/HF		6.5	1	102	21.6 (14.1-30.1)	NA	NA	NA	NA		
Obesity		5.2	3	219	25.4 (1.0-64.7)	96.8 (93.4-98.4)	5.6 (3.9-8.0)	<0.0001	0.461		
Stroke		6.5	2	382	8.1 (5.5-11.1)	0.0	1.0	0.976	NA		
Systemic lupus erythematous		5.2	1	221	51.1 (44.5-57.7)	NA	NA	NA	NA		
POPULATION-BASED DISEASE SPECIFIC											
Diabetes mellitus		5.2	3	2352	34.3 (24.8-44.4)	95.6 (90.4-98.0)	4.8 (3.2-7.1)	<0.0001	0.341		
Hypertension		5.2	1	1376	11.6 (10.0-13.4)	NA	NA	NA	NA	0.034	
		6.5	1	710	14.9 (12.4-17.6)	NA	NA	NA	NA		
Obesity		5.2	1	154	40.3 (32.6-48.1)	NA	NA	NA	NA		

HIV: human immunodeficiency syndrome; MI: myocardial infarction; CHD: coronary heart disease; HF: heart failure

Supplementary Table 2. Summary and comparison statistics for dyslipidaemia based on high-density lipoprotein cholesterol

Groups	Subgroups	Cut-off, mmol/L	N studies	N participants	% (95% CI)	I^2 (95% CI)	H (95% CI)	P heterogeneity	P Egger test	P-diff criteria	P-diff subgroups
COMMUNITY-BASED NON-DISEASE SPECIFIC											

All		0.9	6	5771	19.5 (10.5-30.4)	98.9 (98.5-99.2)	9.6 (8.2-11.3)	<0.0001	0.801	0.002	
		1.0	30	49857	41.1 (33.0-49.4)	99.7 (99.7-99.7)	18.5 (17.8-19.4)	<0.0001	0.002		
By Sex	**Males**	1.0	15	12704	33.9 (22.3-46.7)	99.5 (99.4-99.6)	14.0 (13.0-15.1)	<0.0001	0.040		0.127
	Females	1.0	17	17781	48.0 (35.2-60.8)	99.6 (99.6-99.7)	16.8 (15.8-17.9)	<0.0001	0.008		
By Region	**Central**	1.0	1	452	10.0 (7.4-12.9)	NA	NA	NA	NA		<0.0001
	Eastern	1.0	5	25213	53.8 (37.7-69.5)	99.8 (99.8-99.9)	25.2 (230-27.6)	<0.0001	0.0007		
	Northern	1.0	6	6948	34.2 (20.7-49.2)	99.3 (99.1-99.5)	12.3 (10.8-14.2)	<0.0001	0.392		
	Southern	1.0	6	7295	48.6 (33.8-63.5)	99.4 (99.2-99.5)	12.9 (11.3-14.8)	<0.0001	0.619		
	Western	1.0	12	9949	38.7 (28.4-49.5)	99.1 (98.9-99.3)	10.5 (9.5-11.6)	<0.0001	0.693		
By Setting	**Urban**	1.0	18	12762	31.9 (24.0-40.5)	99.0 (98.8-99.2)	10.0 (9.2-10.9)	<0.0001	0.370		0.0097
	Rural	1.0	12	23982	49.7 (39.3-60.1)	99.6 (99.5-99.6)	15.1 (13.9-16.4)	<0.0001	0.056		
By Representativeness	**National**	1.0	3	6074	27.6 (15.0-42.3)	99.3 (98.9-99.6)	12.0 (9.7-15.0)	<0.0001	0.965		0.077
	Subnational	1.0	27	43783	42.7 (34.5-51.0)	99.7 (99.6-99.7)	17.2 (16.4-18.1)	<0.0001	0.0008		
By Publication date	**Published <2010**	1.0	4	3246	18.4 (14.8-22.3)	85.9 (65.4-94.2)	2.7 (1.7-4.2)	<0.0001	0.528		<0.0001
	Published ≥2010	1.0	26	46661	45.0 (36.7-53.4)	99.7 (99.7-99.7)	18.0 (17.1-18.8)	<0.0001	0.010		
By Median sample size	**Lower (<999)**	1.0	15	7483	34.5 (20.7-49.8)	99.4 (99.4-99.5)	13.5 (12.5-14.6)	<0.0001	0.945		0.159
	Higher (≥999)	1.0	15	42374	47.7 (37.5-58.0)	99.8 (99.7-99.8)	21.1 (20.0-22.3)	<0.0001	0.003		
HOSPITAL-BASED NON-DISEASE SPECIFIC											
All		0.9	4	534	37.7 (0.3-90.0)	99.4 (99.2-99.6)	13.2 (11.1-15.6)	<0.0001	0.633	0.976	
		1.0	22	6911	38.6 (29.8-47.8)	98.2 (97.9-98.5)	7.5 (6.8-8.2)	<0.0001	0.071		

HOSPITAL-BASED DISEASE SPECIFIC											
Bipolar mood disorders		0.9	1	130	59.2 (50.6-67.6)	NA	NA	NA	NA		
Diabetes mellitus		0.8	1	218	15.6 (11.1-20.7)	NA	NA	NA	NA	<0.0001	
Diabetes mellitus		0.9	2	448	58.3 (53.6-62.8)	0.0	1.0	0.825	NA		
Diabetes mellitus		1.0	14	3159	42.1 (32.3-52.2)	96.8 (95.8-97.6)	5.6 (4.9-6.5)	<0.0001	0.148		
Diabetes mellitus		1.6	1	401	11.5 (8.5-14.8)	NA	NA	NA	NA		
Groups	**Subgroups**	**Cut-off, mmol/L**	**N studies**	**N participants**	**% (95% CI)**	**I^2 (95% CI)**	**H (95% CI)**	**P heterogeneity**	**P Egger test**	**P-diff criteria**	**P-diff subgroups**
Diabetic nephropathy		1.0	1	72	58.3 (46.7-69.5)	NA	NA	NA	NA		
HIV		0.9	1	327	32.4 (27.4-37.6)	NA	NA	NA	NA	<0.0001	
HIV		1.0	30	70348	53.7 (48.6-58.8)	99.1 (99.0-99.2)	10.6 (10.0-11.33)	<0.0001	0.013		
HIV		1.2	1	304	45.7 (40.1-51.3)	NA	NA	NA	NA		
HIV		1.3	1	159	56.6 (48.8-64.2)	NA	NA	NA	NA		
Hypertension		0.9	1	100	3.0 (0.4-7.5)	NA	NA	NA	NA	<0.0001	
Hypertension		1.0	9	3978	39.4 (29.4-9.9)	97.4 (96.3-98.1)	6.2 (5.2-7.3)	0.685			
Hypertension		1.2	1	403	30.0 (25.6-34.6)	NA	NA	NA	NA		
Mental illness		1.0	1	276	52.5 (46.6-58.4)	NA	NA	NA	NA		
Obesity		1.0	1	129	21.7 (15.0-29.3)	NA	NA	NA	NA		
Post-menopause		1.0	1	183	66.1 (59.1-72.8)	NA	NA	NA	NA		
Pregnancy		1.0	2	725	7.7 (5.8-9.8)	0.0	1.0	0.501	NA		

Psoriasis		1.0	1	150	56.7 (48.6-64.5)	NA	NA	NA	NA		
Rheumatoid arthritis		1.0	1	92	95.7 (90.3-99.1)	NA	NA	NA	NA		
Skin disease		1.0	1	300	13.3 (9.7-17.4)	NA	NA	NA	NA		
Systemic lupus erythematosus		1.0	1	221	44.8 (38.3-51.4)	NA	NA	NA	NA		
POPULATION-BASED DISEASE SPECIFIC											
Diabetes mellitus		1.0	5	2526	39.5 (26.7-53.0)	97.3 (95.6-98.3)	6.1 (4.8-7.8)	<0.0001	0.952		
Hypertension		0.9	1	710	25.1 (21.9-28.3)	NA	NA	NA	NA		
Obesity		1.0	1	154	27.9 (21.1-35.3)	NA	NA	NA	NA		

HIV: human immunodeficiency syndrome; MI: myocardial infarction; CHD: coronary heart disease; HF: heart failure

Supplementary Table 3. Summary and comparison statistics for dyslipidaemia based on low-density lipoprotein cholesterol

Groups	**Subgroups**	**Cut-off, mmol/L**	**N studies**	**N participants**	**% (95% CI)**	**I^2 (95% CI)**	**H (95% CI)**	**P heterogeneity**	**P Egger test**	**P-diff criteria**	**P-diff subgroups**
COMMUNITY-BASED NON-DISEASE SPECIFIC											
All		2.6	2	1830	21.3 (16.6-26.5)	81.2 (19.9-95.6)	2.3	0.021	NA	0.226	
		3.3	14	23844	25.7 (16.2-36.6)	99.6 (99.6-99.7)	16.9 (15.8-18.1)	<0.0001	0.002		
		4.0	5	5921	13.5 (5.7-24.0)	99.1 (98.7-99.4)	10.6 (8.9-12.5)	<0.0001	0.484		
By Sex	**Males**	3.3	7	8041	21.6 (10.5-35.2)	99.3 (99.1-99.5)	11.9 (10.4-13.5)	<0.0001	0.004		0.230
	Females	3.3	7	10852	34.1 (19.2-50.7)	99.6 (99.5-99.7)	16.0 (14.4-17.7)	<0.0001	0.001		
By Region	**Central**	3.3	0	NA	NA	NA	NA	NA	NA		0.305
	Eastern	3.3	3	15689	14.6 (6.6-25.0)	99.5 (99.3-99.7)	14.9 (12.3-17.9)	<0.0001	0.029		

	Northern	3.3	0	NA	NA	NA	NA	NA	NA		
	Southern	3.3	3	2824	25.1 (3.5-57.7)	99.7 (99.6-99.8)	18.0 (15.2-21.2)	<0.0001	0.809		
	Western	3.3	8	5331	30.7 (12.4-52.8)	99.6 (99.5-99.7)	15.6 (14.2-17.2)	<0.0001	0.055		
By Setting	**Urban**	3.3	6	3822	35.0 (24.8-46.0)	97.6 (96.4-98.4)	6.5 (5.3-8.0)	<0.0001	0.612		<0.0001
	Rural	3.3	7	19337	9.4 (5.2-14.6)	98.9 (98.6-99.2)	9.7 (8.4-11.3)	<0.0001	0.329		
By Representativeness	**National**	3.3	0	NA	NA	NA	NA	NA	NA		NA
	Subnational	3.3	14	23844	25.7 (16.2-36.6)	99.6 (99.6-99.7)	16.9 (15.8-18.1)	<0.0001	0.002		
By Publication date	**Published <2010**	3.3	1	441	44.9 (40.3-49.7)	NA	NA	NA	NA		0.0008
	Published ≥2010	3.3	13	24403	24.4 (15.0-35.2)	99.6 (99.6-99.7)	16.8 (15.7-18.1)	<0.0001	0.005		
By Median sample size	**Lower (< 671)**	3.3	7	2291	44.2 (33.6-55.0)	96.2 (94.1-97.6)	5.1 (4.1-6.4)	<0.0001	0.709		0.003
	Higher (≥ 671)	3.3	7	21553	11.3 (4.9-19.8)	99.6 (99.5-99.7)	16.3 (14.7-18.1)	<0.0001	0.204		
HOSPITAL-BASED NON-DISEASE SPECIFIC											
All		2.6	6	2532	48.9 (34.7-63.1)	96.6 (94.6-97.9)	5.5 (4.3-6.9)	<0.0001	0.432	<0.0001	
		3.3	7	881	18.5 (6.7-34.2)	96.4 (94.5-97.7)	5.3 (4.3-6.6)	<0.0001	0.958		
		4.0	4	1094	10.3 (2.2-23.0)	96.2 (92.9-98.0)	5.1 (3.8-7.0)	<0.0001	0.196		
HOSPITAL-BASED DISEASE SPECIFIC											
Chronic kidney disease		3.3	1	217	41.0 (34.5-47.6)	NA	NA	NA	NA		
Diabetes mellitus		2.6	5	564	40.4 (25.9-55.8)	92.0 (84.2-95.9)	3.5 (2.5-4.9)	<0.0001	0.697	<0.0001	
Diabetes mellitus		3.3	8	2067	50.1 (37.6-62.3)	96.9 (95.5-97.9)	5.7 (4.7-9.6)	<0.0001	0.933		
Diabetes mellitus		4.0	2	520	4.2 (0.0-15.8)	95.3 (86.2-98.4)	4.6	<0.0001	NA		

Groups	Subgroups	Cut-off, mmol/L	N studies	N participants	% (95% CI)	I^2 (95% CI)	H (95% CI)	P heterogeneity	P Egger test	P-diff criteria	P-diff subgroups
Diabetic nephropathy		3.3	1	72	45.8 (34.4-57.5)	NA	NA	NA	NA		
HIV		2.6	1	406	44.1 (39.3-48.9)	NA	NA	NA	NA	<0.0001	
HIV		3.3	14	64453	20.8 (16.8-25.1)	98.9 (98.7-99.1)	9.6 (8.6-10.6)	<0.0001	0.129		
HIV		4.0	2	7701	2.5 (2.2-2.9)	0.0	1.0	0.706	NA		
Hypertension		2.6	3	1262	34.6 (9.5-65.5)	98.9 (98.3-99.4)	9.7 (7.6-12.5)	<0.0001	0.355	0.917	
Hypertension		3.3	3	618	32.7 (17.5-50.0)	93.4 (84.1-97.3)	3.9 (2.5-6.1)	<0.0001	0.479		
Obesity		2.6	1	129	9.3 (4.8-15.0)	NA	NA	NA	NA		
Rheumatoid arthritis		4.0	1	92	48.9 (38.7-59.2)	NA	NA	NA	NA		
Systemic lupus erythematosus		3.3	1		30.3 (24.4-36.6)	NA	NA	NA	NA		
POPULATION-BASED DISEASE SPECIFIC											
Diabetes mellitus		2.6	1	74	44.6 (33.4-56.1)	NA	NA	NA	NA		
Hypertension		4.0	1	710	16.5 (13.8-19.3)	NA	NA	NA	NA		
Obesity		3.3	1	154	48.7 (40.8-56.6)	NA	NA	NA	NA		

HIV: human immunodeficiency syndrome; MI: myocardial infarction; CHD: coronary heart disease; HF: heart failure

Supplementary Table 4. Summary and comparison statistics for dyslipidaemia based on low-density lipoprotein cholesterol

Groups	Subgroups	Cut-off, mmol/L	N studies	N participants	% (95% CI)	I^2 (95% CI)	H (95% CI)	P heterogeneity	P Egger test	P-diff criteria	P-diff subgroups
COMMUNITY-BASED NON-DISEASE SPECIFIC											

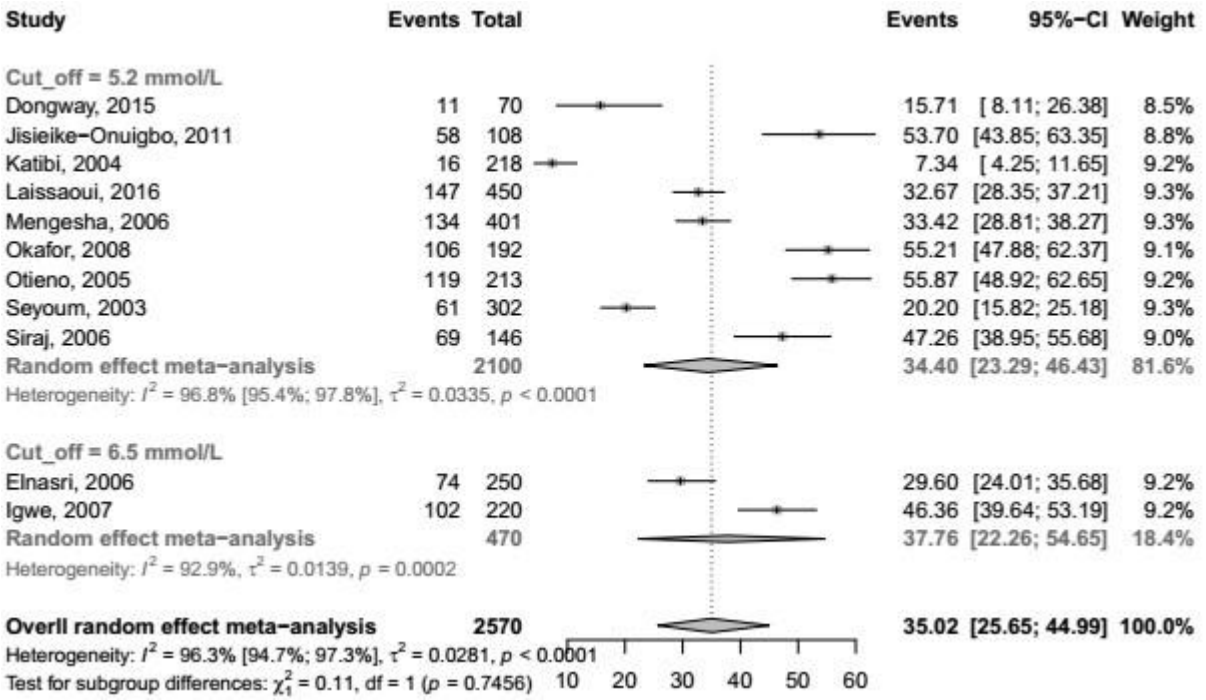
All		1.7	39	65267	16.4 (11.8-21.6)	99.6 (99.6-99.7)	16.8 (16.2-17.5)	<0.0001	0.755	<0.0001	
		2.2	14	35833	10.0 (6.8-13.7)	99.1 (98.9-99.3)	10.7 (9.7-11.7)	<0.0001	0.475		
		5.2	1	441	5.0 (3.1-7.2)	NA	NA	NA	NA		
By Sex	**Males**	1.7	16	13194	16.4 (10.5-23.3)	98.9 (98.6-99.1)	9.4 (8.5-10.3)	<0.0001	0.102		0.986
	Females	1.7	19	21730	16.4 (9.8-24.3)	99.5 (99.4-99.6)	14.1 (13.2-15.1)	<0.0001	0.602		
By Region	**Central**	1.7	2	2025	3.3 (0.0-14.5)	98.4 (96.4-99.3)	7.9	<0.0001	NA		0.0005
	Eastern	1.7	7	27643	18.7 (11.9-26.5)	99.5 (99.4-99.6)	14.9 (13.3-16.6)	<0.0001	0.099		
	Northern	1.7	10	17563	29.3 (20.0-39.5)	99.5 (99.4-99.6)	14.0 (12.7-15.3)	<0.0001	0.180		
	Southern	1.7	5	6309	21.5 (12.5-32.2)	98.9 (98.4-99.2)	9.6 (8.0-11.5)	<0.0001	0.885		
	Western	1.7	15	11727	9.1 (4.6-14.9)	98.9 (98.6-99.1)	9.4 (8.6-10.4)	<0.0001	0.830		
By Area	**Urban**	1.7	20	12784	18.8 (12.2-26.4)	99.0 (98.9-99.2)	10.2 (9.4-11.1)	<0.0001	0.826		0.007
	Rural	1.7	15	20739	8.3 (4.9-12.5)	98.8 (98.5-99.0)	9.2 (8.3-10.1)	<0.0001	0.923		
By Representativeness	**National**	1.7	5	15588	34.0 (19.4-50.3)	99.8 (99.7-99.8)	21.0 (18.9-23.3)	<0.0001	0.313		0.009
	Subnational	1.7	34	49679	14.2 (10.7-18.1)	99.3 (99.2-99.3)	11.6 (11.0-12.3)	<0.0001	0.109		
By Publication date	**Published <2010**	1.7	8	16486	17.2 (8.8-27.7)	99.5 (99.4-99.6)	14.4 (13.0-16.0)	<0.0001	0.380		0.870
	Published ≥2010	1.7	31	48781	16.2 (10.9-22.4)	99.7 (99.6-99.7)	17.1 (16.3-17.9)	<0.0001	0.768		
By Median sample size	**Lower (≤ 1012)**	1.7	20	9342	15.7 (10.1-22.3)	98.5 (98.2-98.7)	8.1 (7.4-8.9)	<0.0001	0.345		0.781
	Higher (≥ 1012)	1.7	19	55925	17.2 (10.5-25.0)	99.8 (99.8-99.8)	22.9 (21.9-24.0)	<0.0001	0.578		
HOSPITAL-BASED NON-DISEASE SPECIFIC											
All		1.4	1	213	11.7 (7.7-16.4)	NA	NA	NA	NA	<0.0001	
		1.7	24	5759	26.0 (18.0-34.8)	98.0 (97.5-98.3)	7.0 (6.4-7.7)	<0.0001	0.034		

