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Prevalence of curable sexually transmitted infections and bacterial vaginosis during pregnancy in sub-Saharan Africa: A systematic review and meta-analysis

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Abstract

Objective: Sexually transmitted infections (STIs) remain a global public health problem with a high burden among pregnant women. STIs in pregnant women may lead to various adverse pregnancy outcomes. In most sub-Saharan African countries, syndromic management is used for screening and treatment of STIs. We aimed to update and summarize pooled prevalence of curable STIs and bacterial vaginosis (BV) among pregnant women in sub-Saharan Africa.

Methods: Electronic databases and reference lists of relevant published and unpublished studies were searched from March 2015 to October 2020. Studies were included if they estimated prevalence of *Chlamydia trachomatis* (CT), *Trichomonas vaginalis* (TV), *Neisseria gonorrhoeae* (NG), *Treponema pallidum* (syphilis), *Mycoplasma genitalium* (MG) and BV among pregnant women in sub-Saharan Africa. Meta-analyses were performed with observed prevalences corrected for diagnostic errors to estimate the pooled prevalence of diagnosed infections by region.

Results: A total of 48 studies met the inclusion criteria, providing 85-point prevalence estimates for curable STIs and BV. Pooled prevalence estimates (with 95% CI and number of women tested) were as follows: MG, 13.5% (4.0-27.2, n=1076); CT, 10.8% (6.9-15.5, n=6700); TV,

13.8% (10.0-18.0, n=9264); NG, 3.3% (2.1-4.7, n=6019); syphilis, 2.9% (2.0-4.0, n=95308) and BV, 36.6% (27.1-46.6, n=5042). By region, BV was the most prevalent and ranged from 28.5% (24.5-32.8, n=1030) in Eastern Africa to 52.4% (33.5-70.9, n=2305) in Southern Africa; NG had the lowest prevalence, ranging from 1.4% (95% CI: 0.1-3.1, n=367) in Central Africa to 4.4% (2.6-6.4, n=4042) in Southern Africa.

Conclusion: The prevalence of curable STIs and BV in sub-Saharan Africa is substantial in pregnant women, but most prevalent in Southern Africa where HIV prevalence is highest. It is crucial to integrate screening of curable STIs into antenatal care programs which have previously focused on diagnosis and treatment of syphilis and HIV.

Background

Sexually transmitted infections (STIs) are widespread globally and have serious sexual, reproductive, and maternal-child health consequences. Curable STIs and reproductive tract infections in pregnant women, specifically *Chlamydia trachomatis* (CT), *Neisseria gonorrhoeae* (NG), *Trichomonas vaginalis* (TV), *Treponema pallidum* (syphilis), *Mycoplasma genitalium* (MG), and bacterial vaginosis (BV) may lead to various adverse pregnant outcomes including premature rupture of membranes [1, 2], preterm labour, preterm delivery [1], chorioamnionitis [2], low birth weight [1, 3], congenital infection [3-5], and even stillbirth [6, 7] or neonatal mortality [3, 5]. Furthermore, recent studies have suggested the possibility of increased vertical transmission of HIV among mothers with bacterial STIs [8, 9]. Around the world, STI management in antenatal clinics varies by country and STI. All regions, including sub-Saharan Africa (SSA) have introduced universal screening of syphilis in pregnant women attending antenatal clinics [10, 11]. In most low- and middle-income countries (LMICs), there is lack of laboratory systems to support aetiological screening in pregnancy and the cost of the laboratory testing is also prohibitive [7, 12]. However, for STIs such as CT and NG, cheaper and point-of-care molecular tests are being introduced [13]. Management of STIs and BV during pregnancy in many developing countries has been limited due to the lack of simple and affordable point-of-care diagnostic tests [2], hence, a syndromic approach in most African countries. However, the World Health Organization recommends aetiological approach ensuring that STI diagnosis is accessible, ensuring the quality of diagnostic to minimize risk of misdiagnosis [14]. Since curable STIs are frequently asymptomatic in pregnant women, syndromic management misses most of these infections [12]. Additionally, BV, which has been associated with increased risk of STIs such as HIV, CT and NG [15, 16], is highly prevalent in pregnant women and usually asymptomatic [15-19].

A few studies have reviewed data on the prevalence of curable STIs in pregnant women in African countries. Chico *et al* [20] reviewed the prevalence of malaria, STIs and BV in pregnancy in SSA in studies published up to 2011, but excluded studies from South Africa. A prior review by Joseph Davey *et al* [21] focused on LMICs, which included SSA and other regions up to 2015, but excluded MG and BV data, presenting a need for an updated review of literature focused on SSA. One of the objectives of the WHO Global Health Sector Strategy on STIs 2016–2021 is to estimate the incidence of STIs especially in regions such as SSA, where STI diagnostic testing is limited [14]. We aim to estimate

the average prevalence of diagnosed curable STIs and BV among pregnant women in SSA, updating the previous review of studies published up to 2015, in order to determine patterns of distribution and inform interventions to address high prevalence areas.