		2.2	5	1547	13.4 (4.4-26.1)	97.1 (95.2-98.2)	5.8 (4.6-7.5)	<0.0001	0.975		
		4.5	1	100	2.0 (0.0-5.9)	NA	NA	NA	NA		
HOSPITAL-BASED DISEASE SPECIFIC											
Bipolar mood disorder		1.7	1	130	53.1 (44.4-61.6)	NA	NA	NA	NA		
CHD/HF		1.7	2	7003	20.5 (6.4-39.9)	94.7 (83.9-98.3)	4.4	<0.0001	NA		
Groups	**Subgroups**	**Cut-off, mmol/L**	**N studies**	**N participants**	**% (95% CI)**	**I^2 (95% CI)**	**H (95% CI)**	**P heterogeneity**	**P Egger test**	**P-diff criteria**	**P-diff subgroups**
Diabetes mellitus		1.7	15	3484	35.5 (28.9-42.5)	94.2 (91.8-95.8)	4.1 (3.5-4.9)	<0.0001	0.198	0.080	
Diabetes mellitus		2.2	5	1154	26.0 (18.5-34.4)	89.0 (77.0-94.7)	3.0 (2.1-4.4)	<0.0001	0.602		
Diabetic nephropathy		1.7	1	72	66.7 (55.3-77.1)	NA	NA	NA	NA		
HIV		1.2	1	253	5.5 (3.0-8.7)	NA	NA	NA	NA	<0.0001	
HIV		1.7	34	70856	22.7 (20.2-25.4)	97.4 (96.9-97.8)	6.2 (5.7-6.7)	<0.0001	0.021		
HIV		2.2	8	8702	15.3 (8.2-24.1)	98.1 (97.3-98.6)	7.2 (6.1-8.5)	<0.0001	0.319		
Hypertension		1.7	8	3781	22.2 (11.7-34.8)	98.4 (97.8-98.8)	8.0 (6.8-9.3)	<0.0001	0.271	0.0001	
Hypertension		4.5	1	100	2.0 (0.0-5.9)	NA	NA	NA	NA		
Mental illness		1.7	1	276	14.5 (10.6-18.9)	NA	NA	NA	NA		
Myocardial infarction		2.2	1	620	26.1 (22.7-29.7)	NA	NA	NA	NA		
Obesity		1.7	3	219	17.9 (0.9-47.3)	94.8 (88.3-97.7)	4.4 (2.9-6.4)	<0.0001	0.370		

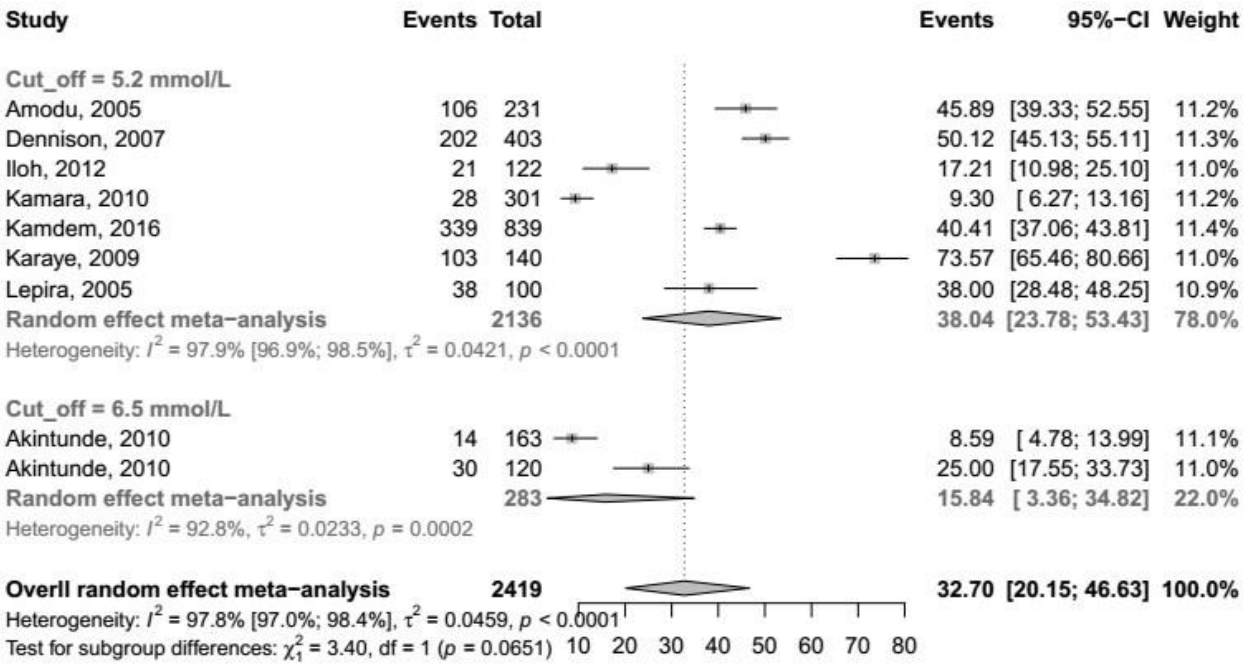
Post-menopause		1.7	1	183	68.3 (61.4-74.9)	NA	NA	NA	NA		
Pregnancy		1.7	2	725	65.7 (22.2-97.3)	97.5 (93.7-99.0)	6.3	<0.0001	NA		
Psoriasis		1.7	1	150	34.0 (26.6-41.8)	NA	NA	NA	NA		
Rheumatoid arthritis		1.7	1	92	34.8 (25.3-44.9)	NA	NA	NA	NA		
Skin disease		1.7	1	300	3.3 (1.6-5.7)	NA	NA	NA	NA		
Stroke		1.7	1	160	6.3 (2.9-10.6)	NA	NA	NA	NA		
Systemic lupus erythematosus		1.7	1	221	35.7 (29.5-42.2)	NA	NA	NA	NA		
POPULATION-BASED DISEASE SPECIFIC											
Diabetes mellitus		1.7	5	2526	3.9 (1.2-7.7)	92.3 (85.1-96.1)	3.6 (2.6-5.0)	<0.0001	0.01		
Hypertension		2.2	1	710	18.0 (15.3-20.9)	NA	NA	NA	NA		
Obesity		1.7	1	154	13.6 (8.6-19.5)	NA	NA	NA	NA		

HIV: human immunodeficiency syndrome; MI: myocardial infarction; CHD: coronary heart disease; HF: heart failure

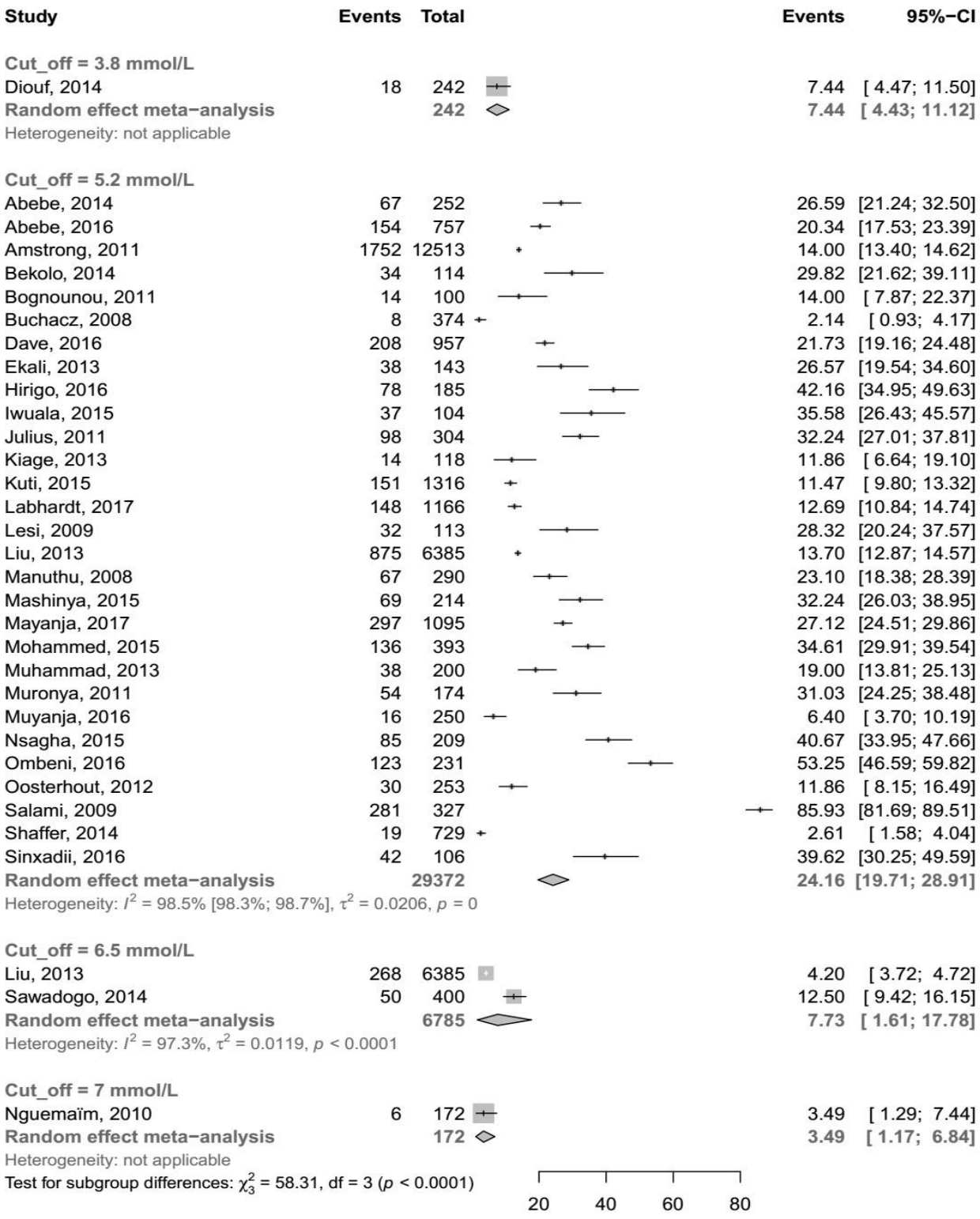
Supplementary Figure 1. Prevalence of dyslipidaemia based on total cholesterol in patients with diabetes mellitus from hospital-based studies



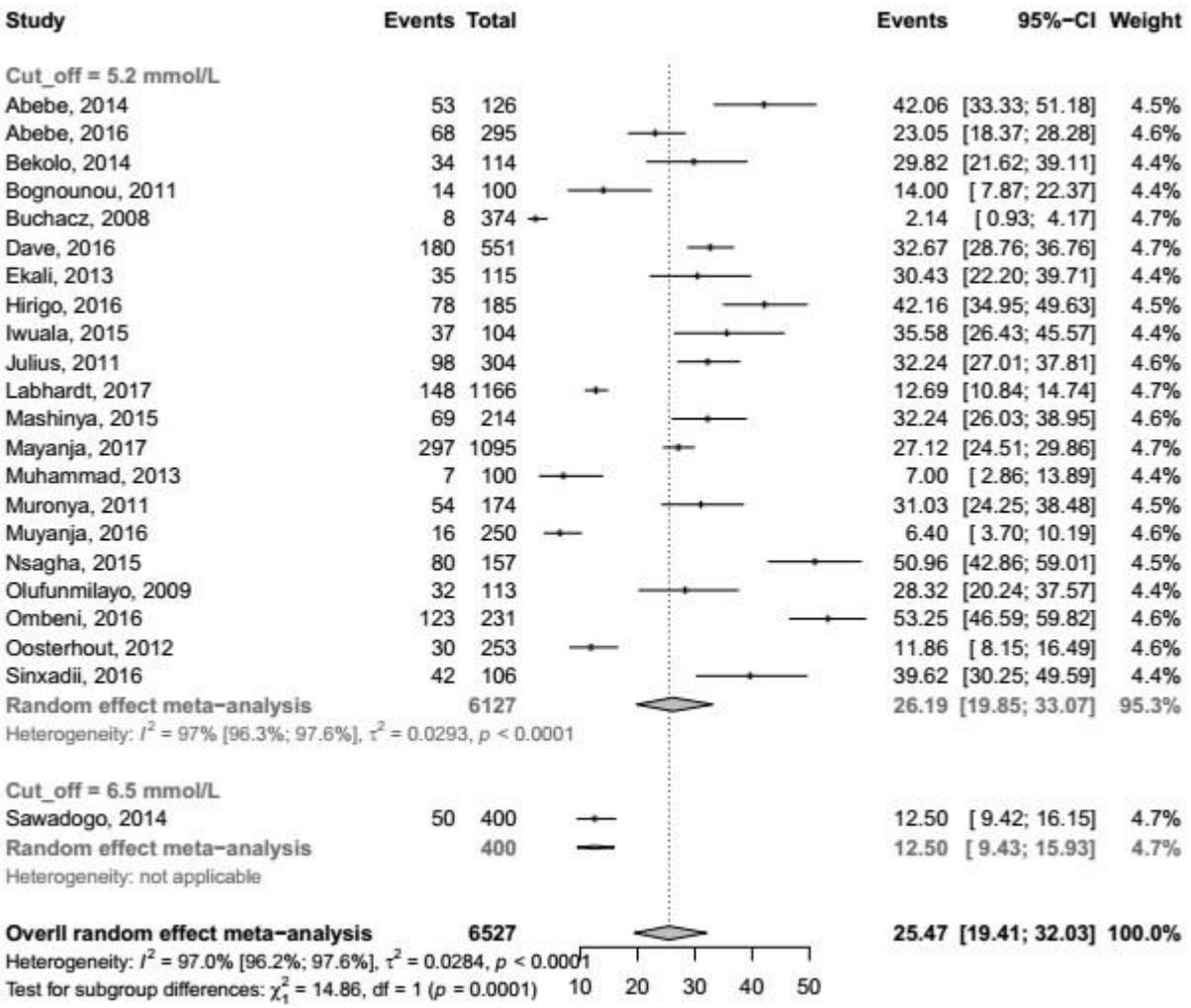
Supplementary Figure 2. Prevalence of dyslipidaemia based on total cholesterol in patients with hypertension from hospital-based studies



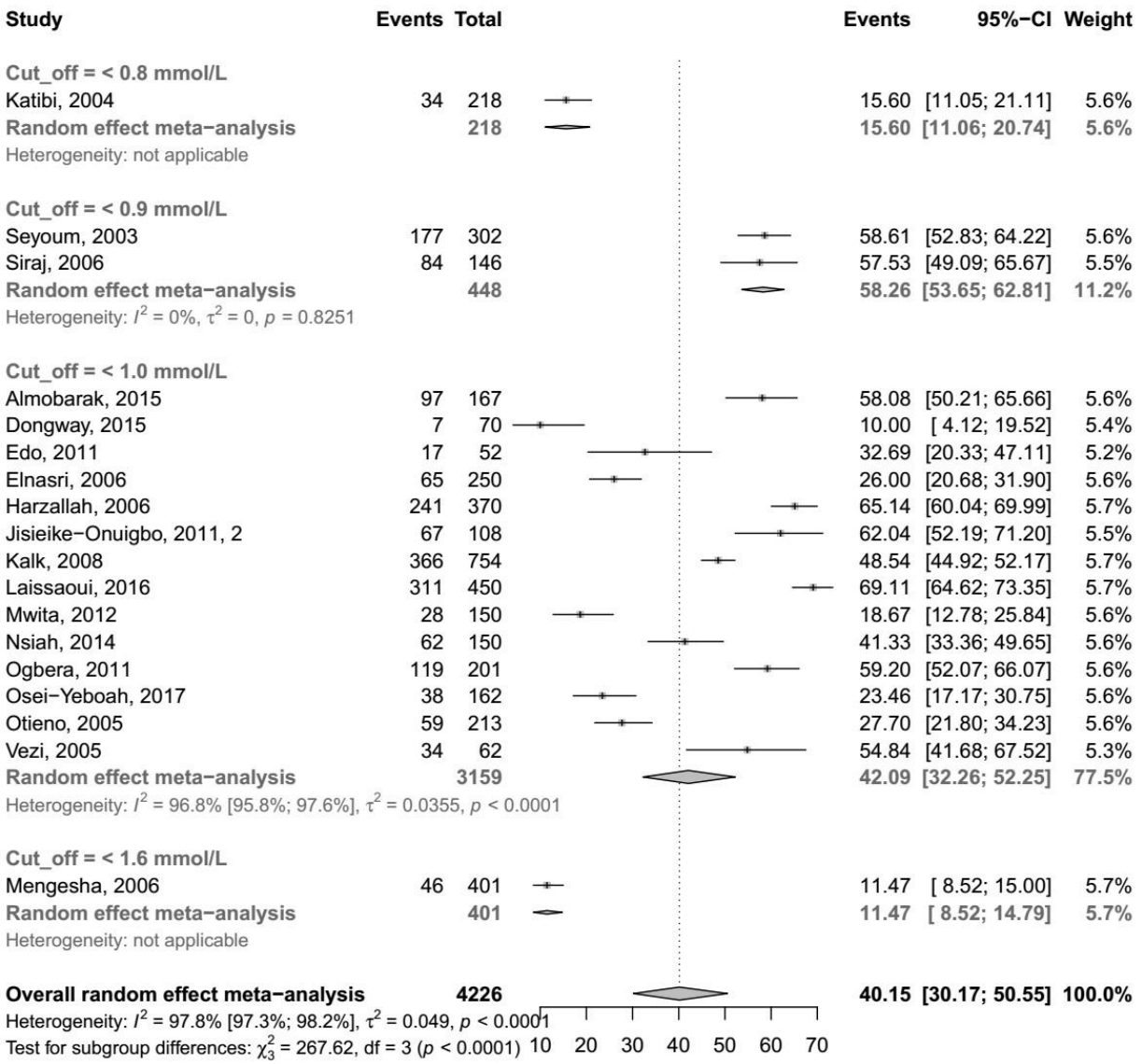
Supplementary Figure 3. Prevalence of dyslipidaemia based on total cholesterol in patients with human immunodeficiency virus from hospital-based studies



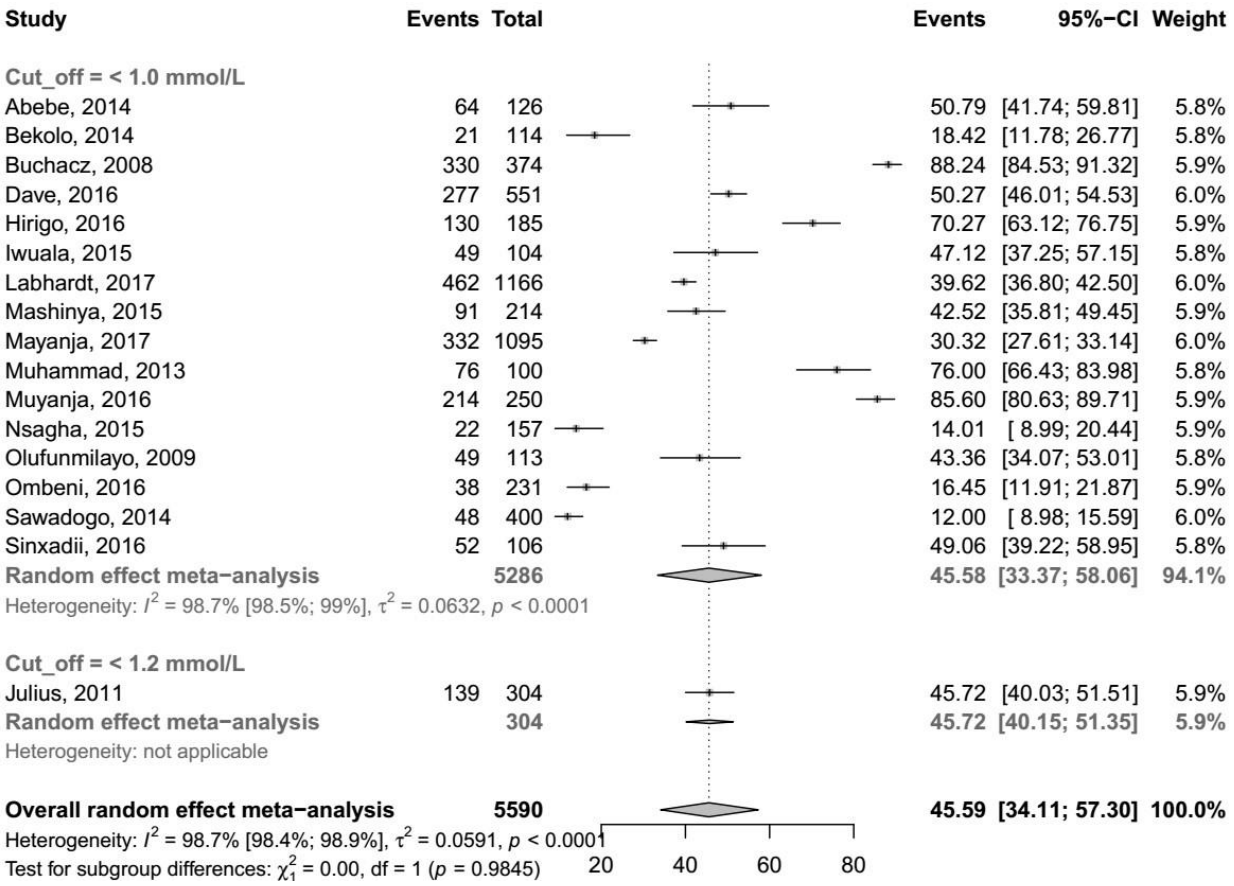
Supplementary Figure 4. Prevalence of dyslipidaemia based on total cholesterol in patients with human immunodeficiency virus on antiretroviral therapy from hospital-based studies