Methods

This review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist for reporting of the review. The protocol was registered with PROSPERO 2020 CRD42020199303 [22].

Search strategy

Both published and unpublished literature were searched from March 2015 up to October 2020. Search terms (Table S1) were used to search MEDLINE, EMBASE, EBSCOhost, Google Scholar, Cochrane Register of Controlled trials, CINAHL, WHOLIS, Web of Science, and Scopus for publications indexed from 2015 – 2020. No restriction was placed on publication language. Reference lists of eligible studies were manually searched.

Study selection

Primary studies were included if (a) the study was prospective, cross-sectional or case-control study; (b) participants were pregnant women (all ages) from SSA; (c) the study reported the prevalence of diagnosed curable STIs and BV; and (d) the study reported the use of a diagnostic test. All retrieved articles from the listed databases were loaded into Endnote to remove duplicates, imported into Raynn QCRI [23] and independently screened by two reviewers (DCN and ECH) using titles and abstracts. If data were believed to have appeared in more than 1 article, we reviewed the full text and removed studies that were confirmed to be duplicates. For longitudinal studies, the point prevalence of curable STIs or BV at baseline was extracted. Where study eligibility was unclear, a review was independently carried out by a third study team member (DJD). The same process was applied for assessment of full texts. When a study reported more than one STI prevalence, we recorded each infection and each sample size separately. A PRISMA flowchart was produced to reflect the review process (Figure 1).

Data extraction

A predefined data extraction form was used for data extraction. DCN and ECH independently extracted data from included studies. Where differences arose, a consensus was reached through discussion with a third-party reviewer (DJD). Authors of studies with missing information were contacted for additional information and clarification. Data extraction included publication details, study characteristics and setting, study design, sample size and prevalence of STI or BV.

Assessment of risk of bias in included studies

Assessment of risk of bias for all studies was done using the Joanna Briggs Institute (JBI) critical appraisal tool for studies reporting prevalence data (Appendix S1). The tool critically

assesses the methodological quality and internal validity of a study to determine possibilities of bias in the design, conduct and analysis. Studies were rated high risk of bias for scores 5 and below, moderate risk of bias for 6-7 scores and low risk of bias for 8-9 scores. DCN and CW independently reported their judgment of the risk of bias as either being low, moderate, high or unclear and cases of discrepancies were resolved through discussion with ECH.

Data synthesis and analyses

Various diagnostic tests were used across studies (Table S2) reporting point prevalence data. We applied a standard method to adjust the observed prevalences based on the known sensitivity and specificity of the diagnostic from literature [24]. Corrected point prevalence estimates are shown in Table S3. Data were analysed using Stata Corp V.14 [25]. We assumed that prevalence follows binomial distribution, and that double arcsine transformation addresses problem of proportions close to zero and gives stable variance. We applied the corrected point prevalence data to random-effects models using the metaprop command in Stata [26], which incorporates the Freeman-Tukey double arcsine transformation of proportions [27]. Forest plots and the overall random-effects pooled estimates were generated from the corrected point prevalence to display prevalence with the corresponding 95% confidence interval for each study. The statistical heterogeneity between studies was assessed using the I^2 statistic from the meta-analysis. Sub-group analyses were conducted on the potential factors that could explain the variability in prevalence estimates across studies. The separate sensitivity analyses stratified studies by risk of bias, study type and sample size less or more than 500.

Results

Search results

The electronic search identified 7889 articles. After removal of duplicates, 7760 articles remained for screening. 7686 articles that were found to be irrelevant to this review were excluded, leaving 74 articles for full-text review. Using the predefined inclusion and exclusion criteria as a guide, 26 articles were excluded (Figure 1), leaving 48 articles which met the inclusion criteria.

Description of included studies

Type of study—A total of 48 articles retrieved from the electronic search met our inclusion criteria, providing 85-point prevalence estimates. Out of these studies included in our review, 2 were RCTs [s1, s2], 33 were cross-sectional studies [s3-s35], 12 were cohort studies [s36-s47] and one study was a diagnostic study [s48]. All unpublished literature identified were duplicates of published articles.

Setting—Studies included in the review were from 14 SSA countries (Figure S1). The 85-point prevalence estimates are shown in Figure 2. Publications of the included studies are listed in Appendix S2.

Diagnostic tests—The most commonly used diagnostic test was molecular testing, accounting for 37 tests out of 85 (43.5%), as detailed in Table 1 and Table S3. Molecular

tests were mostly conducted in CT studies (n=11, 84.6%) and NG (n=11, 84.6%) with the use of Gene XpertVR CT/NG in almost half of the CT and NG studies. Rapid tests were used in 24 (28.2%) studies and mostly for screening of syphilis. Out of 22 studies reporting screening of syphilis, 17 (77.2%) had confirmatory treponemal testing and 5 (22.7%) used only non-treponemal tests. Microscopic examinations were used in 24 (28.2%) studies and mostly for screening of TV (n=12, 52.1%) and BV (n=11, 91.6%).

Risk of bias assessment for included studies

Overall, 43 studies (89.5%) were rated low risk of bias (Figure S2). Five studies (10.4%) were of moderate risk of bias. For the internal validity, all the studies clearly defined target population and used the same data collection tools for all the participants (Figure S2).

Prevalence of each curable STI and BV in sub-Saharan Africa (SSA)

Five STIs (MG, CT, TV, NG and syphilis) and BV were included in the meta-analysis (Figure 2). Subgroup analysis was carried out to see if prevalence of STIs varied by setting with SSA classified into four regions based on the United Nations geo-scheme classification: Southern, Western, Central and Eastern Africa. The detailed analyses of subregions are shown in Table 2, Figure S3, Figure S4, Figure S5 and Figure S6.

Mycoplasma genitalium—The pooled prevalence of MG in SSA was 13.5% (95% CI: 4.0-27.2). Southern Africa had the highest pooled prevalence of MG of 18.0% (95% CI: 14.4-21.8) and Eastern African had the lowest pooled prevalence of 6.7% (95% CI; 4.9-8.7).

Chlamydia trachomatis—The pooled prevalence of CT in SSA was 10.8% (95% CI: 6.9-15.5). Southern Africa had the highest pooled prevalence of CT of 14.7% (95% CI: 8.2-22.6). In Eastern and Central Africa, the pooled prevalence for CT was 7.8% (95% CI: 5.0-11.3) and 3.3% (95% CI: 1.9-5.6) respectively.

Trichomonas vaginalis—The pooled prevalence of TV in SSA was 13.8% (95% CI: 10.0-18.0). The pooled prevalence of TV was similar in Southern and Central Africa, with estimates of 15.1% (95% CI: 9.9-21.0) and 14.4% (95% CI: 11.2-18.4) respectively. The pooled prevalence of TV infection in Eastern and Western Africa was 13.4% (95% CI: 5.1-24.7) and 13.0% (95% CI: 6.6-21.3) respectively.

Neisseria gonorrhoeae—The pooled prevalence of NG infection in SSA was 3.3% (95% CI: 2.1-4.7). Southern Africa had the highest pooled prevalence of NG infection of 4.4% (95% CI: 2.6-6.4), which compared to Eastern Africa: 2.4% (95% CI: 1.2-4.0) and Central Africa: 1.4% (95% CI: 0.6-3.1).

Syphilis—The pooled prevalence of syphilis in SSA was 2.9% (95% CI: 2.0-4.0). Central Africa had the highest pooled prevalence of syphilis of 6.3% (95% CI: 6.0-6.6), Eastern and Southern Africa had similar pooled prevalence, 2.8% (95% CI: 2.1-3.7) and 2.5% (95% CI: 1-9.2), respectively and Western Africa's prevalence was lowest at 1.8% (95% CI: 1.5-2.2).

Bacterial vaginosis—The pooled prevalence of BV was higher than all the STIs in SSA with an estimate of 36.6% (95% CI: 27.1-46.6). Southern Africa had the highest pooled prevalence of BV of 52.4% (95% CI: 34-70.9). The pooled prevalence of BV was similar in Eastern and Western Africa, with estimates of 28.5% (95% CI: 24.5-32.8) and 29.4% (95% CI: 22.6-36.7) respectively.

The heterogeneity between studies quantified with I^2 was high in the overall pooled estimates. We performed sensitivity analyses shown in Table 3, stratifying analysis by risk of bias assessment, sample size and study type. Pooled estimates were not influenced by risk of bias assessment (Table 3 and Figure S7). Pooled estimates were not different between studies with sample sizes more than 500 versus less than 500 for CT, NG and syphilis (Figure S8 and Figure S9), but for TV and BV, 10.7% (95% CI: 4.0-20.2) and 42.8% (95% CI: 30.1-56.0) versus 14.7% (95% CI: 10.7-19.7) and 32.6% (95% CI: 19.9-48.6) respectively. Pooled estimates were not different when comparing longitudinal versus cross-sectional studies (Figure S10 and Figure S11).

Discussion

This review illustrates the complexity, diversity, and heterogeneity of the epidemiology of curable STIs in the sub-Saharan Africa region and a large variation in diagnostic tests used. Notably, this review found a lack of recent data on the prevalence of curable STIs among pregnant women in many countries of the SSA region. Only 14 out of 46 SSA countries had studies that met eligibility criteria and were included in the review. Despite the risk of adverse pregnancy outcomes because of STIs during pregnancy [1, 3, 6], the lack of prevalence data for pregnant women in many countries within the region could present serious challenges around STI management in these countries.