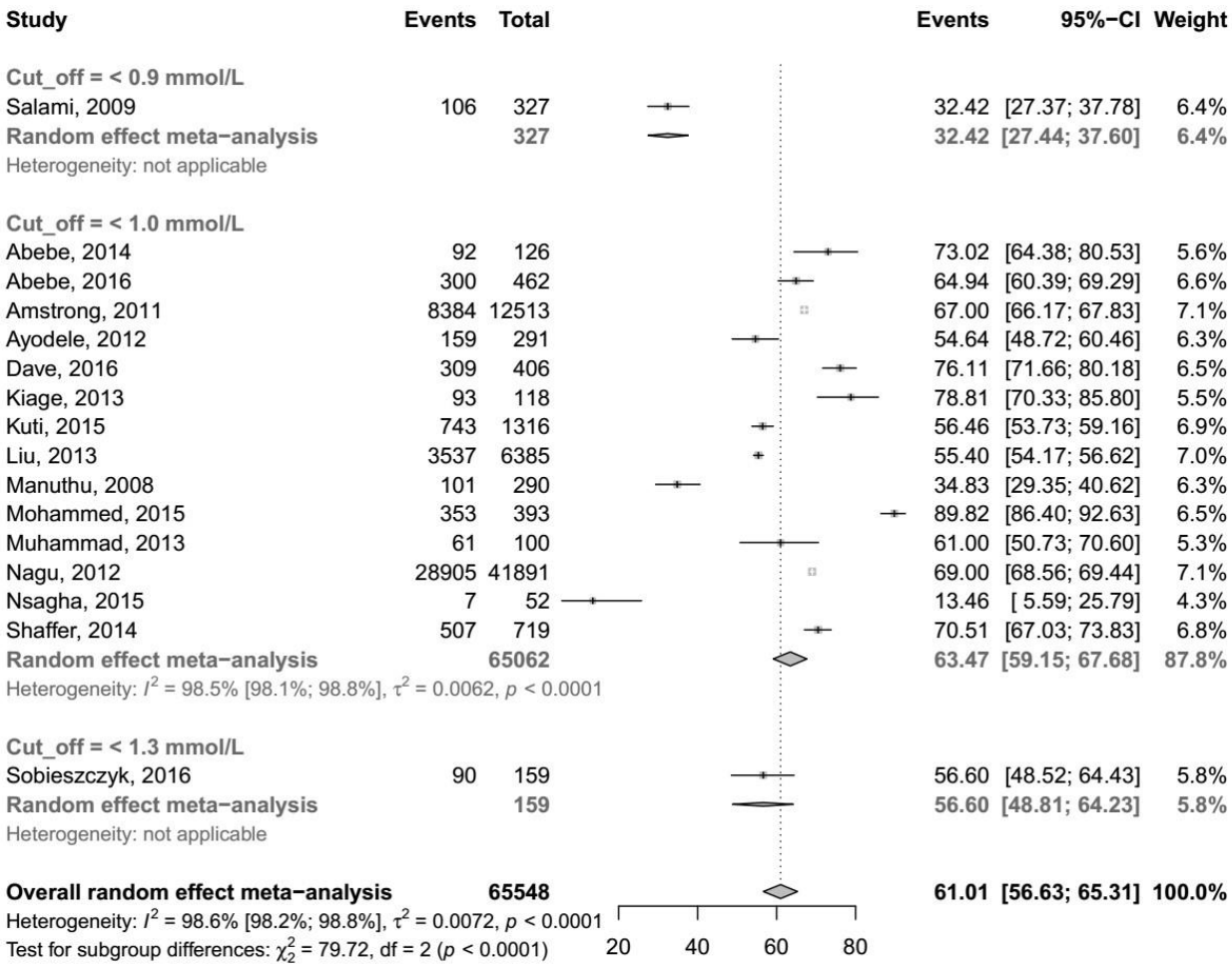
Supplementary Figure 5. Prevalence of dyslipidaemia based on high -density cholesterol in patients with diabetes mellitus from hospital-based studies



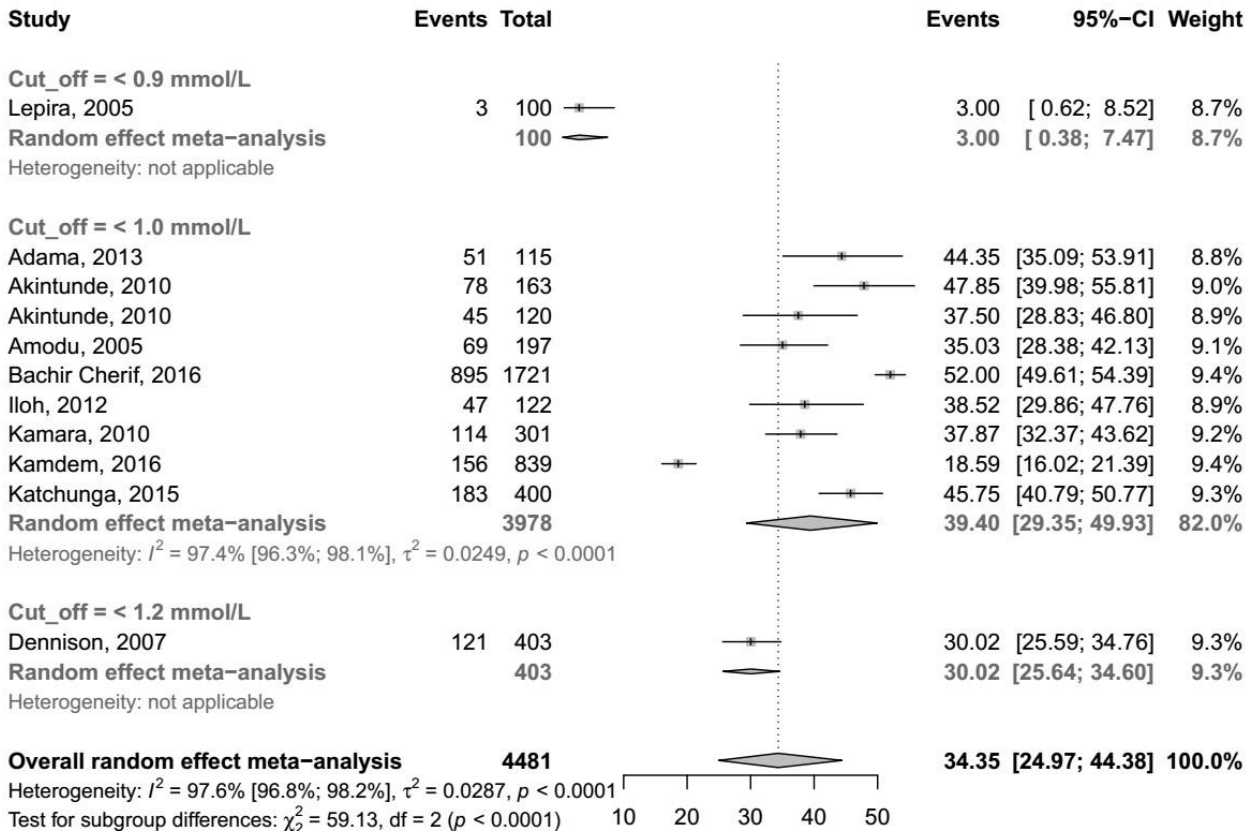
Supplementary Figure 6. Prevalence of dyslipidaemia based on high-density cholesterol in patients with human immunodeficiency virus on antiretroviral therapy from hospital-based studies



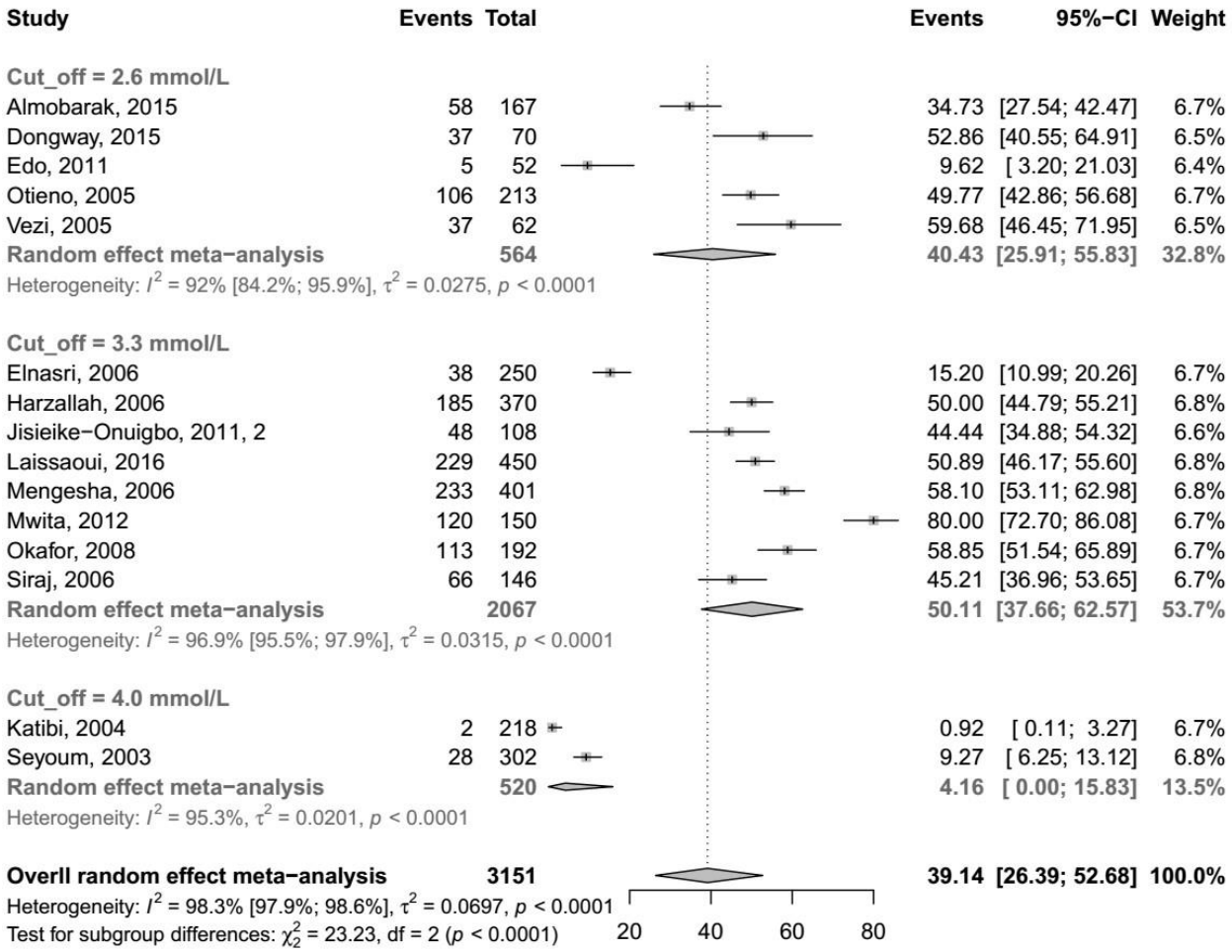
Supplementary Figure 7. Prevalence of dyslipidaemia based on high-density cholesterol in patients with human immunodeficiency virus from hospital-based studies



Supplementary Figure 8. Prevalence of dyslipidaemia based on high-density cholesterol in patients with hypertension from hospital-based studies



Supplementary Figure 9. Prevalence of dyslipidaemia based on low-density cholesterol in patients with diabetes mellitus from hospital-based studies



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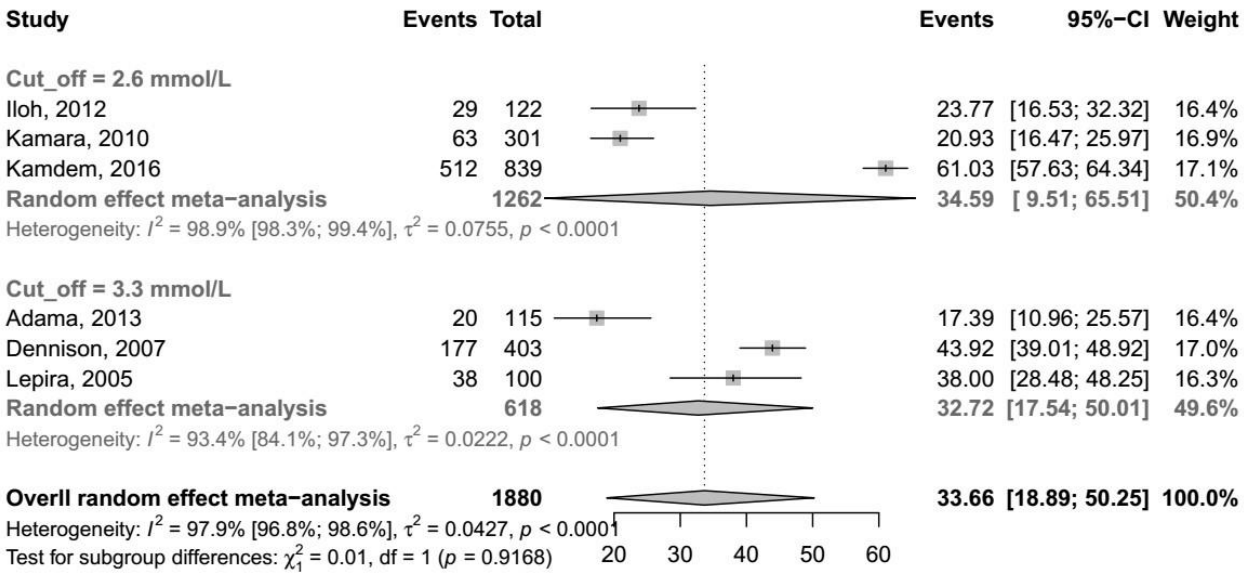
Supplementary Figure 10. Prevalence of dyslipidaemia based on low density cholesterol in patients with hypertension from hospital-based studies



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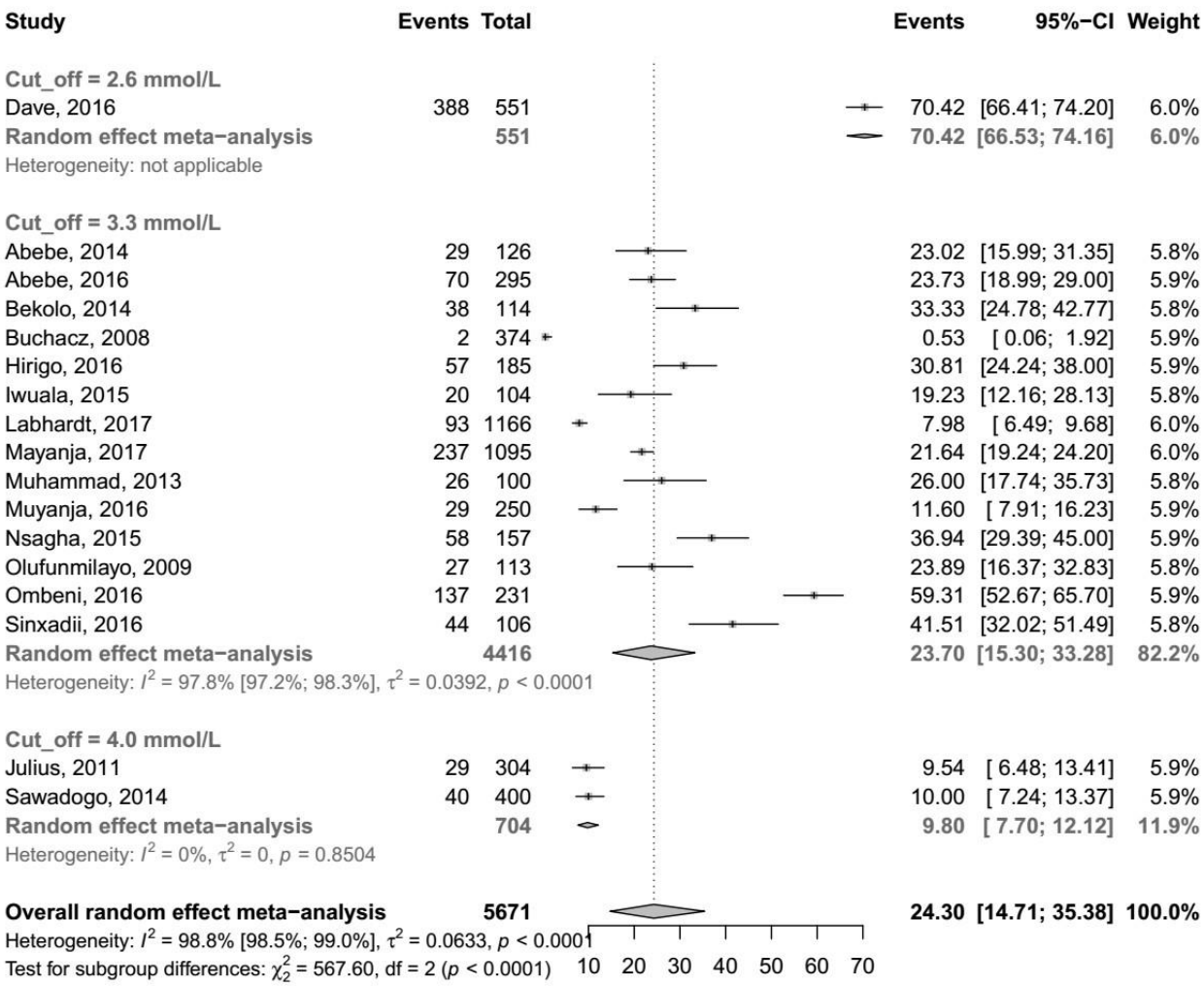
Supplementary Figure 11. Prevalence of dyslipidaemia based on low density cholesterol in patients with human immunodeficiency virus on antiretroviral therapy from hospital-based studies