This review found high pooled prevalence of curable STIs and BV in pregnant women similar to those in reviews by Chico *et al* [20] and Joseph Davey *et al* [21]. Chico *et al* [20] had similar findings to this review whereby BV had the highest prevalence in the region ranging from 37% to 50%. Similarly, both syphilis and NG had the lowest pooled prevalence ranging from 3.5% to 4.4% and 2.7% to 3.7% respectively. The review by Joseph Davey *et al* [21] found the pooled prevalence of TV ranging from 6.8% to 24.6% and NG ranging from 2.2% to 4.4%. These pooled estimates are consistent with findings from this current review. This persisting high prevalence of curable STIs and BV in pregnancy highlights the need to improve sexual and reproductive health among child-bearing women with interventions targeting behavioural and cultural factors.

In this review BV had the highest pooled prevalence estimate , consistent with the 2012 review by Chico *et al* [20]. Given that SSA has the highest antenatal HIV prevalence [16], diagnosis and treatment of BV may be important in prevention of HIV acquisition for pregnant women [17, 19], as well as vertical transmission of HIV [8, 9]. Although there are no experimental studies to show that diagnosis and treatment of BV reduces HIV acquisition, a meta-analysis showed that BV was associated with increased risk of HIV infection [17]. The second highest pooled prevalence estimate was MG, in studies from Southern Africa [s30, s45] and Eastern Africa [s16, s43]. This finding could be due to recent

improvements in diagnostic techniques,enabling a broader understanding of the consequence of this organism [s45]. We found high pooled prevalence estimates for CT and TV in pregnant women, which are similar to previous reviews done within the region [20, 21]. These high prevalence levels are mainly associated with higher-risk behaviours before and during pregnancy such as multiple sex partners and unprotected sex [12, 21]. Demonstrated and well documented in other studies, the prevalence of inflammatory STIs such as CT and TV increase the risk of HIV acquisition [9, 18], hence the need for the adoption of aetiologic STI screening and treatment in antenatal care. In this review, we observed a slight decrease in the mean prevalence of syphilis compared to the previous review by Joseph Davey *et al* [21] where the pooled prevalence of syphilis ranged from 4.6% to 6.5%. Similar to the previous review, most of syphilis testing was done with point of care tests. This decrease may be attributed to the successful integration of point-of-care rapid syphilis testing and same day treatment integrated into antenatal care in all countries within the region, which has not been the case with other curable STIs [10]. The pooled prevalence estimate of NG is similar to that in the 2012 review by Chico *et al* [20] and the 2015 review by Joseph Davey *et al* [21]. Given the global threats of antimicrobial resistance, particularly in the case of *N. gonorrhoeae* [14], this study further highlights the importance of investing in aetiological management by improving STI identification through use of rapid diagnostic tests.

Overall, Southern Africa had the highest pooled prevalence estimates of curable STIs and BV among pregnant women, similar with findings in the previous reviews [20, 21]. Southern Africa bears a heavy HIV burden, accounting for more than 40% of people living with HIV in 2019 [28]. It is important to note that South Africa is disproportionately represented in the Southern African region, and studies from South Africa had particularly high prevalence of curable STIs and BV [1, 12, 15, 16]. The dual burden of curable STIs and HIV remains a major threat to reproductive health and highlights the need for focus on STI diagnosis and treatment.

A variety of diagnostic methods were used in studies included for this review. We corrected point prevalence data for diagnostic error based on the sensitivities and specificities from the literature. Most studies on CT and NG used molecular tests which are better for aetiological management [29]. Cheaper, more reliable and more feasible screening tests for CT and NG are being introduced and can be integrated in antenatal care in resource limited settings [13, 30]. Microscopic examination tests for BV and TV, respectively by grading with the Nugent scoring system and by using the wet mount, are notably lower in sensitivity but have been shown to perform significantly better than syndromic management [13, 29, 30]. More than three quarters of the syphilis studies had confirmatory treponemal testing, reflecting wide acceptance of the diagnostic gold standard which has been integrated into antenatal clinics in most of the African countries.

We presented pooled prevalence estimates irrespective of the degree of between-study heterogeneity to facilitate the comparison of patterns between regions for each infection. Therefore, observed heterogeneity should be taken into account when interpreting these pooled prevalence estimates. We attempted to identify factors accounting for heterogeneity by performing several sensitivity analyses. The sensitivity analyses performed suggest that risk of bias and study design did not influence the pooled estimates. Differences were

observed for BV and TV estimates when stratified by sample size more than versus less than 500. Therefore an unavoidable limitation was that heterogeneity persisted even after stratifying by region, risk of bias, study design and sample size.