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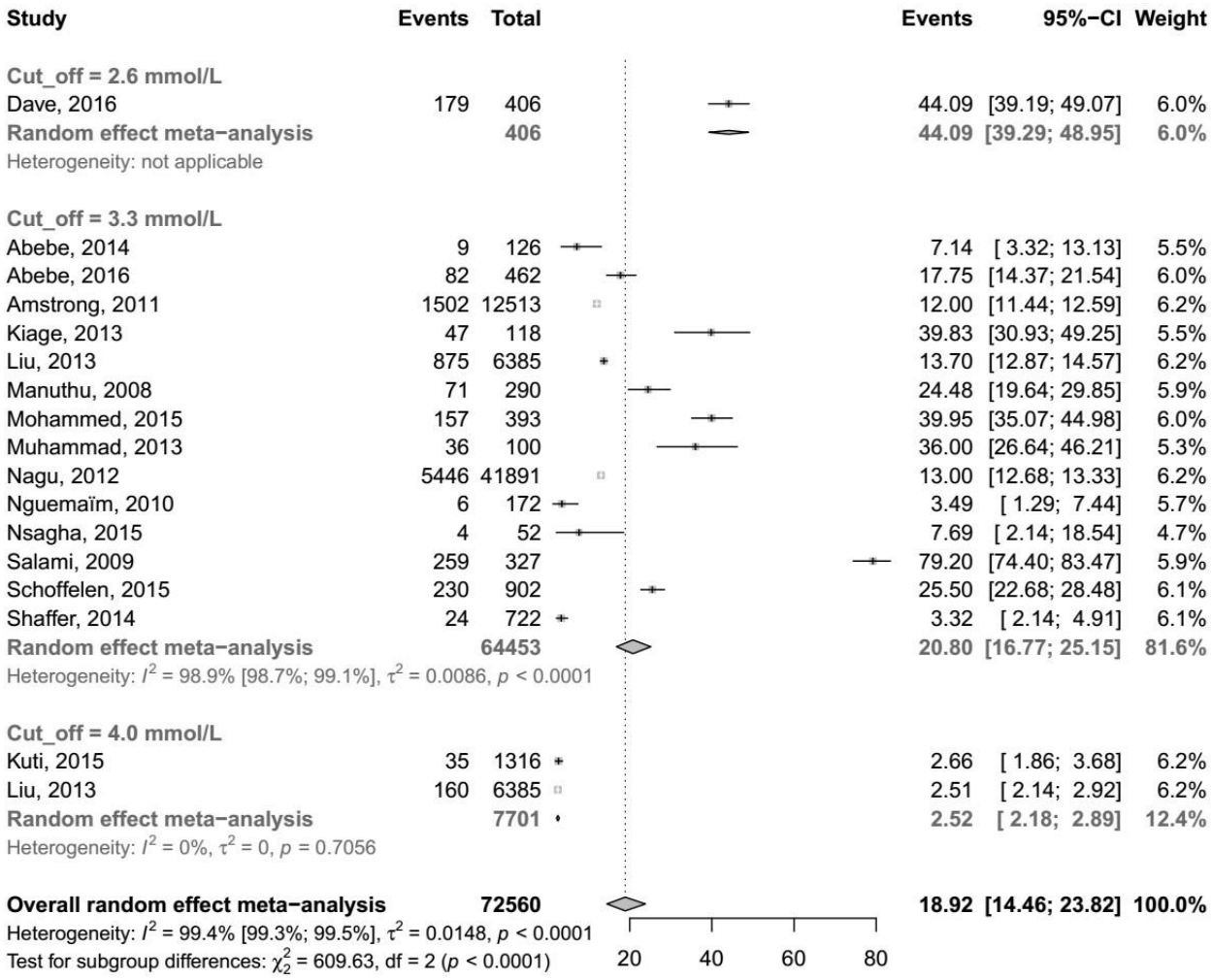
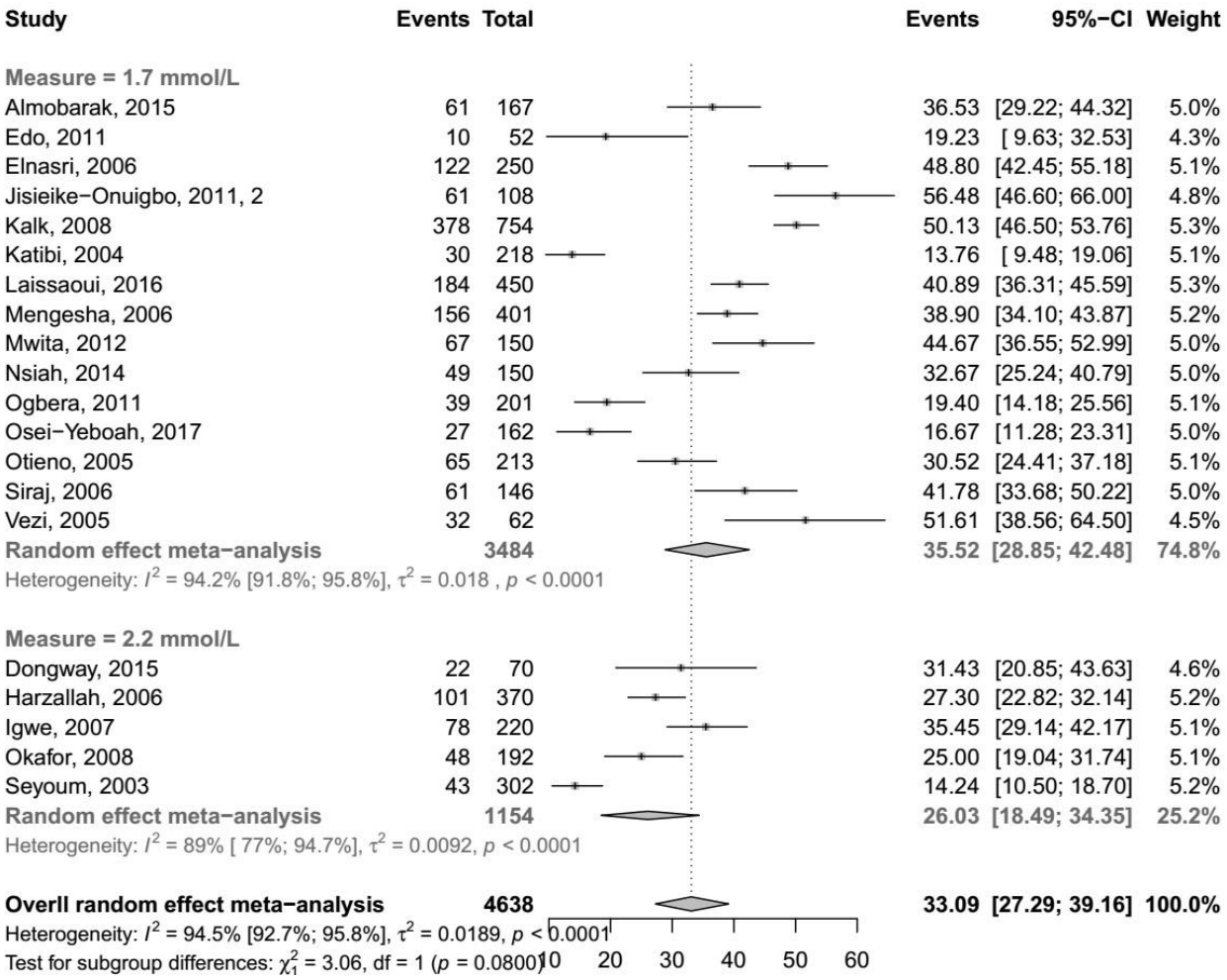
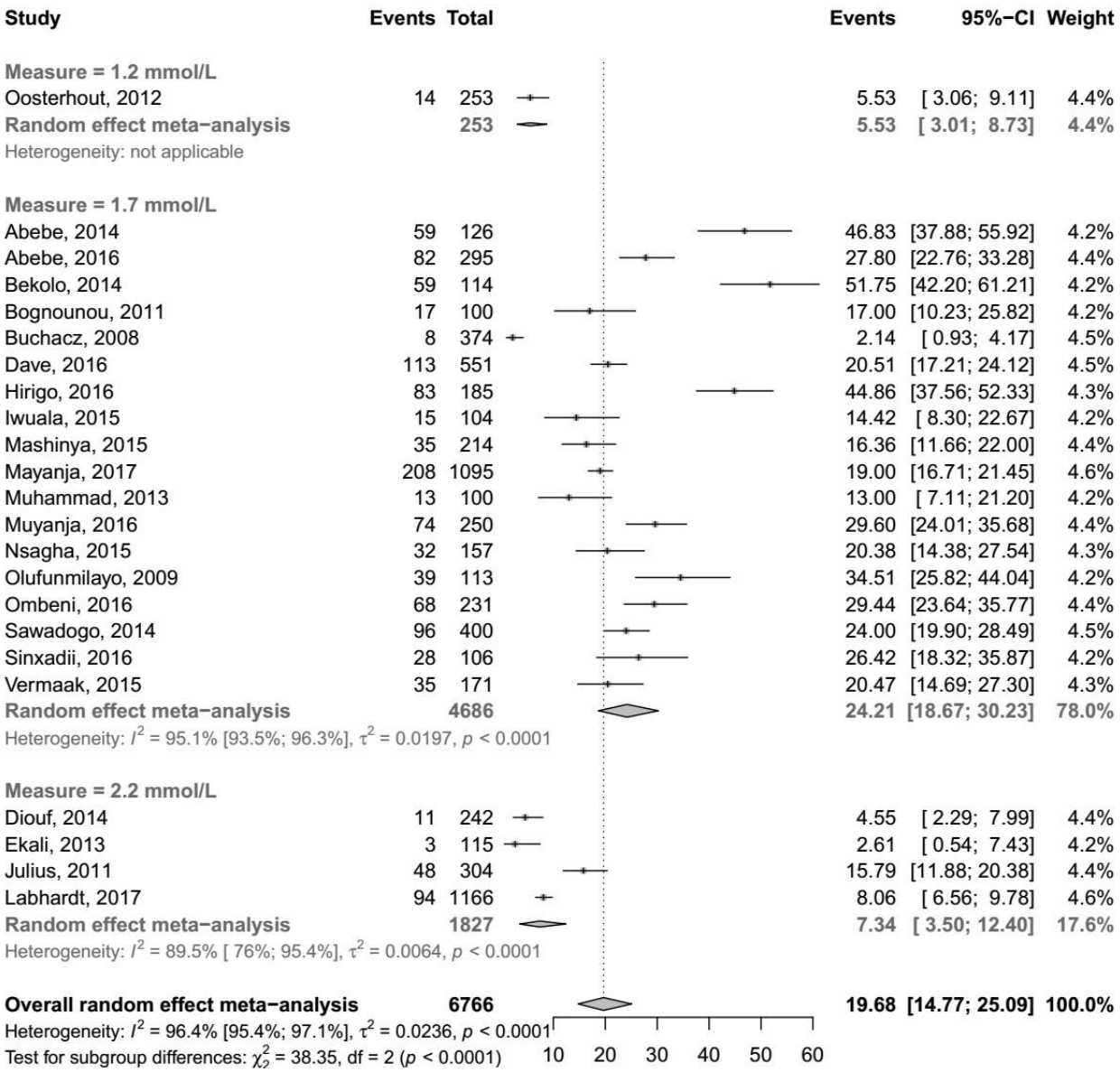
Supplementary Figure 12. Prevalence of dyslipidaemia based on low density cholesterol in patients with human immunodeficiency virus from hospital-based studies



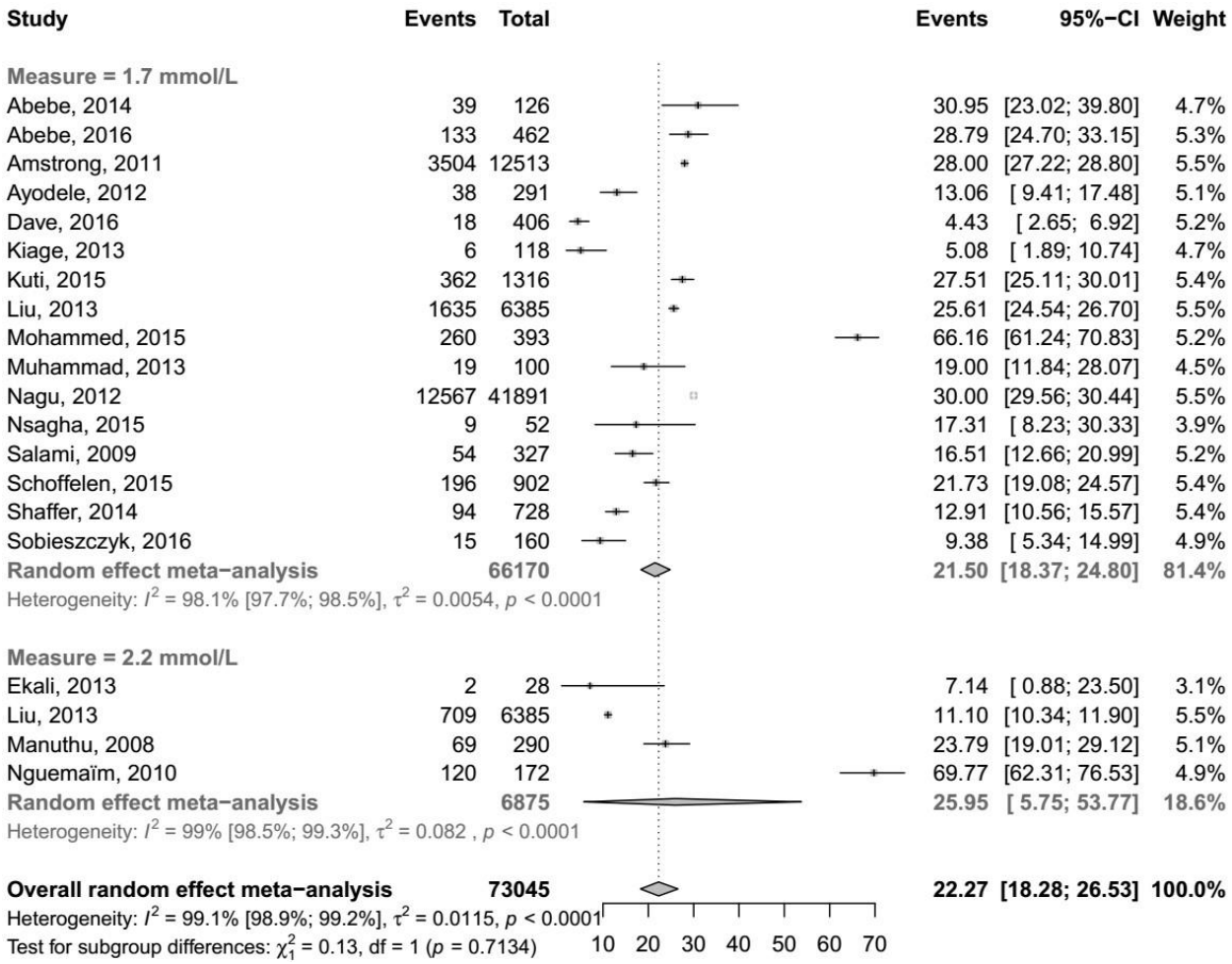
Supplementary Figure 13. Prevalence of dyslipidaemia based on triglycerides in patients with diabetes mellitus from hospital-based studies



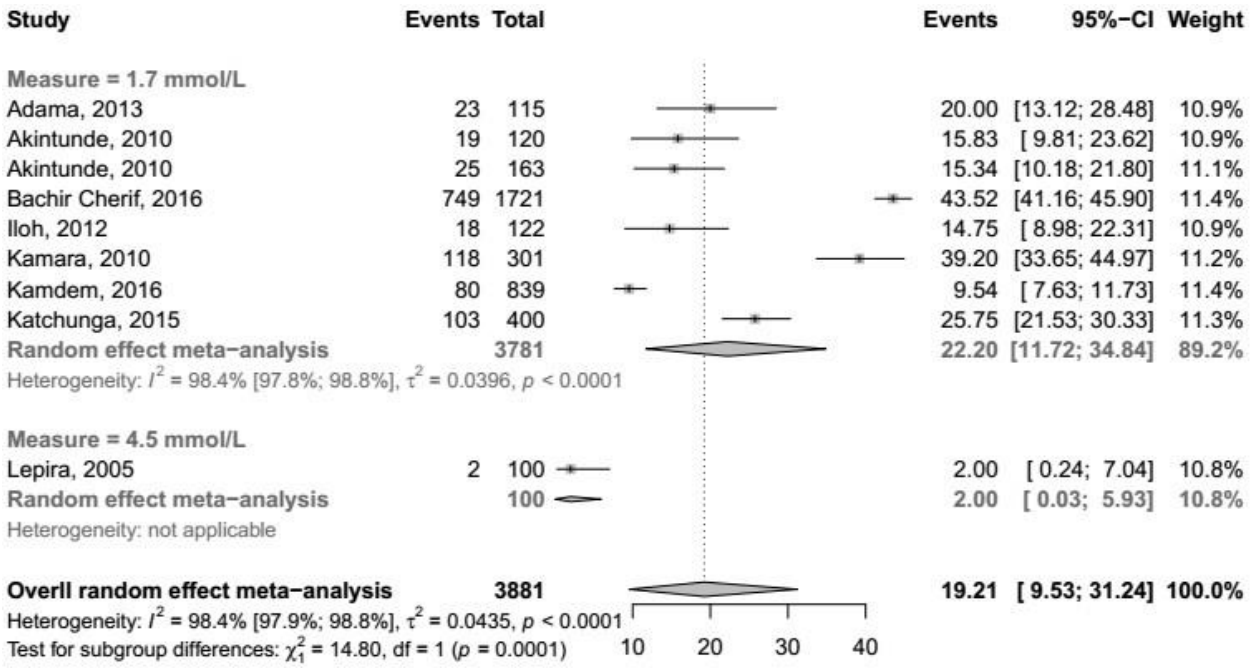
Supplementary Figure 14. Prevalence of dyslipidaemia based on triglycerides in patients with human immunodeficiency virus on antiretroviral therapy from hospital-based studies



Supplementary Figure 15. Prevalence of dyslipidaemia based on triglycerides in patients with human immunodeficiency virus from hospital-based studies



Supplementary Figure 16. Prevalence of dyslipidaemia based on triglycerides in patients with hypertension from hospital-based studies



References

1. Abebe M, Kinde S, Belay G, Gebreegziabxier A, Challa F, Gebeyehu T, Nigussie P, Tegbaru B. Antiretroviral treatment associated hyperglycemia and dyslipidemia among HIV infected patients at Burayu Health Center, Addis Ababa, Ethiopia: a cross-sectional comparative study. BMC Res Notes. 2014; 7:380.
2. Abd Elaziz KM, Gabal MS, Aldafrawy OA, Abou Seif HA, Allam MF. Prevalence of metabolic syndrome and cardiovascular risk factors among voluntary screened middle-aged and elderly Egyptians. J Public Health (Oxf). 2015; **37**:612-7.
3. Abebe SM, Getachew A, Fasika S, Bayisa M, Girma Demisse A, Mesfin N. Diabetes mellitus among HIVinfected individuals in followup care at University of Gondar Hospital, Northwest Ethiopia. BMJ Open 2016;6:e011175.
4. Adamu UG, Okuku GA, Oladele CO, Abdullahi A, Oduh JI, Fasae AJ.Serum lipid profile and correlates in newly presenting Nigerians with arterial hypertension. Vasc Health Risk Manag. 2013; **9**:763-8.
5. Adlouni A, el Messal M, Ghalim N, Saïle R. Apolipoproteins and lipoprotein particles in Moroccan patients with previous myocardial infarction. Int J Clin Lab Res. 1997; **27**:247-52.
6. Ahaneku GI, Ahaneku JE, Osuji CU, Oguejiofor CO, Anisiuba BC, Opara PC. Lipid and Some Other Cardiovascular Risk Factors Assessment in a Rural Community in Eastern Nigeria. Ann Med Health Sci Res. 2015; **5**:284-91.
7. Akintunde AA, Ayodele EO, Akinwusi OP, Opadijo GO. Dyslipidemia Among Newly Diagnosed Hypertensives: Pattern and Clinical Correlates. J Natl Med Assoc. 2010; **102**:403-7.
8. Akintunde AA, Oloyede TW. Metabolic syndrome and occupation: Any association? Prevalence among auto technicians and school teachers in South West Nigeria. Diabetes Metab Syndr. 2016. pii: S1871-4021(16)30271-5.
9. Akintunde AA. Epidemiology of conventional cardiovascular risk factors among hypertensive subjects with normal and impaired fasting glucose. S Afr Med J. 2010; **100**:594-7.
10. Akpa MR, Agomouh DI, Alasia DD. Lipid profile of healthy adult Nigerians in Port Harcourt, Nigeria. Niger J Med. 2006; 15:137-40.
11. Alikor CA, Emem-Chioma PC, Odia OJ.Prevalence of hyperuricaemia in a rural population of Nigeria Niger Delta region. Niger J Med. 2013; **22**:187-92.
12. Almobarak AO, Barakat S, Suliman EA, Elmadhoun WM, Mohamed NA, Abobaker IO, Noor SK, Bushara SO, Ahmed MH. Prevalence of and predictive factors for nonalcoholic fatty liver disease in Sudanese individuals with type 2 diabetes: Is metabolic syndrome the culprit? Arab J Gastroenterol. 2015; 16:54-8.
13. Amodu PH, Mbah IO, Lawson L. Prevalence Of Obesity and Dyslipidaemia in Hypertensives Seen in Abuja, Nigeria. Scand J Clin Lab Invest Suppl. 2005; **240**:14-7.
14. Armstrong C, Liu E, Okuma J, Spiegelman D, Guerino C, Njelekela M, Grinspoon S, Fawzi W, Hawkins C. Dyslipidemia in an HIV-positive, antiretroviral treatment-naïve population in Dar es Salaam, Tanzania. J Acquir Immune Defic Syndr. 2011 Jun 1;57(2):141-5.
15. Asiki G, Murphy GA, Baisley K, Nsubuga RN, Karabarinde A, Newton R, Seeley J, Young EH, Kamali A, Sandhu MS. Prevalence of dyslipidaemia and associated risk factors in a rural population in South-Western Uganda: a community based survey. PLoS One. 2015; 10(5):e0126166.

16. Ayodele OE, Akinboro AO, Akinyemi SO, Adepeju AA, Akinremi OA, Alao CA, Popoola AA. Prevalence and Clinical Correlates of Metabolic Syndrome in Nigerians Living with Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome. Metab Syndr Relat
Disord. 2012; **10**:373-9.
17. Ba ML. Epidemiology of obesity in Mauritania. Tunis Med. 2000; **78**:671-6.
18. Babua C, Kalyesubula R, Okello E, Kakande B, Sebatta E, Mungoma M, Mondo CK. Cardiovascular risk factors among patients with chronic kidney disease attending a tertiary hospital in Uganda. Cardiovasc J Afr. 2015; **26**:177-80.
19. Bachir Cherif A, Bouamra A, Taleb A, Bouraghda A, Rabia S, Imouloudene N, Temmar M, Bouafia MT. The characteristics of arterial hypertension in postmenopausal women in the area of Blida (Algeria). Ann Cardiol Angeiol (Paris). 2016; 65:146-51.
20. Bachir Cherif A, Bouamra A, Taleb A, Nedjar R, Bouraghda A, Hamida F, Temmar M, Bouafia MT. Differences in prevalence, treatment and control rates of hypertension between male and female in the area of Blida (Algeria). Ann Cardiol Angeiol (Paris). 2017; 66:123-129.
21. Bachir Cherif A, Temmar M, Chibane A, Labat C, Atif ML, Taleb A, Benetos A, Bouafia MT. The metabolic syndrome in hypertensive black population of South Algeria. Ann Cardiol Angeiol (Paris). 2015; 64:158-63.
22. Baragou S, Djibril M, Atta B, Damorou F, Pio M, Balogou A.Prevalence of cardiovascular risk factors in an urban area of Togo: a WHO STEPS-wise approach in Lome, Togo. Cardiovasc J Afr. 2012 Jul;23(6):309-12.
23. Bekolo CE, Nguena MB, Ewane L, Bekoule PS, Kollo B.The lipid profile of HIV-infected patients receiving antiretroviral therapy in a rural Cameroonian population. BMC Public Health. 2014;**14**:236.
24. Belfki H, Ben Ali S, Aounallah-Skhiri H, Traissac P, Bougatef S, Maire B, Delpeuch F, Achour N, Ben Romdhane H. Prevalence and determinants of the metabolic syndrome among Tunisian adults: results of the Transition and Health Impact in North Africa (TAHINA) project. Public Health Nutr. 2013; **16**:582-90.
25. Ben Ali S, Belfki-Benali H, Aounallah-Skhiri H, Traissac P, Maire B, Delpeuch F, Achour N, Ben Romdhane H. Menopause and Metabolic Syndrome in Tunisian Women. Biomed Res Int. 2014; **2014**:457131.
26. Ben Romdhane H, Skhiri H, Bougatef S, Gharbi D, Ben Alaya N, Achour N. Cardiovascular disease surveillance in Tunisia. Tunis Med. 2005; 83 Suppl 5:8-13.
27. Benjamin LA, Corbett EL, Connor MD, Mzinganjira H, Kampondeni S, Choko A, Hopkins M, Emsley HC, Bryer A, Faragher B, Heyderman RS, Allain TJ, Solomon T. HIV, antiretroviral treatment, hypertension, and stroke in Malawian adults: a case-control study. Neurology. 2016; 86:324-33.
28. Berrios X, Koponen T, Huiguang T, Khaltaev N, Puska P, Nissinen A. Distribution and prevalence of major risk factors of noncommunicable diseases in selected countries: the WHO Inter-Health Programme. Bull World Health Organ. 1997; **75**:99-108.
29. Bimenya GS, Okot JK, Nangosa H, Anguma SA, Byarugaba W. Plasma cholesterol and related lipid levels of seemingly healthy public service employees in Kampala, Uganda. Afr Health Sci. 2006; **6**:139-44.

30. Bognounou R, Diendéré A, Diallo I, Tieno H, Guira O, Ouedraogo DD, Drabo YJ. Metabolic disorders and cardiovascular risk factors observed in patients infected by the HIV with antiretroviral therapy in Burkina Faso. Med Trop (Mars). 2011; 71:626-7.
31. Boukli Hacène L, Khelil MA, Chabane Sari D, Meguenni K, Meziane Tani A. Prevalence of cardiovascular risk factors in urban and rural communities in the Wilaya of Tlemcen (Algeria): A comparative study. Rev Epidemiol Sante Publique. 2017; **65**:277-284.
32. Bovet P, Shamlaye C, Kitua A, Riesen WF, Paccaud F, Darioli R. High Prevalence of Cardiovascular Risk Factors in the Seychelles (Indian Ocean). Arterioscler Thromb. 1991; **11**:1730-6.
33. Bovet P, Viswanathan B, Louange M, Gedeon J. National Survey of Noncommunicable Diseases in Seychelles 2013-2014 (Seychelles Heart Study IV): methods and main findings. 2015. http://www.who.int/chp/steps/Seychelles_2013_STEPS_Report.pdf
34. Bovet P, Shamlaye C, Gabriel A, Riesen W, Paccaud F.Prevalence of cardiovascular risk factors in a middle-income country and estimated cost of a treatment strategy. BMC Public Health. 2006;**6**:9.
35. Buchacz K, Weidle PJ, Moore D, Were W, Mermin J, Downing R, Kigozi A, Borkowf CB, Ndazima V, Brooks JT. Changes in lipid profile over 24 months among adults on first-line highly active antiretroviral therapy in the home-based AIDS care program in rural Uganda. J Acquir Immune Defic Syndr. 2008; 47:304-11.
36. Capingana Dp, Magalhães P, Silva AB, Gonçalves MA, Baldo MP, Rodrigues SL, Simões CC, Ferreira AV, Mill JG. Prevalence of cardiovascular risk factors and socioeconomic level among public-sector workers in Angola. BMC Public Health 2013; 13:732.
37. Charlton KE, Wolmarans P, Marais AD, Lombard CJ. Macronutrient intake and cardiovascular risk factors in older coloured South Africans. East Afr Med J. 1997; 74:478-86.
38. Chatti S, Debbabi F, Ben Abdelaziz A, Harbaoui R, Ghannem H, Mrizak N. Cardiovascular risk factors among shift workers in company of electricity production in the Centre of Tunisia. Ann Cardiol Angeiol (Paris). 2010; **59**:190-5.
39. Christensen DL, Faurholt-Jepsen D, Birkegaard L, Mwaniki DL, Boit MK, Kilonzo B, Brage S, Friis H, Tetens I, Borch-Johnsen K, Vistisen D. Cardiovascular risk factors in rural Kenyans are associated with differential age gradients, but not modified by sex or ethnicity. Ann Hum Biol. 2016; **43**:42-9.
40. Dave JA, Levitt NS, Ross IL, Lacerda M, Maartens G, Blom D. Anti-retroviral therapy increases the prevalence of dyslipidemia in South African HIV-infected patients. PLoS One. 2016; **11**(3):e0151911.
41. Dennison CR, Peer N, Lombard CJ, Kepe L, Levitt NS, Steyn K, Hill MN. Cardiovascular risk and comorbid conditions among Black South Africans with hypertension in public and private primary care settings: the HiHi study. Ethn Dis. 2007; **17**:477-83.
42. Desormais I, Aboyans V, Guerchet M, Ndamba-Bandzouzi B, Mbelesso P, Dantoine T, Mohty D, Marin B, Preux PM, Lacroix P; EPIDEMCA investigators. Prevalence of peripheral artery disease in the elderly population in urban and rural areas of Central Africa: the EPIDEMCA study. Eur J Prev Cardiol. 2015; 22:1462-72.
43. Diouf A, Cournil A; groupe d'étude de la Cohorte ANRS 1215.Prevalence of metabolic complications after 10 years of antiretroviral treatment in Senegal. Bull Soc Pathol Exot. 2014;**107**:234-7.

44. Dongway AC, Faggad AS, Zaki HY, Abdalla BE. C-reactive protein is associated with lowdensity lipoprotein cholesterol and obesity in type 2 diabetic Sudanese. Diabetes Metab Syndr Obes. 2015; **8**:427-35.
45. Dos Prazeres Tavares H, Dos Santos DC, Abbade JF, Negrato CA, de Campos PA, Calderon IM, Rudge MV. Prevalence of metabolic syndrome in non-diabetic, pregnant Angolan women according to four diagnostic criteria and its effects on adverse perinatal outcomes. Diabetol Metab Syndr. 2016; **8**:27.
46. Dowse GK, Gareeboo H, Alberti KG, Zimmet P, Tuomilehto J, Purran A, Fareed D, Chitson P, Collins VR. Changes in population cholesterol concentrations and other cardiovascular risk factor levels after five years of the non-communicable disease intervention programme in Mauritius. Mauritius Non-communicable Disease Study Group. BMJ. 1995; 311:1255-9.
47. Edo A, Adediran OS. Dyslipidaemia among Nigerian Oil Workers withType 2 Diabetes Mellitus. West Afr J Med. 2011; **30**:206-9.
48. Eghan BA Jr, Acheampong JW. Dyslipidemia in Outpatients at General Hospital in Kumasi, Ghana: Cross-sectional Study. Croat Med J. 2003; **44**:576-8.
49. Ejim EC, Okafor CI, Emehel A, Mbah AU, Onyia U, Egwuonwu T, Akabueze J, Onwubere BJ. Prevalence of cardiovascular risk factors in the middle-aged and elderly population of a nigerian rural community. J Trop Med. 2011; 2011:308687.
50. Ekali LG, Johnstone LK, Echouffo-Tcheugui JB, Kouanfack C, Dehayem MY, Fezeu L, Nouthe B, Hayes L, Unwin NC, Sobngwi E. Fasting blood glucose and insulin sensitivity are unaffected by HAART duration in Cameroonians receiving first-line antiretroviral treatment. Diabetes Metab. 2013; **39**:71-7.
51. El ayachi M, Mziwira M, Vincent S, Defoort C, Portugal H, Lairon D, Belahsen R.Lipoprotein profile and prevalence of cardiovascular risk factors in urban Moroccan women. Eur J Clin Nutr. 2005; **59**:1379-86.
52. El Boukhrissi F, Bamou Y, Ouleghzal H, Safi S, Balouch L. Prevalence of risk factors for cardiovascular disease and metabolic syndrome among women in the region of Meknes, Morocco. Médecine des maladies Métaboliques 2017; 11:188-194.
53. El Mabchour A, Agueh V, Delisle H. Determinants and relationship of homocysteinemia with cardiometabolic risk factors. A study in Benin, West Africa. Presse Med. 2010 Nov;39(11):e23846.
54. Elnasri HA, Ahmed AM. Patterns of lipid changes among type 2 diabetes patients in Sudan. East Mediterr Health J. 2008; **14**:314-24.
55. Essais O, Jabrane J, Bouguerra R, El Atti J, Ben Rayana C, Gaïgi S, Ben Slama C, Zouari B. Distribution and prevalence of dyslipidemia in Tunisia: results of the Tunisian National Nutrition Survey. Tunis Med. 2009; **87**:505-10.
56. Ezzaher A, Haj MD, Mechri A, Neffati F, Douki W, Gaha L, Najjar MF. Metabolic syndrome in Tunisian bipolar I patients. Afr Health Sci. 2011; **11**:414-20.
57. Fezeu L, Balkau B, Kengne AP, Sobngwi E, Mbanya JC. Metabolic syndrome in a sub-Saharan African setting: Central obesity may be the key determinant. Atherosclerosis. 2007; **193**:70-6.
58. Gamal SM, Fawzy SM, Abdo M, Elgengehy FT, Ghoniem S, Alkemry. Immunological profile and dyslipidemia in Egyptian Systemic Lupus Erythematosus patients. Egyptian Rheumatologist (2017) 39, 89–92

59. Gannar F, Cabrera de León A, Brito Díaz B, Del Cristo Rodríguez Pérez M, Marcelino Rodríguez I, Ben Dahmen F, Sakly M, Attia N. Social class and metabolic syndrome in populations from Tunisia and Spain. Diabetol Metab Syndr. 2015;7:88.
60. Gebre-Yohannes A, Rahlenbeck SI. Coronary heart disease risk factors among blood donors in northwest Ethiopia. East Afr Med J. 1998; 75:495-500.
61. Ghannem H, Limam K, Ben Abdelaziz A, Mtiraoui A, Hadj Fredj A, Marzouki M. Risk factors of cardiovascular diseases in a semi-urban community in Sahel (Tunisia). Rev Epidemiol Sante Publique. 1992; **40**:108-12.
62. Gharbi M, Belhani A, Aouidet A, Ben Rayana C, Achour A, Nasraoui A, Tritar B, Kallel Z. Level of cardiovascular risk factors in the urban and rural populations of Cap-Bon: Tunisia. Rev Epidemiol Sante Publique. 1996; 44:125-32.
63. Habil E, Faris R, Magid A, Rady M.Predictive model of coronary heart disease in Egypt (a disease with multiple risk factors). J Egypt Public Health Assoc. 1999; **74**:297-312.
64. Hadj-Taieb S, Elasmi M, Hammami MB, Marrakchi R, Amani K, Omar S, Sanhaji H, Jemaa R, Feki M, Kaabachi N. Dyslipidemia in the Greater Tunis Population: Prevalence and Determinants. Clin Lab. 2012; **58**:763-70.
65. Haregu TN, Oti S, Ngomi N, Khayeka-Wandabwa C, Egondi T, Kyobutungi C. Interlinkage among cardio-metabolic disease markers in an urban poor setting in Nairobi, Kenya. Glob Health Action. 2016; **9**:30626.
66. Harzallah F, Ncibi N, Alberti H, Ben Brahim A, Smadhi H, Kanoun F, Slimane H. Clinical and metabolic characteristics of newly diagnosed diabetes patients. Diabetes Metab. 2006; **32**:632-5.
67. Hassen Zrour S, Hassine Neffeti F, Sakly N, Jguirim M, Korbaa W, Younes M, Bejia I, Touzi M, Fadel NM, Bergaoui N. Lipid profile in Tunisian patients with rheumatoid arthritis. Clin Rheumatol. 2011; **30**:1325-31.
68. Herter-Aeberli I, Cherkaoui M, El Ansari N, Rohner R, Stinca S, Chabaa L, von Eckardstein A, Aboussad A, Zimmermann MB. Iodine Supplementation Decreases Hypercholesterolemia in Iodine-Deficient, Overweight Women: A Randomized Controlled Trial. J Nutr. 2015; 145:206775.
69. Hirigo AT, Tesfaye DY. Influences of gender in metabolic syndrome and its components among people living with HIV virus using antiretroviral treatment in Hawassa, southern Ethiopia. BMC Res Notes. 2016; **9**:145.
70. Houehanou YC, Lacroix P, Mizehoun GC, Preux PM, Marin B, Houinato DS .Magnitude of cardiovascular risk factors in rural and urban areas in Benin: findings from a nationwide steps survey. PLoS One. 2015; **10**(5):e0126441.
71. Ibrahim MM, Appel LJ, Rizk HH, Helmy S, Mosley J, Ashour Z, El-Aroussy W, Roccella E, Whelton P. Cardiovascular risk factors in normotensive and hypertensive Egyptians. J Hypertens. 2001; 19:1933-40.
72. Igwe CU, Duru LA, Ukwamedua H, Ikaraoha CI. Prevalence of hyperlipidaemia among insulindependent and non-insulin-dependent diabetes mellitus patients in Delta State, Nigeria. Trop Doct. 2007; **37**:120-1.
73. Iloh G, Amadi AN, Njoku PU, Ofoedu JN, Awa-Madu J.The magnitude of abdominal adiposity and atherogenic dyslipidemia among geriatric Nigerians with arterial hypertension in a rural hospital in South-eastern Nigeria. Niger J Clin Pract. 2012;**15**:462-8.
74. Iloh G, Amadi AN, Nwankwo BO, Ugwu VC.Obesity in adult Nigerians: a study of its pattern and common primary co-morbidities in a rural Mission General Hospital in Imo state, South-Eastern Nigeria. Niger J Clin Pract. 2011; **14**:212-8.

75. Iwuala SO, Lesi OA, Olamoyegun MA, Sabir AA, Fasanmade OA.Lipoatrophy among patients on antiretroviral therapy in Lagos, Nigeria: Prevalence, pattern and association with cardiovascular risk factors. Niger J Clin Pract. 2015; **18**:626-32.
76. Jean-Luc Gradidge P, Norris SA, Jaff NG, Crowther NJ. Metabolic and body composition risk factors associated with Metabolic Syndrome in a Cohort of Women with a high prevalence of cardiometabolic disease. PLoS One. 2016; 11(9):e0162247.
77. Jemaa R, Kafsi MN, Kallel A, Mechmeche R, Zaouali RM, Haouala H, Elasmi M, Gueddiche M, Slimane L, Belhani A, Kaabachi N, Mebazaa A. Distribution of cardiovascular risk factors in a Tunisian cohort of 6901 coronary patients. Arch Mal Coeur Vaiss. 2004; 97:20-4.
78. Jisieike-Onuigbo NN, Unuigbe EI, Oguejiofor CO. Dyslipidemias in type 2 diabetes mellitus patients in Nnewi South-East Nigeria. Ann Afr Med. 2011; **10**:285-9.
79. Jisieike-Onuigbo NN, Unuigbe EI, Kalu OA, Oguejiofor CO, Onuigbo PC.Prevalence of dyslipidemia among adult diabetic patients with overt diabetic nephropathy in Anambra state South-East Nigeria. Niger J Clin Pract. 2011; **14**:171-5.
80. Julius H, Basu D, Ricci E, Wing J, Basu JK, Pocaterra D, Bonfanti P.The burden of metabolic diseases amongst HIV positive patients on HAART attending The Johannesburg Hospital. Curr HIV Res. 2011 Jun;9(4):247-52.
81. Kadiri S, Salako BL. Cardiovascular risk factors in middle aged Nigerians. East Afr Med J. 1997; 74:303-6.
82. Kalk WJ, Joffe BI. The Metabolic Syndrome, Insulin Resistance, and Its Surrogates in African and White Subjects with Type 2 Diabetes in South Africa. Metab Syndr Relat Disord. 2008; **6**:247-55.
83. Kamara NT, Asiimwe S. Dyslipidaemia and hypertension among adults with diabetes in rural Uganda. Trop Doct. 2010 Jan;40(1):41-2.
84. Kamdem F, Doualla MS, Kemta Lekpa F, Temfack E, Ngo Nouga Y, Sontsa Donfack O, Dzudie A, Kingue S. Prevalence and factors associated with hyperuricaemia in newly diagnosed and untreated hypertensives in a sub-Saharan African setting. Arch Cardiovasc Dis. 2016; 109:527532.
85. Karaye KM, Okeahialam BN, Wali SS. Impact of income on the profile of cardiovascular risk factors among hypertensives in a Nigerian tertiary health centre: a cross-sectional study. Cardiovasc J Afr. 2009; 20:251-5.
86. Katchunga PB, Bapolisi AM, M'Buyamba-Kabangu JR, Hermans MP. Bioelectrical impedance outperforms waist
circumference for predicting cardiometabolic risk in Congolese hypertensive subjects: a crosssectional study. BMC Cardiovasc Disord. 2015;15:17.
87. Katibi IA, Akande AA, Salami AK. Lipid abnormalities among type 2 diabetes mellitus patients: our experience in llorln, Nigeria. Trop Doct. 2004; **34**:254-5.
88. Khalfa A, Tiali A, Zemour L, Fatah A, Mekki K. Prevalence of metabolic syndrome and its association with lifestyle and cardiovascular biomarkers among postmenopausal women in western Algeria. Int J Gynaecol Obstet. 2017; **138**:201-206.
89. Kiage JN, Heimburger DC, Nyirenda CK, Wellons MF, Bagchi S, Chi BH, Koethe JR, Arnett DK, Kabagambe EK. Cardiometabolic risk factors among HIV patients on antiretroviral therapy. Lipids Health Dis. 2013 Apr 10;12:50.
90. Koopman JJ, van Bodegom D, Jukema JW, Westendorp RG. Risk of cardiovascular disease in a traditional African population with a high infectious load: a population-based study. PLoS One. 2012;7(10):e46855.