Conclusion

The prevalence of curable STIs in sub-Saharan Africa is substantial among pregnant women, especially in the Southern Africa region where HIV prevalence is highest. Currently with syndromic management of STIs as standard of care in most African countries, a major concern is that many asymptomatically infected individuals go without diagnosis and treatment. Therefore, it is crucial to expand and integrate screening and rapid treatment of other curable STIs into existing antenatal care programs already focusing on syphilis and HIV.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgement

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Key message

1. A considerable pooled prevalence of curable STIs and BV in pregnancy was observed, especially in Southern Africa where HIV prevalence is highest.

2. More inexpensive, reliable and feasible STI screening tests are being introduced and these can be integrated in antenatal care in resource limited settings.

3. High prevalence of curable STIs and BV in sub-Saharan Africa provide compelling evidence to employ rapid diagnostic test for STI screening during pregnancy.

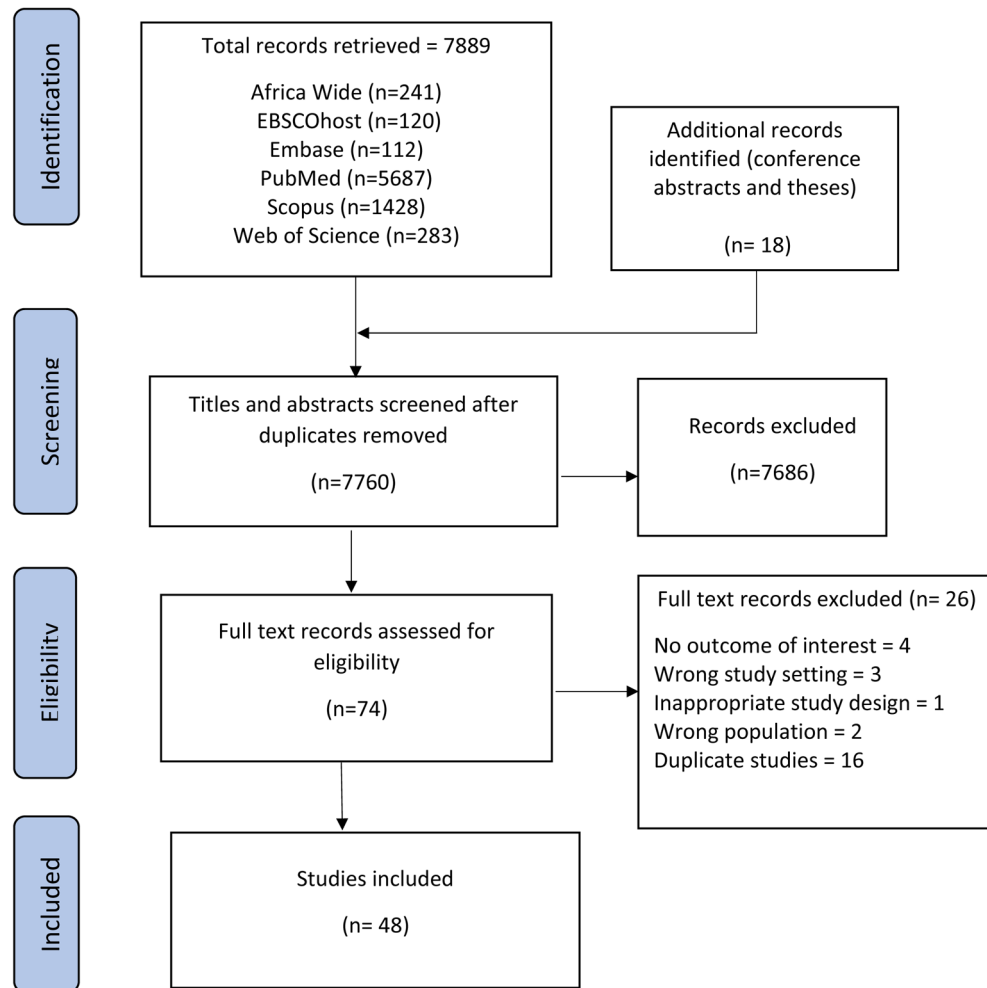*Sex Transm Infect.* Author manuscript; available in PMC 2022 November 01.

Figure 1:
PRISMA flowchart for selection of studies of STIs and BV among pregnant women in sub-Saharan Africa: 2015–2020.
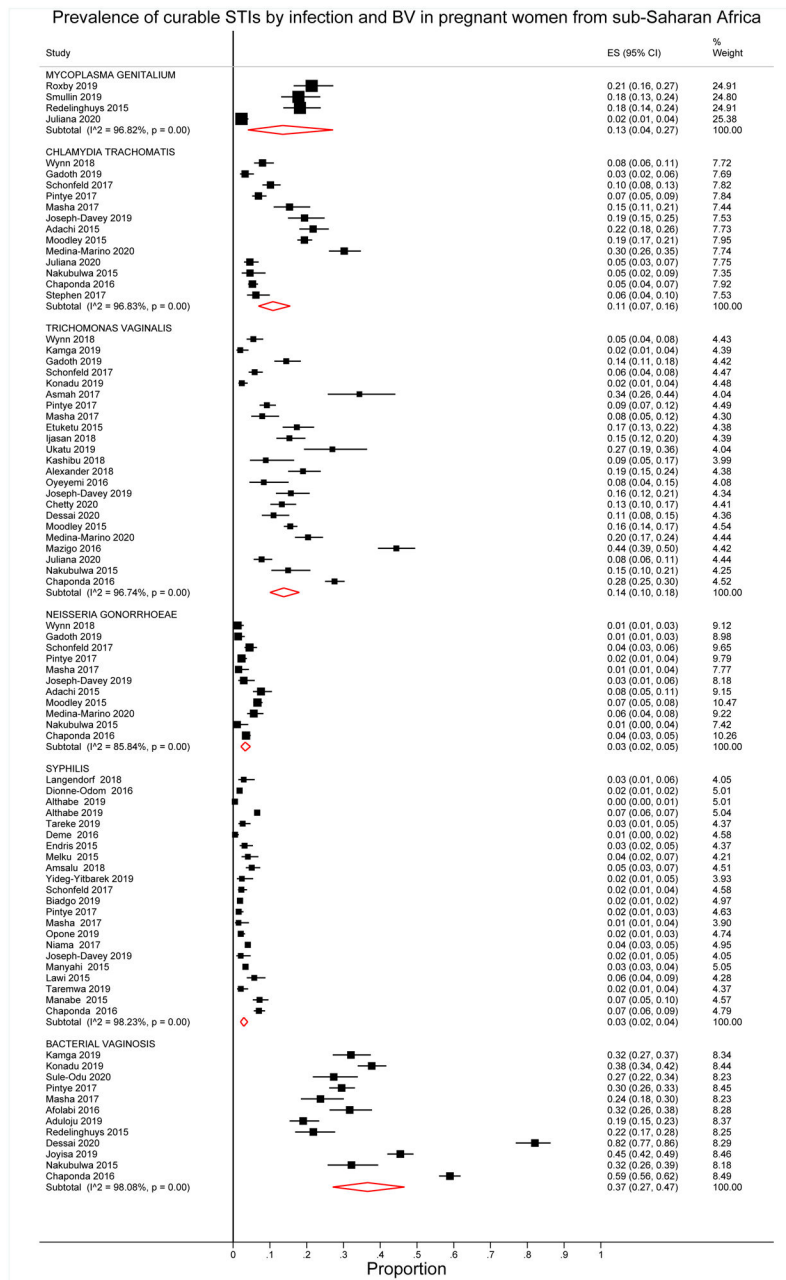
Figure 2:
Forest plot showing prevalence of curable STIs and BV among pregnant women in sub-Saharan Africa.

Table 1:

Characteristics of included studies of curable STI diagnosis in pregnant women in sub-Saharan Africa (2015–2020)

Study ID	Participants	Country	Type of study	Type of diagnostic test	Sample size
Adachi *et al.*, 2015	Pregnant WLHIV	South Africa	Cross-sectional	Xpert® CT/NG assay on the GeneXpert platform	409
Endris *et al.*, 2015	Pregnant women	Ethiopia	Cross-sectional	RPR and TPHA confirmatory test	385
Etuketu *et al.*, 2015	Pregnant women	Nigeria	Cross-sectional	Microscopic examination	300
Lawi *et al.*, 2015	Pregnant women	Tanzania	Cross-sectional	RPR and TPHA confirmatory test	331
Manyahi *et al.*, 2015	Pregnant women	Tanzania	Cross-sectional	RPR test only	38920
Manabe *et al.*, 2015	Pregnant WLHIV	Uganda	Cohort study	RPR – non-treponemal tests	570
Melku *et al.*, 2015	Pregnant women	Ethiopia	Cross-sectional	RPR and TPHA confirmatory test	300
Moodley *et al.*, 2015	Pregnant women	South Africa	RCT	BD Probetec ETAmplified DNA Assay for CT and NG, PCR assays for TV	1480
Nakubulwa *et al.*, 2015	Pregnant women	Uganda	Cross-sectional	Gram stain for CT and NG, Nugent scores for BV and DNA PCR tests for TV	174
Redelinghuys *et al.*, 2015	Pregnant women	South Africa	Cross-sectional	Gram-stained vaginal smears were graded with the Nugent scoring system	220
Afolabi *et al.*, 2016	Pregnant women	Nigeria	Cohort study	Nugent Scoring for BV	246
Chaponda *et al.*, 2016	Pregnant women	Zambia	Cohort study	PCR assays for CT, NG and TV Gram stain and Nugent scores for BV and RPR test only for syphilis	1084
Dionne-Odom *et al.*, 2016	Pregnant women	Cameroon	Cross-sectional	Syphilis Ultra-rapid Test Strip	7069
Deme *et al.*, 2016	Pregnant women	Ethiopia	Cross-sectional	RPR test only	574
Mazigo *et al.*, 2016	Pregnant women	Tanzania	Cross-sectional	Giemsa stains examined on microscope	365
Oyeyemi *et al.*, 2016	Pregnant women	Nigeria	Cross-sectional	Microscopic examination	108
Asmah *et al.*, 2017	Pregnant women	Ghana	Cross-sectional	Microscope examination	99
Masha et al., 2017	Pregnant women	Kenya	Cross-sectional	Gene Xpert assays and microscopic examination	202
Niama *et al.*, 2017	Pregnant women	Republic of Congo	Cross-sectional	RPR and TPHA confirmatory test	2923
Pintye *et al.*, 2017	Pregnant women	Kenya	Cohort study	NAAT –APTIMA Combo 2 Assay for CT and NG, RPR test for syphilis and microscopic examination for BV and TV	654
Stephen *et al.*, 2017	Pregnant women	Zimbabwe	Cross-sectional	Rapid immunoassay for CT	242
Schonfeld *et al.*, 2017	Pregnant women	Ethiopia	Cohort study	Immunochromatographic rapid test for CT, NG and TV	580
Amsalu *et al.*, 2018	Pregnant women	Ethiopia	Cross-sectional	RPR and TPHA confirmatory test	494
Alexander *et al.*, 2018	Pregnant women	Nigeria	Cross-sectional	Mount microscopy	300
Ijasan *et al.*, 2018	Pregnant women	Nigeria	Cross-sectional	Microscopic examination	320