91. Kruger HS, Schutte AE, Walsh CM, Kruger A, Rennie KL. Body mass index cut-points to identify cardiometabolic risk in black South Africans. Eur J Nutr. 2017; 56:193-202.
92. Kuti MA, Adesina OA, Awolude OA, Ogunbosi BO, Fayemiwo SA, Akinyemi JO, Adetunji AA, Irabor AE, Odaibo GN, Prosper O, Taiwo BO, Olaleye D, Murphy RL, Kanki P, Adewole IF. Dyslipidemia in ART-Naive HIV-Infected Persons in Nigeria—Implications for Care. J Int Assoc Provid AIDS Care. 2015; 14:355-9.
93. Laabes EP, Thacher TD, Okeahialam BN. Risk factors for heart failure in adult Nigerians. Acta Cardiol. 2008; 63:437-43.
94. Labhardt ND, Müller UF, Ringera I, Ehmer J, Motlatsi MM, Pfeiffer K, Hobbins MA, Muhairwe JA, Muser J, Hatz C. Metabolic syndrome in patients on first-line antiretroviral therapy containing zidovudine or tenofovir in rural Lesotho, Southern Africa. Trop Med Int Health. 2017; **22**:725733.
95. Laissaoui A, Allem R, Azzoug S, Yahiaoui I, Belouazni A. HbA1c as a Predictor of Dyslipidemia in Algerian Type 2 Diabetic Patients. Romanian Journal of Diabetes Nutrition and Metabolic Diseases. 2016; **23**:139-146.
96. Latifa BH, Kaouel M. Cardiovascular risk factors in Tlemcen (Algeria). Sante. 2007; 17:153-8.
97. Lepira FB, M'Buyamba-Kabangu JR, Kayembe KP, Nseka MN. Correlates of serum lipids and lipoproteins in Congolese patients with arterial hypertension. Cardiovasc J S Afr. 2005; 16:24955.
98. Lesi OA, Soyebi KS, Eboh CN. Fatty Liver and Hyperlipidemia in a Cohort of HIV-positive Africans on highly active Antiretroviral Therapy. J Natl Med Assoc. 2009; **101**:151-5.
99. Lissock CN, Sobngwi E, Ngassam E, Ngoa Etoundi LS. Rural and urban differences in metabolic profiles in a Cameroonian population. Pan Afr Med J. 2011;10:1.
100. Liu E, Armstrong C, Spiegelman D, Chalamilla G, Njelekela M, Hawkins C, Hertzmark E, Li N, Aris E, Muhihi A, Semu H, Fawzi W. First-line antiretroviral therapy and changes in lipid levels over 3 years among HIV-infected adults in Tanzania. Clin Infect Dis. 2013; 56:1820-8.
101. Manuthu EM, Joshi MD, Lule GN, Karari E. Prevalence of dyslipidemia and dysglycaemia in HIV infected patients. East Afr Med J. 2008; **85**:10-7.
102. Mashinya F, Alberts M, Van Geertruyden JP, Colebunders R. Assessment of cardiovascular risk factors in people with HIV infection treated with ART in rural South Africa: a cross sectional study. AIDS Res Ther. 2015;12:42.
103. Mayanja BN, Kasamba I, Levin J, Namakoola I, Kazooba P, Were J, Kaleebu P, Munderi P; CoLTART study team. COHORT PROFILE: The Complications of Long-Term Antiretroviral Therapy study in Uganda (CoLTART), a prospective clinical cohort. AIDS Res Ther. 2017;**14**:26.
104. Mengesha AY. Lipid profile among diabetes patients in Gaborone, Botswana. S Afr Med J. 2006; **96**:147-8.
105. Meziane M, Kelati A, Najdi A, Berraho A, Nejjari C, Mernissi FZ. Metabolic syndrome in Moroccan patients with psoriasis. Int J Dermatol. 2016; **55**:396-400.
106. Micah FB, Nkum BC. Lipid disorders in hospital attendants in Kumasi, Ghana. Ghana Med J. 2012; **46**:14-21.
107. Mohammed AE, Shenkute TY, Gebisa WC. Diabetes mellitus and risk factors in human immunodeficiency virus-infected individuals at Jimma University Specialized hospital, Southwest Ethiopia. Diabetes Metab Syndr Obes. 2015; **8**:197-206.
108. Mollentze WF, Moore AJ, Steyn AF, Joubert G, Steyn K, Oosthuizen GM, Weich DJ. Coronary heart disease risk factors in a rural and urban Orange Free State black population. S Afr Med J. 1995 Feb;85(2):90-6.

109. Muhammad S, Sani MU, Okeahialam BN.Prevalence of dyslipidemia among human immunodeficiency virus infected Nigerians. Ann Afr Med. 2013; **12**:24-8.
110. Muronya W, Sanga E, Talama G, Kumwenda JJ, van Oosterhout JJ. Cardiovascular risk factors in adult Malawians on long-term antiretroviral therapy. Trans R Soc Trop Med Hyg. 2011 Nov;105(11):644-9.
111. Murphy GA, Asiki G, Ekoru K, Nsubuga RN, Nakiyingi-Miiro J, Young EH, Seeley J, Sandhu MS, Kamali A. Sociodemographic distribution of non-communicable disease risk factors in rural Uganda: a cross-sectional study. Int J Epidemiol. 2013; **42**:1740-53.
112. Muyanja D, Muzoora C, Muyingo A, Muyindike W, Siedner MJ. High Prevalence of Metabolic Syndrome and Cardiovascular Disease Risk Among People with HIV on Stable ART in Southwestern Uganda. AIDS Patient Care STDS. 2016; 30:4-10.
113. Mwita JC, Mugusi F, Lwakatare J, Chiwanga F. Hypertension control and other cardiovascular risk factors among diabetic patients at Muhimbili National Hospital, Tanzania. East Afr J Public Health. 2012; 9:70-3.
114. Nagu TJ, Kanyangarara M, Hawkins C, Hertmark E, Chalamila G, Spiegelman D, Mugusi F, Fawzi W. Elevated alanine aminotransferase in antiretroviral-naïve HIV-infected African patients: magnitude and risk factors. HIV Med. 2012; 13:541-8.
115. Naifar M, Rekik N, Messedi M, Chaabouni K, Lahiani A, Turki M, Abid M, Ayedi F, Jamoussi K. Male hypogonadism and metabolic syndrome. Andrologia. 2015; **47**:579-86.
116. Napoli N, Zardi E, Strollo R, Arigliani M, Daverio A, Olearo F, Tosi D, Dicuonzo G, Scarpa F, Pedone C, Tegue Simo HH, Mottini G, Pozzilli P. Increased Carotid Thickness in Subjects with Recently Diagnosed Diabetes from Rural Cameroon. PLoS One. 2012; **7**(8):e41316.
117. 117. Nguemaïm NF, Mbuagbaw J, Nkoa T, Alemnji G, Této G, Fanhi TC, Asonganyi T, SaméEkobo A. Serum lipid profile in highly active antiretroviral therapy-naı¨ve HIV-infected patients in Cameroon: a case–control study. HIV Med. 2010; **11**:353-9.
118. Njelekela MA, Mpembeni R, Muhihi A, Mligiliche NL, Spiegelman D, Hertzmark E, Liu E, Finkelstein JL, Fawzi WW, Willett WC, Mtabaji J Gender-related differences in the prevalence of cardiovascular disease risk factors and their correlates in urban Tanzania. BMC Cardiovasc Disord. 2009; **9**:30.
119. Njelekela MA, Negishi H, Nara Y, Sato T, Tomohiro M, Kuga S, Noguchi T, Kanda T, Yamori M, Mashalla Y, Liu LJ, Ikeda K, Mtabaji J, Yamori Y. Obesity and lipid profiles in middle aged men and women in Tanzania. East Afr Med J. 2002; 79:58-64.
120. Nsagha DS, Weledji EP, Assob NJ, Njunda LA, Tanue EA, Kibu OD, Ayima CW, Ngowe MN. Highly active antiretroviral therapy and dyslipidemia in people living with HIV/AIDS in Fako Division, South West Region of Cameroon. BMC Cardiovasc Disord. 2015; 15:95.
121. Nsiah K, Shang VO, Boateng KA, Mensah FO.Prevalence of metabolic syndrome in type 2 diabetes mellitus patients. Int J Appl Basic Med Res. 2015; **5**:133-8.
122. Nwose EU, Oguoma VM, Bwititi PT, Richards RS. Metabolic Syndrome and Prediabetes in Ndokwa Community of Nigeria: Preliminary Study. N Am J Med Sci. 2015; **7**: 53–58.
123. Oboh HA, Adedeji AA. Correlation of waist-hip-ratio and waist-height-ratio to cardiovascular risks factors in a Nigerian population. Nig Q J Hosp Med. 2011; 21:16-24.
124. Odenigbo CU, Oguejiofor OC, Odenigbo UM, Ibeh CC, Ajaero CN, Odike MA.Prevalence of dyslipidaemia in apparently healthy professionals in Asaba, South South Nigeria. Niger J Clin Pract. 2008; **11**:330-5.

125. Oelofse A, Jooste PL, Steyn K, Badenhorst CJ, Lombard C, Bourne L, Fourie J.The lipid and lipoprotein profile of the urban black South African population of the Cape Peninsula - the BRISK study. S Afr Med J. 1996; **86**:162-6.
126. Ogbera A, Fasanmade O, Kalra S. Menopausal symptoms and the metabolic syndrome in Nigerian women with type 2 diabetes mellitus. Climacteric. 2011; **14**:75-82.
127. Oghagbon EK, Okesina AB, Adebisi SA. Awareness of atherosclerosis risk factors in Nigeria. J R Soc Promot Health. 2004; 124:180-3.
128. Oguoma VM, Nwose EU, Ulasi II, Akintunde AA, Chukwukelu EE, Araoye MA, Edo AE, Ijoma CK, Onyia IC, Ogbu II, Onyeanusi JC, Digban KA, Onodugo OD, Adediran O, Opadijo OG, Bwititi PT, Richards RS, Skinner TC. Maximum accuracy obesity indices for screening metabolic syndrome in Nigeria: A consolidated analysis of four cross-sectional studies. Diabetes Metab Syndr. 2016; **10**:121-7.
129. Okafor CI, Fasanmade OA, Oke DA. Pattern of dyslipidaemia among Nigerians with type 2 diabetes mellitus. Niger J Clin Pract. 2008; 11:25-31.
130. Oladapo OO, Salako L, Sodiq O, Shoyinka K, Adedapo K, Falase AO. A prevalence of cardiometabolic risk factors among a rural Yoruba south-western Nigerian population: a population-based survey. Cardiovasc J Afr. 2010; **21**:26-31.
131. Olamoyegun MA, Oluyombo R, Asaolu SO. Evaluation of dyslipidemia, lipid ratios, and atherogenic index as cardiovascular risk factors among semi-urban dwellers in Nigeria. Ann Afr Med. 2016; **15**:194-199.
132. Oluyombo R, Akinwusi PO, Olamoyegun MO, Ayodele OE, Fawale MB, Okunola OO, Olanrewaju TO, Akinsola A. Clustering of cardiovascular risk factors in semi-urban communities in south-western Nigeria. Cardiovasc J Afr. 2016; **27**:322-327.
133. Ombeni W, Kamuhabwa AR. Lipid Profile in HIV-Infected Patients Using FirstLine Antiretroviral Drugs. J Int Assoc Provid AIDS Care. 2016; 15:164-71.
134. Omech B, Tshikuka JG, Mwita JC, Tsima B, Nkomazana O, Amone-P'Olak K. Prevalence and determinants of metabolic syndrome: a cross-sectional survey of general medical outpatient clinics using National Cholesterol Education Program-Adult Treatment Panel III criteria in Botswana. Diabetes Metab Syndr Obes. 2016; **9**:273-9.
135. Osei-Yeboah J, Owiredu WK, Norgbe GK, Yao Lokpo S, Gyamfi J, Alote Allotey E, Asumbasiya Aduko R, Noagbe M, Attah FA. The Prevalence of Metabolic Syndrome and Its Components among People with Type 2 Diabetes in the Ho Municipality, Ghana: A CrossSectional Study. Int J Chronic Dis. 2017; **2017**:8765804.
136. Otieno CF, Mwendwa FW, Vaghela V, Ogola EN, Amayo EO. Lipid profile of ambulatory patients with type 2 diabetes mellitus at Kenyatta National Hospital, Nairobi. East Afr Med J. 2005; 82(12 Suppl):S173-9.
137. Pauletto P, Puato M, Caroli MG, Casiglia E, Munhambo AE, Cazzolato G, Bittolo Bon G, Angeli MT, Galli C, Pessina AC. Blood pressure and atherogenic lipoprotein profiles of fishdiet and vegetarian villagers in Tanzania: the Lugalawa study. Lancet. 1996; **348**:784-8.
138. Peer N, Steyn K, Levitt N. Differential obesity indices identify the metabolic syndrome in Black men and women in Cape Town: the CRIBSA study. J Public Health (Oxf). 2016; **38**:175-
82.

139. Pessinaba S, Mbaye A, Kane A, Guene BD, Mbaye Ndour M, Niang K, Jobe M, Cazaubon M, Mathieu JB, Kane M, Sow DD, Diack B, Kane A.Screening for asymptomatic peripheral arterial occlusive disease of the lower limbs by measuring the ankle-brachial index in the general population (Senegal). J Mal Vasc. 2012; **37**:195-200.
140. Pessinaba S, Mbaye A, Yabéta GA, Harouna H, Sib AE, Kane AD, Bodian M, Ndiaye MB, Mbaye-Ndour M, Niang K, Diagne-Sow D, Diack B, Kane M, Diao M, Mathieu JB, Kane A. Prevalence survey of cardiovascular risk factors in the general population in St. Louis (Senegal). Ann Cardiol Angeiol (Paris). 2013; **62**:253-8.
141. Prakaschandra DR, Esterhuizen TM, Motala AA, Gathiram P, Naidoo DP. High prevalence of cardiovascular risk factors in Durban South African Indians: The Phoenix Lifestyle Project. S Afr Med J. 2016; **106**:284-9.
142. Rguibi M, Belahsen R. High blood pressure in urban Moroccan Sahraoui women. J Hypertens. 2007; **25**:1363-8.
143. Sabir AA, Jimoh A, Iwuala SO, Isezuo SA, Bilbis LS, Aminu KU, Abubakar SA, Saidu Y. Metabolic syndrome in urban city of North-Western Nigeria: prevalence and determinants. Pan Afr Med J. 2016; 23:19.
144. Sabir AA, Isezuo SA, Ohwovoriole AE, Fasanmade OA, Abubakar SA, Iwuala S, Umar MT. Rural-urban difference in plasma lipid levels and prevalence of dyslipidemia in Hausa-Fulani of north-western Nigeria. Ethn Dis. 2013; **23**:374-8.
145. Sabir FM, Hassan DA and Elamin MI. Prevalence of Metabolic Syndrome among Young Sudanese University Students Using Three Different Criteria of WHO, IDF and NCEP-ATP III. Pediatr Neonatal Nurs 2(2): doi http://dx.doi.org/10.16966/2470-0983.112
146. Salami AK, Akande AA, Olokoba AB.Serum lipids and glucose abnormalities in HIV/AIDS patients on antiretroviral therapies. West Afr J Med. 2009; **28**:10-5.
147. Saloojee S, Burns JK, Motala AA. Metabolic Syndrome in South African Patients with Severe Mental Illness: Prevalence and Associated Risk Factors. PLoS One. 2016; **11**(2):e0149209.
148. Sawadogo A, Sanou S, Hema A, Kamboule BE, Kabore NF, Sore I, Konate A, Poda GE, Zoungrana J, Sawadogo AB. Metabolic syndrome and cardiovascular risk patients under antiretrovirals in a hospital day at Bobo-Dioulasso (Burkina Faso). Bull Soc Pathol Exot. 2014; **107**:151-8.
149. Schoffelen AF, de Groot E, Tempelman HA, Visseren FL, Hoepelman AI, Barth RE. Carotid Intima Media Thickness in Mainly Female HIV-Infected Subjects in Rural South Africa: Association with Cardiovascular but Not HIV-Related Factors. Clin Infect Dis. 2015; **61**:160614.
150. Sellam EB, Bour A. Prevalence of risk factors for cardiovascular disease in women in Oujda (Morocco). Medecine des amaldies metaboliques. 2016; **10**:63-69.
151. Sewdarsen M, Vythilingum S, Jialal I, Becker P.Lipid and lipoprotein abnormalities in South African Indian men with myocardial infarction. Cardiology. 1991; **78**:348-56.
152. Seyoum B, Abdulkadir J, Berhanu P, Feleke Y, Mengistu Z, Worku Y, Ayana G.Analysis of serum lipids and lipoproteins in Ethiopian diabetic patients. Ethiop Med J. 2003; **41**:1-8.
153. Shaffer D, Hughes MD, Sawe F, Bao Y, Moses A, Hogg E, Lockman S, Currier J. Cardiovascular disease risk factors in HIV-infected women after initiation of

lopinavir/ritonavir- and nevirapine-based antiretroviral therapy in Sub-Saharan Africa: A5208 (OCTANE). J Acquir Immune Defic Syndr. 2014; 66:155-63.
154. Shoukry MI, Fareed S. Plasma lipid and lipoprotein concentrations in an Egyptian male sample. Lipids. 1982; **17**:692-5.
155. Sinxadi PZ, McIlleron HM, Dave JA, Smith PJ, Levitt NS, Haas DW, Maartens G. Plasma Efavirenz Concentrations Are Associated With Lipid and Glucose Concentrations. Medicine (Baltimore). 2016; **95**(2):e2385.
156. Siraj ES, Seyoum B, Saenz C, Abdulkadir J.Lipid and lipoprotein profiles in Ethiopian patients with diabetes mellitus. Metabolism. 2006; **55**:706-10.
157. Sliwa K, Lyons JG, Carrington MJ, Lecour S, Marais AD, Raal FJ, Stewart S. Different lipid profiles according to ethnicity in the Heart of Soweto study cohort of de novo presentations of heart disease. Cardiovasc J Afr. 2012; 23:389-95.
158. Sobieszczyk ME, Werner L, Mlisana K, Naicker N, Feinstein A, Gray CM, Masson L, Passmore JS, Williamson C, Abdool Karim Q, Abdool Karim SS, Garrett NJ. Metabolic Syndrome After HIV Acquisition in South African Women. J Acquir Immune Defic Syndr. 2016; **73**:438-445.
159. Sobngwi E, Ndour-Mbaye M, Boateng KA, Ramaiya KL, Njenga EW, Diop SN, Mbanya JC, Ohwovoriole AE. Type 2 diabetes control and complications in specialised diabetes care centres of six sub-Saharan African countries: The Diabcare Africa study. Diabetes Res Clin Pract. 2012; **95**:30-6.
160. Sodjinou R, Agueh V, Fayomi B, Delisle H.Obesity and cardio-metabolic risk factors in urban adults of Benin: Relationship with socio-economic status, urbanisation, and lifestyle patterns. BMC Public Health. 2008; **8**:84.
161. Steyn K, Benadé AJ, Langenhoven ML, Joubert G, Rossouw JE. Hypercholesterolaemia in the coloured population of the Cape Peninsula (CRISIC study). S Afr Med J. 1987; 71(8):483-6.
162. Steyn K, Fourie JM, Shepherd J. Detection and measurement of hypercholesterolaemia in South Africans attending general practitioners in private practice--the cholesterol monitor. S Afr Med J. 1998; 88:1569-74.
163. Steyn K, Fourie J, Benadé AJ, Rossouw JE, Langenhoven ML, Joubert G, Chalton DO. Factors associated with high density lipoprotein cholesterol in a population with high high density lipoprotein cholesterol levels. Arteriosclerosis. 1989; **9**:390-7.
164. Steyn K, Levitt NS, Hoffman M, Marais AD, Fourie JM, Lambert EV, Gaziano TA, Kepe L, Lombard CJ.The global cardiovascular diseases risk pattern in a peri-urban working-class community in South Africa. The Mamre study. Ethn Dis. 2004; **14**:233-42.
165. Swai AB, McLarty DG, Kitange HM, Kilima PM, Tatalla S, Keen N, Chuwa LM, Alberti KG. Low Prevalence of Risk Factors for Coronary Heart Disease in Rural Tanzania. Int J Epidemiol. 1993; **22**:651-9.
166. Tachebele B, Abebe M, Addis Z, Mesfin N .Metabolic syndrome among hypertensive patients at University of Gondar Hospital, North West Ethiopia: a cross sectional study. BMC Cardiovasc Disord. 2014; **14**:177.
167. Tazi MA, Abir-Khalil S, Chaouki N, Cherqaoui S, Lahmouz F, Sraïri JE, Mahjour J.Prevalence of the main cardiovascular risk factors in Morocco: results of a National Survey, 2000. J Hypertens. 2003; **21**:897-903.

168. Thiombiano LP, Mbaye A, Sarr SA, Ngaide AA, Kane A, Diao M, Kane A, Ba SA. Prevalence of dyslipidemia in the rural population of Gueoul (Senegal). Ann Cardiol Angeiol (Paris). 2016; **65**:77-80.
169. Tibazarwa K, Ntyintyane L, Sliwa K, Gerntholtz T, Carrington M, Wilkinson D, Stewart S. A time bomb of cardiovascular risk factors in South Africa: results from the Heart of SowetoStudy "Heart Awareness Days". Int J Cardiol. 2009; 132:233-9.
170. Turpin CA, Ahenkorah L, Owiredu WK, Laing EF, Amidu N. The prevalence of the metabolic syndrome among Ghanaian pregnancy-induced hypertensive patients using the World Health Organization and the National Cholesterol Education Program II Criteria. J Med Sci. 2008; **8**:443-451.
171. Udenze IC, Azinge EC, Arikawe AP, Egbuagha EU, Onyenekwu C, Ayodele O, Adizua UC. The prevalence of metabolic syndrome in persons with type 2 diabetes at the Lagos University Teaching Hospital, Lagos, Nigeria. West Afr J Med. 2013; 32:126-32.
172. Uwanuruochi K, Ukpabi OJ, Onwuta CN, Onwubere BJ, Anisiuba BC, Michael FS. Cardiovascular risk factors in adult staff of Federal Medical Centre, Umuahia: a comparison with other Nigerian studies. West Afr J Med. 2013; 32:243-7.
173. van Oosterhout JJ, Mallewa J, Kaunda S, Chagoma N, Njalale Y, Kampira E, Mukaka M, Heyderman RS. Stavudine Toxicity in Adult Longer-Term ART Patients in Blantyre, Malawi. PLoS One. 2012;7(7):e42029.
174. Vermaak JR, Dave JA, Levitt N, Heckmann JM. Sensory neuropathy and metabolic risk factors in human immune deficiency virus infected South Africans receiving protease inhibitors. AIDS Res Ther. 2015;12:30.
175. Vezi ZB, Naidoo DP. Dyslipidaemia among black patients with type 2 diabetes. Cardiovasc J S Afr. 2005; **16**:194-8.
176. Walker AR, Walker BF, Manetsi B, Molefe O, Walker AJ, Vorster HH. Obesity in indigent elderly rural African women: effects on hypertension, hyperlipidaemia and hyperglycaemia. Int J Vitam Nutr Res. 1991; **61**:244-50.
177. Walker AR, Walker BF, Manetsi B, Tsotetsi NG, Walker AJ. Obesity in black women in Soweto, South Africa: minimal effects on hypertension, hyperlipidaemia and hyperglycaemia. J R Soc Health. 1990; **110**:101-3
178. Wekesa C, Asiki G, Kasamba I, Waswa L, Reynolds SJ, Nsubuga RN, Newton R, Kamali A. Atherogenic Risk Assessment among Persons Living in Rural Uganda. J Trop Med. 2016; **2016**:7073894.
179. Workalemahu T, Gelaye B, Berhane Y, Williams MA.Physical Activity and Metabolic Syndrome among Ethiopian Adults. Am J Hypertens. 2013; **26**:535-40.
180. Wyndham CH, Seftel HC, Pilcher GJ, Baker SG. Prevalence of hypercholesterolemia in young Afrikaners with myocardial infarction. Ischaemic heart disease risk factors. S Afr Med J. 1987; **71**:139-42.
181. Zabsonre P, Yameogo A, Millogo A, Dyemkouma FX, Durand G.Risk and severity factors in cerebrovascular accidents in West African Blacks of Burkina Faso. Med Trop (Mars). 1997; **57**:147-52.