Study ID	Participants	Country	Type of study	Type of diagnostic test	Sample size
Kashibu et al., 2018	Pregnant women	Nigeria	Cross-sectional	Wet mount and giemsa stained smear microscopy	90
Langendorf et al., 2018	Pregnant women	Burkina Faso	Cross-sectional	T-Rapid Diagnostic Test screening for syphilis	242
Wynn et al., 2018	Pregnant women	Botswana	Cohort study	Gene XpertVR CT/NG and XpertVR TV assays	400
Althabe et al., 2019	Pregnant women	DRC and Zambia	RCT	POC rapid tests and TPHA confirmatory test	36036
Aduloju et al., 2019	Pregnant women	Nigeria	Cross-sectional	Microscopy by Spiegel's method	362
Biadgo et al., 2019	Pregnant women	Ethiopia	Cross-sectional	RPR and TPHA confirmatory test	3504
Gadoth et al., 2019	Pregnant women	DRC	Cohort study	Gene Xpert assays and microscopic examination	367
Kamga et al., 2019	Pregnant women	Cameroon	Cross-sectional	Microscopic examination	309
Joseph Davey et al., 2019	Pregnant women	South Africa	Cohort study	Gene XpertVR CT/NG and XpertVR TV assays, RPR test for syphilis and TPHA confirmatory test	242
Joyisa et al., 2019	Pregnant women	South Africa	Cross-sectional	Gram staining and Nugent scores and microscopic examination	750
Konadu et al., 2019	Pregnant women	Ghana	Cross-sectional	Gram stained smear microscopy	589
Roxby et al., 2019	Pregnant WLHIV	Kenya	Cohort study	Aptima research-only transcription mediated amplification (TMA) assay	220
Opone et al., 2019	Pregnant women	Nigeria	Cross-sectional	Acon Ultra Rapid Syphilis test strip - treponemal antibodies test	911
Ukatu et al., 2019	Pregnant women	Nigeria	Cross-sectional	Sterile speculum for vaginal and sample urine	100
Smullin et al., 2019	Pregnant women	South Africa	Cohort study	Aptima assay for MG	197
Tareke et al., 2019	Pregnant women	Ethiopia	Cross-sectional	RPR and TPHA confirmatory test	384
Taremwa et al., 2019	Pregnant women	Uganda	Cross-sectional	RPR and TPHA confirmatory test	382
Yideg Yitbarek et al., 2019	Pregnant women	Ethiopia	Cross-sectional	VDRL test for Syphilis	210
Chetty et al., 2020	Pregnant women	South Africa	Cross-sectional	Applied Biosystems™ TaqMan® Assays	362
Medina-Marino et al., 2020	Pregnant WLHIV	South Africa	Cohort study	Gene XpertVR CT/NG and XpertVR TV assays	427
Dessai et al., 2020	Pregnant women	South Africa	Diagnostic study	BD Affirm™ VPIII assay (POCT)	273
Juliana et al., 2020	Pregnant women	Tanzania	Cross-sectional	Goffin Molecular Diagnostics for CT, NG and TV, M. genitalium assay for MG	439
Sule-Odu et al., 2020	Pregnant women	Ghana	Cohort study	Gram-stained vaginal smears were graded with the Nugent scoring system	201

ANC - antenatal clinics; BD - Becton Dickinson; BV - bacterial vaginosis; CT - Chlamydia trachomatis; NG - Neisseria gonorrhoeae; MG - Mycoplasma genitalium.