VIII- Addendum

We performed meta-regression analyses to explore possible impact of study characteristics on the reported estimates (Tables 1-5). The study region, either central, eastern, northern, southern or western Africa, had an impact on the pooled prevalence of elevated triglycerides (cutoff of 1.7 mmol/L) in both univariate and multivariate analysis (Table 5). The country where studies were conducted did not influence pooled prevalence rates. The year of study publication had an impact on the pooled prevalence of low HDL cholesterol (cutoff of 1.0 mmol/L) in both univariate and multivariate analysis (Table 3).

Table 1. Meta-regression analysis for elevated total cholesterol in the general population from community-based studies in Africa with a cutoff of 5.2 mmol/l

Variables	Univariable					Multivariable*			
	R^2, %	Beta	95%CI-LB	95%CI-UB	P value	Beta	95%CI-LB	95%CI-UB	P-value
Year	0.0	0.002	-0.007	0.011	0.728	0.001	-0.008	0.009	0.891
Region (Central)	15.0				0.092				
- Eastern		0.386	-0.001	0.774		0.324	-0.090	0.738	0.125
- Northern		0.471	0.088	0.853		0.389	-0.026	0.804	0.066
- Southern		0.475	0.084	0.867		0.475	0.065	0.885	0.023
- Western		0.351	-0.025	0.726		0.349	-0.046	0.743	0.083
Subnational (National)	6.1	-0.145	-0.297	0.008	0.062	-0.143	-0.341	0.054	0.156

Number of studies = 37; * I^2 = 99.6%; R^2 = 6.8%; CI-UB: confidence interval of the upper bound; CI-LB: confidence interval of the lower bound

Table 2. Meta-regression analysis for elevated total cholesterol in the general population from community-based studies in Africa with a cutoff of 6.5 mmol/l

Variables	Univariable					Multivariable*			
	R^2, %	Beta	95%CI-LB	95%CI-UB	P value	Beta	95%CI-LB	95%CI-UB	P value
Year	7.7	-0.005	-0.012	0.002	0.150	0.002	-0.007	0.010	0.740
Region (Central)	25.2				0.021				
- Eastern		0.136	-0.137	0.409		0.137	-0.214	0.488	0.445
- Northern		0.046	-0.234	0.325		0.062	-0.259	0.384	0.704
- Southern		0.252	-0.114	0.619		0.295	-0.177	0.766	0.221
- Western		-0.131	-0.430	0.168		-0.138	-0.471	0.196	0.418
National (Subnational)	0.0	0.048	0.778	-0.287	0.660	0.030	-0.147	0.207	0.743

Number of studies = 20; * I^2 = 99.2%; R^2 = 10.5%; CI-UB: confidence interval of the upper bound; CI-LB: confidence interval of the lower bound

Table 3. Meta-regression analysis for low HDL cholesterol in the general population from community-based studies in Africa with a cutoff of 1.0 mmol/l

Variables	Univariable					Multivariable*			
	R^2, %	Beta	95%CI-LB	95%CI-UB	P value	Beta	95%CI-LB	95%CI-UB	P value
Year	22.8	0.027	0.010	0.044	0.001	0.027	0.012	0.043	<.001
Region (Central)	6.0				0.361				
- Eastern		0.366	-0.125	0.857		0.401	-0.005	0.806	0.053
- Northern		0.303	-0.157	0.763		0.252	-0.126	0.629	0.191
- Southern		0.449	-0.011	0.909		0.434	0.059	0.810	0.023
- Western		0.313	-0.132	0.758		0.246	-0.116	0.609	0.183
Subnational (National)	7.8	0.118	-0.139	0.375	0.368	0.132	-0.095	0.358	0.254

Number of studies = 27; * I^2 = 99.5%; R^2 = 38.6%; CI-UB: confidence interval of the upper bound; CI-LB: confidence interval of the lower bound

Table 4. Meta-regression analysis for elevated LDL cholesterol in the general population from community-based studies in Africa with a cutoff of 3.0 mmol/l

Variables	Univariable					Multivariable*			
	R^2, %	Beta	95%CI-LB	95%CI-UB	P value	Beta	95%CI-LB	95%CI-UB	P value
Year	0.0	-0.007			0.738	-0.016	-0.083	0.052	0.651
Region (Eastern)	0.0				0.876				
- Southern		0.044	-0.567	0.655		0.155	-0.659	0.969	0.709
- Western		0.125	-0.412	0.662		0.197	-0.458	0.853	0.556

Number of studies = 12; * I^2 = 99.7%; R^2 = 0.0%; CI-UB: confidence interval of the upper bound; CI-LB: confidence interval of the lower bound

Table 5. Meta-regression analysis for elevated triglycerides in the general population from community-based studies in Africa with a cutoff of 1.7 mmol/l

Variables	Univariable					Multivariable*			
	R^2, %	Beta	95%CI-LB	95%CI-UB	P value	Beta	95%CI-LB	95%CI-UB	P value
Year	0.0	0.003	-0.004	0.010	0.440	0.006	-0.004	0.016	0.225
Region (Central)	22.9				0.018				
- Eastern		0.246	>-0.001	0.492		0.291	0.010	0.572	0.043
- Northern		0.298	0.060	0.537		0.350	0.073	0.627	0.013
- Southern		0.231	-0.020	0.482		0.238	-0.058	0.534	0.115
- Western		0.130	-0.110	-0.110		0.104	-0.159	0.367	0.440
Subnational (National)	24.5	-0.166	-0.286	-0.045	0.007	-0.088	-0.282	0.106	0.376

Number of studies = 37; * I^2 = 99.3%; R^2 = 38.1%; CI-UB: confidence interval of the upper bound; CI-LB: confidence interval of the lower bound

XI- Peer-reviewers' comments and authors' replies

Below are the comments of the referees during the two rounds of peer-review by The Lancet Global Health.

1- First review round

REVIEWER # 1

Reviewer's Comment 1: The authors report only prevalence of lipid fraction abnormalities but not dyslipidemia according to International guidelines using any abnormality in lipid fractions such as the NCEP guidelines which include fasting total cholesterol =5.2 mmol/L, HDL cholesterol =1.03 mmol/l, triglyceride = 1.7 mmol/l or LDL cholesterol = 3.4 mmol/l. As reported by authors, there is potential for presenting a lower prevalence of dyslipidemia among Africans. For instance, the prevalence of dyslipidemia has recently been reported as 61% among controls and 78% among stroke cases in Ghana and Nigeria in the SIREN study.

Dominant modifiable risk factors for stroke in Ghana and Nigeria (SIREN): a case-control study.

Owolabi MO, Sarfo F, Akinyemi R, Gebregziabher M, Akpa O, Akpalu A, Wahab K, Obiako R, Owolabi L, Ovbiagele B; SIREN Team; as part of H3Africa Consortium. Lancet Glob Health. 2018 Apr;6(4):e436e446.

1. Could the authors specify if they came across any studies where these lipid fractions were used to compositely define dyslipidemia? Could the authors please synthesize and include additional analysis with such data?

Authors' response 1: Thank you for the comment. First, dyslipidemia was rarely defined using a combination of lipid variables. Furthermore, in the very few studies which did so, dyslipidemia was inconsistently defined across them. It was therefore impossible to conduct a meta-analysis of such data, given the heterogeneity in the definitions. Indeed, each individual form of dyslipidemia reported in our

meta-analysis (total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and triglycerides) was defined using different cut-offs. Consequently, there was huge variability in the composite definitions of dyslipidaemia based on various sets of lipid variables and various cut-offs. For this reason, we only pooled estimates based on individual cut-off for the different forms of dyslipidaemia of interest.

We are mindful as already said in the manuscript and acknowledged by the reviewer, that the prevalence of dyslipidaemia from our review likely underestimate the true estimates of dyslipidaemia in Africa overall and by region. We are grateful to the reviewer for suggesting the recent report from SIREN study to substantiate the fact that prevalence from our review are likely underestimated. However, we do not believe that SIREN findings can be used to gauge the magnitude of this underestimation. The mean age of the control arm of SIREN was 58 years, that is not far from life expectancy in Africa which 61 years in men and 64 in women in 2017. Because the prevalence of dyslipidaemia increases with age, SIREN findings would likely apply to what will be considered as the elderly population (about 5% of the total population) in Africa, and not to a much broader (in term of age) population like our findings.

Reviewer's Comment 2: Can authors please present prevalence of dyslipidemia by age categories to help provide information on age distribution of dyslipidemia among Africans?

Authors' response 2: We thank the reviewer for raising this point. We were interested in presenting prevalence of dyslipidemias according to age categories in adults. Unfortunately, we could not find enough age-categorized data. Furthermore, there was significant overlap in the age categories across the rare studies which presented age-stratified data. Sub-group analysis according to age categories was therefore not possible.

Reviewer's Comment 3: Minor comments:

Introduction:

Please provide references for continental and regional estimates for diabetes and hypertension in paragraph 3 of introduction.

Authors' response 3: Thank you for the suggestion. A reference has been added.

REVIEWER # 2

Reviewer's comment 1: The authors systematically reviewed published studies on dyslipidemia and performed a meta-analysis. They found a summary prevalence of dyslipidemia of 23.6% in the general population, and got even higher prevalence among persons with some medical conditions.

I feel that it is a good work and is acceptable in its present form for publication.

Authors' response 1: We thank the Reviewer for the appreciation.

REVIEWER # 3

Reviewer's comment 1: The studies included in the meta-analysis are mainly those of patients with underlying disease, namely diabetes, HIV infection or hypertension and not a healthy free-living population. It would have been better to restrict this meta-analysis to free-living persons rather than to those with underlying disease as it makes the results very difficult to interpret.

Authors' response 1: We read with great interest this comment and have the following observations: 1) using total cholesterol based dyslipidemia for illustration, we have included in our review 62 communitybased non-disease specific studies with about 120,000 adult participants, and 25 hospital-based nondisease specific studies totalizing over 10,000 adult participants. By comparison, we have included 6 community-based disease-specific studies (4592 participants), and 61 hospital-based disease-specific studies (49134 participants). This distribution is in sharp contradiction with the reviewer's suggestion that

we have included in meta-analysis mainly studies of patients with underlying diseases instead of freeliving population. While there may be an interest in the reviewer's suggestion to *"restrict this metaanalysis to free-living persons rather than to those with underlying disease"*, there is a merit in examining subpopulations. Indeed, information on the prevalence of various forms of dyslipidemia in subpopulations (i.e. disease-specific populations - HIV, diabetes mellitus and hypertension) allows a better understanding of the main drivers of the overall burden of the disease in the general population. One of the strengths of our study is to present useful data for researchers, clinicians and policymakers. Furthermore, with our current presentation allows a clear distinction between the overall and subpopulations estimates. Indeed, in the Results section, using sub-section titles, we clearly present pooled estimates from the general population and from populations with specific diseases, from studies conducted in the community (population-based studies) and those conducted in hospital (hospital-based studies). Therefore, we don't think there should be difficulties in interpreting our results which are well stratified.

Reviewer's comment 2: All races are included, white, coloured, sub-Saharan black African and North African/Arab. As for point 1 this confounds and biases the results.

Authors' response 2: Thank you for this important comment. While we agree with the reviewer that it may be interesting to assess the prevalence by ethnic/racial groups, we do not see how the estimates of prevalence derived from a population will be confounded simply because of the multiethnic/multiracial nature of the population.

Our systematic review and meta-analysis is constrained by the available data from relevant studies. We cannot present pooled estimates for various ethnic or racial populations across Africa because such data are not available. Furthermore, some ethnic groups such as whites do not represent a significant proportion of the African population to allow specific sub-group analysis. We however conducted subgroup-analysis

for all the forms of dyslipidemia according to different regions in Africa using data from communitybased studies, shown in Supplementary Tables 1, 2, 3, and 4. Thus, specific pooled estimates for Northern African populations are therefore available.

Reviewer's comment 3: The cut-offs for lipids selected are rather arbitrary. In the text a cut-off of total cholesterol of 6.5 mmol/L is mentioned and is shown in Figure 2 but not discussed at all in the text. **Authors' response 3:** We thank the Reviewer for this comment. The selection of cut-offs for lipid fraction selected is not arbitrary; it is explained in the Methods section. The studies included in this systematic review reported abnormal blood lipid level defined based on various cut-offs. Therefore, for consistency we grouped studies according to the cut-off used. Table 1 which summarizes the characteristics of included studies provides a clear distribution of studies according to cut-off. For instance regarding total cholesterol, 117 (70.1%) of studies used 5.2 mmol/L and 39 studies (23.3) used 6.5 mmol/L as the defining cut-off for dyslipidemia; with 3 other cut-offs being seldom used. It is not possible to present all the data in the main text of the manuscript due to space constraint and to avoid repetition of the results which are thoroughly presented in the tables, figures and the appendix. Therefore in the Results section, we presented data for the most frequently used cut-offs 5.2 mmol/L and 6.5 mmol/L. Furthermore, we also consider the cut-off which is recommended by guidelines. Regarding total cholesterol for instance, according to current guidelines, it is considered raised if above 5.2 mmol/L.

Pertaining to the discussion, as mentioned above, we can only discussed the most salient findings.

Reviewer's comment 4: It would have been much better to have restricted this meta-analysis to SubSaharan Black Africans rather than all race groups as this is the population in which the prevalence of hyperlipidaemia, and the prevalence/incidence of atherosclerotic cardiovascular disease remain uncertain. In addition there is very little published data on the prevalence of familial hypercholesterolaemia (FH) in

black Africans. With the reported prevalence of at least 1: 500 if not 1:200 world-wide, with a population of over 1,2 billion people, one would expect over 1 million people in Africa to have FH but this has rarely been reported in Black Africans. How many of this meta-analysis cohort had an LDL-cholesterol > 5 mmol/L which is suggestive of FH?

Authors' response 4: Thank you for this comment.

While Black Africans may represent the majority of the population on the African continent, there are many other racial/ethnic groups. Any public health or clinical approach to effectively and comprehensively address dyslipidemia on this continent should account for this fact. As we have also addressed these points in our responses to the comments 2 and 3, to avoid repetition we refer the reviewers to those responses. We have already indicated above that in addition to the overall pooled estimates across Africa, we have provided the results also by region (for community-based studies), which individualized northern Africa from other Africa region. However, the argument of dyslipidemia haven't been better characterized in Northern than in sub-Saharan Africa, used by the reviewer to support his suggestion that our meta-analysis should be restricted to sub-Saharan Africa, is not supported by findings from the current review. In regional analysis of dyslipidemia from community based studies (supplementary Table 1 to 4); for total cholesterol-based dyslipidemia (TC>=5.2), Northern Africa had 9 studies (21381 participants) while Eastern Africa had 9 studies (41000 participants) and West Africa had 16 studies (15000 participants). For high LDL the North had no studies.

Regarding the cut-offs used, Table 1 provides a clear distribution of studies according to cut-off used to define dyslipidemia for each lipid fraction. As shown in this table, no studies used a cut-off of for LDLcholesterol 5 mmol/L.

We appreciate the comment of the reviewer on familial hypercholesterolemia, but we believe that this inherited condition is better addressed in a dedicated review where other features of the conditions are

also investigated; and not in a general review like the current one where the focus is essentially on level of lipid variables.

REVIEWER # 4

Reviewer's comment 1: 1. Abstract top heavy with results; par these down reporting key findings only.

Authors' response 1: Thank you for raising this point. Our study provides a significant amount of information on the prevalence of dyslipidemia in the general population and in key populations such as those with diabetes mellitus, hypertension and HIV, according to each of the four major forms of dyslipidemia including elevated total cholesterol, low HDL-cholesterol, elevated LDL-cholesterol and elevated triglycerides, with a precise diagnosis cut-off. We think that all the results presented in the abstract are relevant. We did our best to be concise.

Reviewer's comment 2: Was random effects an a priori choice, or from post-hoc analyses of your data? Note random effects (plural, see Forest plots).

Authors' response 2: Thank you for the comment. Random effect model was an a-priori choice, as described in the published protocol of this review (our reference #9 in the main manuscript).

Reviewer's comment 3: I would be tempted to include some of the publication bias in the main body of the paper. These tables are not the easiest to understand so detailed explanations are required rather than a passing comment.

Authors' response 3: We thank the reviewer for this comment. As indicated in the methods section (page 7), we tested for publication bias using the Egger test. The various estimates of the test publication bias in Table 1 are for the various subgroups of studies. While we will be happy to follow the reviewer recommendation, we do not see how this can be done. The test of publication bias is relevant to the unpublished studies; it indicates how to put our results in context given that there may be unpublished

studies with potentially different prevalence estimates than the ones reported. We do not see how elaborating more on the test (s) for publication bias will help in better describing the results of the published studies presented in the tables (and in the text) other than it has been done now.

Reviewer's comment 4: Did you access the 'grey literature' (work ongoing but not yet published)?

Authors' response 4: We thank the reviewer for this suggestion. While we could explore the "grey literature", we do not think that unpublished work would provide us with enough information to rigorously assess the quality of the studies. A rigorous assessment of the quality of the data (to ensure the accuracy of the estimates) was a key aspect of our systematic review, thus we focused published data since it is uncommon to have registered protocol for cross sectional studies.

Reviewer's comment 5: There are two columns headed 'Events'. Is the 2nd column the expected events from the meta-analysis? On further reading the 2nd column are proportions. Figure 5, x-axis scale should begin at 5 or 10%.

Authors' response 5: Thank you for these comments. Table 2 to 5 have been modified to address the issues raised.

Reviewer's comment 6: Meta-analysis is not with without it's critics or limitations (see e.g., Greenland S. Am j Epidemiol 1994; 140:783-787 and Bailor JC 3rd. New Eng J Med 1997; 337:559-561). Read and acknowledge.

Authors' response 6: Thank you for your comment. This has been highlighted in the discussion section/paragraph 8/lines 15 – 17.

Reviewer's comment 6: Show the raw data (2x2 Table) on which the interrater agreement was based (Page 8, Kappa=0.81).

Authors' response 7: Of the 3315 studies remaining after removing the duplicates, 178 were classified as eligible and 3058 as non-eligible by the two reviewers. The two reviewers disagreed on the remaining studies with one reviewer classifying 32 of them as eligible and 47 as non-eligible while the other reviewer did the opposite. After reconciliation meeting three of these studies were classified as eligible and the remaining as non-eligible. In a 2x2 table, it will give the figure below, which has been added to the appendix section as 'supplementary table 5' and quoted in the main manuscript on page 8, paragraph 1.

		Reviewer 1		Total reviewer 2
		Eligible	Not eligible	
Reviewer 2	Eligible	178	32	225
	Not eligible	47	3058	3090
Total reviewer 1		210	3105	3315

Reviewer's comment 8: Provide a PRISMA Statement.

Authors' response 8: The PRISMA checklist is provided as supplementary box 1, and referred to in the main manuscript on page 5, paragraph 1.

2- Second review round

REVIEWER # 3

Reviewer's Comment 1: The revised version of the manuscript is greatly improved and I am happy with the responses to most of my queries.

Authors' response 1: We thank the Reviewer for the appreciation.

Reviewer's Comment 2: However I do believe it is important for the authors to emphasize the limitations of the study, namely that it combined community bases and hospital based participants and, more importantly that the prevalence in the different ethnic/racial groups, particularly sub-Saharan black African (which represent the majority of the population on the African continent) was not possible. In addition a limitation of the study was that a breakdown of of the prevalence of dyslipidemia according to age categories was not possible.