TV - Trichomonas vaginalis; POCT – point-of-care test; VDRL - Venereal Disease Research Laboratory; Rapid plasma regain – RPR; Treponema pallidum hemagglutination assay – TPHA; WLHIV, women living with HIV

Table 2:

Pooled prevalence of infection by regions in sub-Saharan Africa

Infection by Region	Pooled prevalence estimate, (95% CI)	No. of studies	Heterogeneity, %
Central Africa			
BV	-		
CT	0.03 (0.02, 0.06)	1	-
NG	0.01 (0.01, 0.03)	1	-
TV	0.14(0.11, 0.18)	1	-
MG	-	-	-
Syphilis	0.01 (0.00, 0.01)	2	-
Eastern Africa			
BV	0.29 (0.24, 0.33)	3	-
CT	0.08 (0.05, 0.11)	5	85.2
NG	0.02 (0.01, 0.04)	5	64.2
TV	0.13 (0.05, 0.25)	6	98.0
MG	0.07 (0.05, 0.09)	2	-
Syphilis	0.03 (0.02, 0.04)	15	86.4
Southern Africa			
BV	0.52 (0.34, 0.71)	4	98.6
CT	0.15 (0.08, 0.23)	7	97.6
NG	0.04 (0.03, 0.06)	6	87.3
TV	0.15 (0.10, 0.21)	7	95.8
MG	0.18 (0.14, 0.22)	2	-
Syphilis	0.03 (0.00, 0.06)	2	-
Western Africa			
BV	0.29 (0.23, 0.37)	5	90.1
CT	-		
NG	-		
TV	0.13 (0.07, 0.21)	9	96.0
MG	-		
Syphilis	0.02 (0.01, 0.02)	3	-

BV - bacterial vaginosis; CT - Chlamydia trachomatis; NG - Neisseria gonorrhoeae; MG - Mycoplasma genitalium; TV - Trichomonas vaginalis and CI - Confidence Interval

Table 3:

Sensitivity analyses of pooled prevalence estimates in sub-Saharan Africa

Sub-analysis	Pooled prevalence estimate, (95% CI)	No. of studies	No. of women positive	No. of women tested	Heterogeneity, %
Low risk of bias					
BV	0.37 (0.27, 0.49)	10	1532	4622	98.3
CT	0.11 (0.07, 0.18)	12	781	6526	97
NG	0.03 (0.01, 0.05)	10	239	5845	86.3
TV	0.12 (0.08, 0.17)	19	1040	8591	97.1
MG	0.13 (0.04, 0.27)	4	124	1076	96.8
Syphilis	0.03 (0.02, 0.04)	22	3395	95308	98.2
Sample size >500					
BV	0.43 (0.30, 0.56)	4	1144	3077	98.1
CT	0.10 (0.04, 0.18)	4	416	3798	97.9
NG	0.04 (0.02, 0.06)	4	166	3798	87.9
TV	0.11 (0.04, 0.20)	5	567	4387	98.6
MG	-	-	-	-	-
Syphilis	0.03 (0.02, 0.04)	12	3294	92136	99.1
Sample size 500					
BV	0.33 (0.20, 0.49)	8	492	1965	97.9
CT	0.11 (0.06, 0.18)	9	371	2902	96.5
NG	0.03 (0.01, 0.05)	7	74	2221	84.5
TV	0.15 (0.10, 0.20)	18	569	4877	95.3
MG	0.13 (0.04, 0.27)	4	124	1076	96.8
Syphilis	0.03 (0.02, 0.04)	10	101	3172	42.1
Longitudinal studies					
BV	0.37 (0.20, 0.55)	4	791	2185	98.4
CT	0.12 (0.06, 0.18)	8	630	5234	97.6
NG	0.03 (0.02, 0.05)	8	206	5234	86.4
TV	0.14 (0.09, 0.19)	8	755	5234	96.9
MG	0.20 (0.16, 0.24)	2	82	417	-
Syphilis	0.03 (0.01, 0.07)	7	2018	38477	99.3
Cross-sectional studies					
BV	0.36 (0.24, 0.50)	8	845	2857	98.0
CT	0.10 (0.04, 0.18)	5	157	1466	95
NG	0.03 (0.00, 0.08)	3	34	785	-
TV	0.14 (0.08, 0.21)	15	381	4030	96.7
MG	0.06 (0.04, 0.08)	2	42	659	-
Syphilis	0.03 (0.02, 0.04)	15	1377	56831	89.3

BV - Bacterial vaginosis; CT - Chlamydia trachomatis; NG - Neisseria gonorrhoeae; MG - Mycoplasma genitalium; TV - Trichomonas vaginalis and CI - Confidence Interval