Authors' response 2: We thank the reviewer for raising these suggestions regarding the limitations of our study. We have now elaborated on the absence of age-specific and ethnic specific estimates in the limitations section of the discussion on page 14 (please, see the relevant statement below). We have however also acknowledged that those are limitations of the primary studies and not necessarily those of the review we have conducted. Furthermore, with several hundred (and even thousand by some estimates) of ethnic groups found in Africa, it is unrealistic to believe (at least for the time being) that disease (or risk factor) estimates in Africa can be provided by ethnic group. Even the comprehensive Global Burden of Disease (GBD) group (with their huge resources) hasn't provided disease burden estimate by ethnic groups in Africa. With reference to the reviewer's assertion that we have combined community-based and hospital-based participants; we continue to believe that this is an overstatement. We have conducted stratified meta-analysis, always distinguishing throughout community-based from hospital-based studies, and in the interpretation, we do not believe that we have used community-based studies to make inference on hospital-based population and vice versa. We do not see our approach as a limitation, but rather as an attempt to provide a comprehensive picture of dyslipidaemia in Africa.

While estimates from community-based studies are for instance very relevant for the general population, for highly medicalized populations like people with HIV, diabetes, etc. estimates from hospital-based studies are highly relevant.

"*Finally, included studies did not provide age-specific and/or ethnic specific estimates, and therefore we were unable to derive pooled estimates of dyslipidaemia according to those major characteristics. Indeed, some variations in the prevalence of dyslipidaemia are expected across different age groups with highest prevalence in the elderly, and potentially across ethnic groups within African populations considering the racial/ethnic differences in dyslipidaemia patterns observed in American populations (Blacks, Asian Americans, Hispanics and non-Hispanic whites) for instance [37]. Realistically however, the huge ethnic diversity in Africa preclude any expectation that comprehensive and reliable ethnic-specific estimates of the disease burden/risk factors in Africa, could be generated through a study like the one we have conducted"*

IX- PUBLISHED PROTOCOL

The protocol which is presented below, was registered in the PROSPERO International Prospective Register of systematic reviews (number CRD42014015376) and published[1].

1. Noubiap JJ, Nansseu JR, Bigna JJ, Jingi AM, Kengne AP. Prevalence and incidence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis protocol. BMJ Open 2015; 5: e007404.

BMJ Open

Prevalence and incidence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis protocol

Jean Jacques N Noubiap,[1,2] Jobert Richie N Nansseu,[3] Jean Joel R Bigna,[4] Ahmadou M Jingi,[5] André Pascal Kengne[6]

To cite: Noubiap JJN, Nansseu JRN, Bigna JJR, *et al*. Prevalence and incidence of dyslipidaemia among adults in Africa: a systematic review and meta-analysis protocol. *BMJ Open* 2015;**5**:e007404. doi:10.1136/bmjopen-2014-007404

► Prepublication history and additional material is available. To view please visit the journal (http://dx.doi.org/10.1136/bmjopen-2014-007404).

Received 8 December 2014
Revised 16 February 2015
Accepted 25 February 2015

For numbered affiliations see end of article.

Correspondence to
Dr Jean Jacques N Noubiap; noubiapjj@yahoo.fr

ABSTRACT

Introduction: Cardiovascular disease (CVD) is the leading cause of death globally and disproportionately affects low-income and middle-income countries. Dyslipidaemia is an important modifiable risk factor for CVD. There are important knowledge gaps regarding the population levels of lipid variables and frequency of non-optimal levels in populations within Africa. We propose to conduct a systematic review to determine the prevalence and occurrence of dyslipidaemia in adult populations within countries in Africa.

Methods and analysis: We will perform a comprehensive search to identify all possible published and unpublished studies on the prevalence or incidence of dyslipidaemia in Africa reported from 1 January 1980, without language restriction. The scientific databases PubMed MEDLINE, EMBASE and ISI Web of Science will be searched, as well as Grey literature. Following study selection, full-text papers acquisition, and data extraction and synthesis, we will appraise the quality of studies and risk of bias, and assess heterogeneity. Prevalence/incidence data will be summarised by country and geographic regions and a meta-analysis will be conducted for variables defined identically across studies. Variance stabilising transformations will be applied as appropriate to the row data before meta-analysis. This systematic review will be reported according to the MOOSE Guidelines for Meta-Analyses and Systematic Reviews of Observational Studies.

Ethics and dissemination: The current study is based on published data and as such ethics consideration is not a requirement. This review is expected to provide relevant data to help in quantifying the magnitude of dyslipidaemia in African populations, to emphasise the need for appropriate prevention and control strategies, and to identify research gaps and remaining challenges. The final report of the systematic review in the form of a scientific paper will be published in peer-reviewed journals. Findings will further be presented at conferences and submitted to relevant health authorities.

Trial registration number: PROSPERO CRD42014015376.

INTRODUCTION

Cardiovascular disease (CVD) including stroke, coronary heart disease and peripheral arterial disease is the leading cause of death globally.[1] An estimated 17.3 million people died from CVD worldwide in 2008, representing 30% of all deaths in that year.[1] Of these deaths, about 7.3 million and 6.2 million, respectively, were due to coronary heart disease and stroke.[2] Furthermore, CVD disproportionally affects low-income and middle-income countries (LMIC), where about 80% of the global CVD mortality occur.[1]

Dyslipidaemia is defined by the presence of non-optimal levels of blood lipids. In clinical practice guidelines, dyslipidaemia is mostly defined by elevated total cholesterol (TC) and/or low-density lipoprotein cholesterol (LDL-C), but the definition is also often extended to include non-optimal levels of high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), apolipoprotein B and apolipoprotein A1.[3] Dyslipidaemia is one the most important modifiable risk factors for CVD.[4–6] According to the WHO, globally, a third of ischaemic heart disease is attributable to high cholesterol. Overall, raised cholesterol is estimated to cause 2.6 million deaths (4.5% of total) and 29.7 million disability adjusted life years (DALYs), or 2% of total DALYs. In 2008, the global prevalence of raised total cholesterol among adults (≥5.0 mmol/L) was 39% (37% for males and 40% for females).[7]

There is robust evidence that successful treatment of dyslipidaemia substantially reduces morbidity and mortality from CVD.[8–11] For instance, such treatment can reduce the risk of heart disease by 30% over 5 years.[8] Moreover, the benefits of lipid-lowering therapy are not only experienced by individuals with CVD, benefits also extend to individuals without clinically overt CVD.[8]

Although the burden of CVD is increasing in developing countries, including those within Africa, critical knowledge gaps on the epidemiology of the disease around the continent remain, including the lack of data regarding the distribution of key risk factors such as dyslipidaemia. We present the protocol for a systematic review to assess the distribution and occurrence of dyslipidaemia among adults within Africa. We are not aware of any previous effort to critically review existing published data on dyslipidaemia in this part of the world.

This protocol is prepared and presented according to the PRISMA-P 2015 guidelines.[12]

OBJECTIVES

To conduct a systematic review and meta-analysis to determine the prevalence, incidence and characteristics of dyslipidaemia in populations within countries in Africa.

REVIEW QUESTION

This systematic review will seek to address the following research question:

What are the prevalence and incidence of dyslipidaemia in adult populations within countries in Africa as reported in studies published from 1980 to 2015?

CRITERIA FOR CONSIDERING STUDIES FOR THE REVIEW

Inclusion criteria

1. We will include cross-sectional, case–control or cohort studies of adult participants residing in African countries reporting the prevalence or incidence of dyslipidaemia, or enough data to compute these estimates.
2. Diagnosis of dyslipidaemia will be based on doctor diagnosis, or measured lipid profile.

We will consider all published and unpublished studies reported from 1 January 1980, while accounting for changes in the definition of dyslipidaemia over time. No language restriction will be applied.

Exclusion criteria

1. Studies conducted among populations of African origin residing outside Africa.
2. Studies not performed in human participants.
3. Studies in subgroups of participants selected on the basis of the presence of dyslipidaemia.
4. Studies in children and adolescents (ie, age <15 years).
5. Case series (sample size of less than 50 participants), letters, reviews, commentaries and editorials.
6. Studies lacking primary data and/or explicit method description.
7. Duplicates; for studies published in more than one report, the most comprehensive and up-to-date version will be used.
8. Studies with serious ethical issues.

SEARCH STRATEGY FOR IDENTIFYING RELEVANT STUDIES

The methods for this systematic review have been developed according to the MOOSE Guidelines for Meta-Analyses and Systematic Reviews of Observational Studies.[13] The search strategy will be implemented in two stages.

Bibliographic database searches

A. We will perform a comprehensive search of databases to identify all relevant articles published on dyslipidaemia in Africa between January 1980 and February 2015 without language restriction. A systematic search of PubMed MEDLINE, EMBASE and ISI Web of Science (Science Citation Index) will be undertaken using a predefined strategy based on the combination of relevant terms and the names of each of the 54 African countries and African subregions to capture the largest number of studies. We will use text words as well as medical subject heading (MeSH) terms; for example 'dyslipidemia', 'hyperlipidemia', 'lipid disorder', 'hypercholesterolemia' and 'hypertriglyceridemia'. These terms and their variants will be used in varying combinations. The literature search strategy will be adapted to suit each database. The main search strategy is shown in table 1.
B. We will manually search the reference lists of eligible articles and relevant reviews, and trace their citations using the ISI Web of Knowledge portal. Grey literature, from key conference proceedings and sources including the African regional database 'African Index Medicus', 'OpenSIGLE', the WHO International Clinical Trials Registry, the WHO Global Infobase and the meta-Register of Controlled Trials (mRCT) will also be reviewed for relevant information.

Selection of studies for inclusion in the review

Two investigators will independently identify articles and sequentially screen their titles and abstracts for eligibility. Full text of articles deemed potentially eligible will be acquired. These investigators will further independently assess the full text of each study for eligibility, and consensually retain studies to be included. Disagreement will be solved by a third assessor. We will use a screening guide to ensure that the selection criteria are reliably applied by all assessors.

APPRAISAL OF THE QUALITY OF INCLUDED STUDIES

We will evaluate included studies for quality and bias using an adapted version of the Risk of Bias Tool for Prevalence Studies developed by Hoy *et al*[14] (see online supplementary appendix S1), which will be applied to screened full-text articles. Assessment of the risk of selection and attrition bias will use the Cochrane guidelines available in Review Manager V.5.3 (http://tech.cochrane.org/revman). Furthermore, the reporting quality of each study will be assessed using the STROBE

Table 1 Search history PubMed

Search	Search terms	Hits
1	Dyslipidemia [tw] OR lipid disorder [tw] OR lipid [tw] OR hypercholesterolemia [tw] OR hypertriglyceridemia [tw] OR hyperlipidemia [tw]	
2	Dyslipidemia [MeSH Terms]	
3	# 1 OR # 2	
4	(((((“Africa”[MeSH] OR Africa*[tw] OR Algeria[tw] OR Angola[tw] OR Benin[tw] OR Botswana[tw] OR “Burkina Faso”[tw] OR Burundi[tw] OR Cameroon[tw] OR “Canary Islands”[tw] OR “Cape Verde”[tw] OR “Central African Republic”[tw] OR Chad[tw] OR Comoros[tw] OR Congo[tw] OR “Democratic Republic of Congo”[tw] OR Djibouti[tw] OR Egypt[tw] OR “Equatorial Guinea”[tw] OR Eritrea[tw] OR Ethiopia[tw] OR Gabon[tw] OR Gambia[tw] OR Ghana[tw] OR Guinea[tw] OR “Guinea Bissau”[tw] OR “Ivory Coast”[tw] OR “Cote d’Ivoire”[tw] OR Jamahiriya [tw] OR Jamahiryia[tw] OR Kenya[tw] OR Lesotho[tw] OR Liberia[tw] OR Libya[tw] OR Libia[tw] OR Madagascar[tw] OR Malawi[tw] OR Mali[tw] OR Mauritania[tw] OR Mauritius[tw] OR Morocco[tw] OR Mozambique[tw] OR Mocambique[tw] OR Namibia[tw] OR Niger[tw] OR Nigeria [tw] OR Principe[tw] OR Reunion[tw] OR Rwanda[tw] OR “Sao Tome”[tw] OR Senegal[tw] OR Seychelles[tw] OR “Sierra Leone”[tw] OR Somalia[tw] OR “South Africa”[tw] OR “St Helena”[tw] OR Sudan[tw] OR Swaziland[tw] OR Tanzania[tw] OR Togo[tw] OR Tunisia[tw] OR Uganda[tw] OR “Western Sahara”[tw] OR Zaire[tw] OR Zambia[tw] OR Zimbabwe[tw] OR “Central Africa”[tw] OR “Central African”[tw] OR “West Africa”[tw] OR “West African”[tw] OR “Western Africa”[tw] OR “Western African”[tw] OR “East Africa”[tw] OR “East African”[tw] OR “Eastern Africa”[tw] OR “Eastern African”[tw] OR “North Africa”[tw] OR “North African”[tw] OR “Northern Africa”[tw] OR “Northern African”[tw] OR “South African”[tw] OR “Southern Africa”[tw] OR “Southern African”[tw] OR “sub Saharan Africa”[tw] OR “sub Saharan African”[tw] OR “subSaharan Africa”[tw] OR “subSaharan African”[tw]) NOT (“guinea pig”[tw] OR “guinea pigs”[tw] OR “aspergillus niger”[tw]))))))	
5	# 3 AND # 4	
6	#5 Limits: 1980/01/01 to 2015/02/28 and studies done in Humans	

checklist (see online supplementary appendix S2).[15] Risk of bias and quality scores will be presented in a table.

DATA EXTRACTION AND MANAGEMENT

Two assessors will independently extract data regarding general information (authors, year, country, type of publication), study characteristics (study design, setting, sample size, response rate, mean or median age and proportions of female participants, diagnosis criteria for dyslipidaemia, possible disease specific to the study population), prevalence and incidence of dyslipidaemia. Where only primary data (sample size and number of outcomes) are provided, these will be used to calculate the prevalence or incidence estimates. Where prevalence/incidence rates or relevance for estimating them are not available, we will contact the corresponding author of the study to request the missing information. Data will be extracted using standardised data collection.

DATA SYNTHESIS INCLUDING ASSESSMENT OF HETEROGENEITY

Prevalence/incidence data will be summarised by country and geographic region (central, eastern, northern, southern and western Africa). A meta-analysis will be conducted for variables defined identically across studies. SEs for the study-specific estimates will be determined from the point estimate and the appropriate denominators, assuming a binominal (or Poisson for incidence data) distribution. We will pool the study-specific estimates using a random effects meta-analysis model to obtain an overall summary estimate of the prevalence/incidence across studies, after stabilising the variance of individual studies with the use of the Freeman-Tukey double arc-sine transformation.[16] Heterogeneity will be assessed using the χ^2 test on Cochrane’s Q statistic[17] and quantified by calculating the I^2.[18] Values of 25%, 50% and 75% for I2 represent, respectively, low heterogeneity, medium heterogeneity and high heterogeneity. We will assess the presence of publication bias using funnel plots and Egger’s test.[19] Where substantial heterogeneity is detected, we will perform subgroup analysis to investigate the possible sources of heterogeneity using the following grouping variables: age group, sex, study setting (rural vs urban; hospital vs community-based), geographical region (central, eastern, northern, southern and western Africa), study quality. We will assess inter-rater agreement for study inclusion using Cohen’s κ coefficient.[20] Data will be analysed using the statistical software R (V.3.0.3 (2014-03-04), The R Foundation for statistical computing, Vienna, Austria).

PRESENTING AND REPORTING THE RESULTS

The study selection process will be summarised using a flow diagram. Reasons for exclusion of studies will be described. This will follow the MOOSE Guidelines for Meta-Analyses and Systematic Reviews of Observational Studies.[13] Quantitative data will be presented in

evidence tables of individual studies as well as in summary tables and forest plots where appropriate. We will examine prevalence/incidence by region, country, setting (rural or urban), time period and disease-specific populations depending on the data available. We plan to report on quality scores and risk of bias for each eligible study. This may be tabulated and accompanied by narrative summaries.

CONCLUSIONS

CVD has reached epidemic proportions in Africa, driven mainly by hypertension, diabetes, obesity and dyslipidaemia.[1] The challenging first step to address the burden of CVD on the continent is to establish accurate epidemiological data on this condition and its risk factors. We anticipate that this review on dyslipidaemia in Africa will have implications for policy, practice and research. This review is expected to provide relevant data to help in quantifying the magnitude of dyslipidaemia in African populations and emphasise the need for appropriate prevention and control strategies. The review will also determine the characteristics of dyslipidaemia in the African populations, and may help to confirm some unique features of dyslipidaemia previously reported in a population of West Africans and African-Americans. Indeed, low HDL-C with normal triglyceride levels was found to be the most common lipid pattern in West Africans and African-Americans with metabolic syndrome, suggesting that the lipid profile associated with cardiovascular risk in populations of African ethnicity may differ from that in Caucasians.[21] Furthermore, this review may identify the research gaps and remaining challenges that may form the basis of future studies targeting various aspects of dyslipidaemia to tackle the burden of the disease in African populations.

The main possible limitations of this review could be the scarcity of studies on the subject and the predominance of clinic-based studies and poor quality data, as revealed by previous reviews on chronic non-communicable diseases in Africa,[22–24] which hampered definitive inferences and drawing relevant conclusions. Data presented would therefore be only general indicators of the epidemiology of dyslipidaemia on the continent.

ETHICS AND DISSEMINATION

The current study is based on published data and as such ethics consideration is not a requirement. The final report of the systematic review in the form of a scientific paper will be published in peer-reviewed journals. Findings will further be presented at conferences and submitted to relevant health authorities. We also plan to update the review in future to monitor changes and guide health service and policy solutions.

Author affiliations
[1]Internal Medicine Unit, Edéa Regional Hospital, Edéa, Cameroon
[2]Medical Diagnostic Center, Yaoundé, Cameroon
[3]Sickle Cell Unit, Mother and Child Centre, Chantal Biya Foundation, Yaoundé, Cameroon
[4]Goulfey District Hospital, Goulfey, Cameroon
[5]Faculty of Medicine and Biomedical Sciences, Department of Internal Medicine and Specialties, University of Yaoundé I, Yaoundé, Cameroon
[6]Non-communicable Disease Research Unit, South African Medical Research Council and University of Cape Town, Cape Town, South Africa

Contributors APK and JJNN conceived and designed the protocol, and JJNN drafted the manuscript. JRNN, JJRB and AMJ revised the manuscript for methodological and clinical content. All authors approved the final version.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. World Health Organization. *Global status report on non communicable diseases 2010*. Geneva, World Health Organization, 2011.
2. World Health Organization. *Global atlas on cardiovascular disease prevention and control*. Geneva, World Health Organization, 2011.
3. Stone NJ, Robinson JG, Lichtenstein AH, *et al*. 2013 ACC/AHA guideline on the treatment of blood cholesterol to reduce atherosclerotic cardiovascular risk in adults: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2014;129(25 Suppl 2): S1–45.
4. Di Angelantonio E, Gao P, Pennells L, *et al*. Emerging Risk Factors Collaboration. Lipid-related markers and cardiovascular disease prediction. *JAMA* 2012;307:2499–506.
5. Voight BF, Peloso GM, Orho-Melander M, *et al*. Plasma HDL cholesterol and risk of myocardial infarction: a Mendelian randomisation study. *Lancet* 2012;380:572–80.
6. Yusuf S, Hawken S, Ounpuu S, *et al*. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case control study. *Lancet* 2004;364:937–52.
7. World Health Organization. Global Health Observatory data. Cholesterol. http://www.who.int/gho/ncd/risk_factors/cholesterol_prevalence/en/ (accessed 14 Feb 2015).
8. Grundy SM, Cleeman JI, Merz CN, *et al*. Implications of recent clinical trials for the National Cholesterol Education Program Adult Treatment Panel III guidelines. *J Am Coll Cardiol* 2004;44:720–32.
9. Law MR, Wald NJ, Thompson SG. By how much and how quickly does reduction in serum cholesterol concentration lower risk of ischaemic heart disease? *BMJ* 1994;308:367–72.
10. Baigent C, Blackwell L, Emberson J, *et al*., Cholesterol Treatment Trialists' (CTT) Collaboration. Efficacy and safety of more intensive lowering of LDL cholesterol: a metaanalysis of data from 170,000 participants in 26 randomised trials. *Lancet* 2010;376:1670–81.
11. Robinson JG, Smith B, Maheshwari N, *et al*. Pleiotropic effects of statins: benefit beyond cholesterol reduction? A meta-regression analysis. *J Am Coll Cardiol* 2005;46:1855–62.
12. Moher D, Shamseer L, Clarke M, *et al*. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015;4:1.
13. Stroup DF, Berlin JA, Morton SC, *et al*. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA* 2000;283:2008–12.
14. Hoy D, Brooks P, Woolf A, *et al*. Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. *J Clin Epidemiol* 2012;65:934–9.
15. von Elm E, Altman DG, Egger M, *et al*. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med* 2007;4:e296.