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Magnitude of *Chlamydia trachomatis* in Ethiopia: A Systematic Review and meta-analysis

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Abstract

Background: *Chlamydia trachomatis* (*C. trachomatis*) is the most prevalent sexually transmitted bacterial infection, particularly in Sub-Saharan Africa. The World Health Organization predicted that 50 million women were newly infected with *C. trachomatis* globally. There has been a lack of countrywide representative study on the pooled prevalence of *C. trachomatis* in Ethiopia. Therefore, this systematic review and meta-analysis aimed to determine the pooled magnitude of *C. trachomatis* in Ethiopia.

Methods: Systematic search was performed to retrieve articles from PubMed, Science Direct databases, and Google Scholar search engine. Thirteen potential studies that provided important data on *C. trachomatis* were systematically reviewed and analyzed. The prevalence of *C. trachomatis* was extracted separately into Microsoft Excel and analyzed using STATA 17.0. The Inverse of variance was done to evaluate heterogeneity across studies. A funnel plot and Egger's test were used to determine the presence of publication bias. A random effect model was used to determine the pooled prevalence of *C. trachomatis*. Subgroup analysis was performed based on year of publication and study design.

Results: A total of 10 studies were included for this systematic review and meta-analysis. From this meta-analysis, the pooled magnitude of *C. trachomatis* was 10.70 % (95 % CI: 2.65-18.74). The subgroup analysis based on year of publication showed that the pooled prevalence of *C. trachomatis* in studies conducted in 2014-2018 was 13.36 % (95 % CI: 5.07–21.65), while it was 9.50 % (95 % CI: -1.69–20.68) in studies conducted in 2019-2024. Also, the subgroup analysis based on type of disease indicated that the prevalence of Trachoma and sexually transmitted diseases causing *C. trachomatis* was 11.30 % (95 % CI: -4.35–26.95) and 9.91 % (95 % CI: 3.36–16.45), respectively. Moreover, the subgroup analysis based on a diagnostic technique showed a significant difference in the prevalence of *C. trachomatis*.

Conclusions and recommendation: This systematic review and meta-analysis revealed a high prevalence of *C. trachomatis* in Ethiopia. This underscores the significant challenges in managing infections caused by *C. trachomatis* in the region. Furthermore, the government and non-governmental organizations should focus on primary prevention of this infection. Similarly, in resource limited countries, policymakers, stakeholders, and healthcare providers should prioritize specific and rapid diagnostic tests for *C. trachomatis*, along with effective treatment options.

Key words: Prevalence; *Chlamydia trachomatis*; Ethiopia; Review

Introduction

Chlamydia trachomatis (*C. trachomatis*) is the most common sexually transmitted bacterial infection. It is a serious public health problem worldwide and the leading cause of sexually transmitted diseases, particularly in Sub-Saharan Africa [1]. The World Health Organization predicted that 50 million women were newly infected with *C. trachomatis* globally, with 34 million in Sub-Saharan Africa and South/Southeast Asia. It is the most implicated organism for infertility and pelvic inflammatory illness [2, 3]. Chlamydia in women can have major and severe health impacts, especially if the infection spreads from the endocervix to the upper genital tract and results in pelvic inflammatory disease, which can cause chronic pelvic pain, ectopic pregnancy, fallopian tube scarring, and tubal infertility[4, 5].

Chlamydia trachomatis possesses 19 different serovars, including the trachoma biovar (serovars A-K) and the lymphogranuloma venereum (LGhasV) biovar (serovars L1, L2, L2a, and L3) [6]. Endemic trachoma is caused by ocular *C. trachomatis* serotypes (A, B, Ba, and C). *Chlamydia trachomatis* serotype D-K causes both neonatal conjunctivitis and adult inclusion conjunctivitis [7]. Trachoma primarily impacts both eyes, presenting symptoms such as itching, irritation, discharge, swollen eyelids, photophobia, and pain. Initial stages are marked by the formation of follicles in the upper tarsal conjunctiva, which contain white blood cells; repeated infections can cause scarring that leads to entropion and trichiasis, ultimately resulting in corneal opacification and potential blindness [8, 9]. *Chlamydia trachomatis* serovars D-K are most usually associated with urogenital infections [10]. Women with genital *C. trachomatis* infection may have changes in vaginal discharge, intermittent, intermenstrual, and/or post-coital bleeding. *Chlamydia trachomatis* can also infect the urethra, and some individuals may present with signs of urinary tract infection [11].

The prevalence of *C. trachomatis* infection in Ethiopia is unknown due to the illness's asymptomatic nature and a lack of laboratory testing facilities. In a prior research, the sero-prevalence of genital chlamydial infection among Ethiopian women was found to be 62%, with 42% having titers indicating recent or current genital infection. In the same study, characteristics shown to be related with infection included age at first coitus, religion, prostitution, number of sexual partners, and the woman's current age [12]. Chlamydial infection is common among women aged 15-29 years due to host characteristics such as sexual partner count, contraception usage, sexual desire, and population movement [13].

Trachoma, caused by recurrent infection with the ocular serovars of the *C. trachomatis* bacterium, is widespread in economically impoverished nations all over the world, particularly in hot dry regions [14]. The World Health Organization has verified 17 nations as having eradicated trachoma as a public health hazard.

As of 2022, the global population living in trachoma endemic areas was predicted to be 132 million people, with Ethiopia accounting for 52% of this figure [15]. Trachoma has been targeted for elimination as a public health problem by 2030 [16]. Despite almost ten years of control measures, trachoma remains a chronic concern in regions of Africa, including certain areas of Ethiopia that are hyperendemic [17].The epidemiology of *C. trachomatis* infection in Ethiopia is not well known due to its asymptomatic nature and a lack of laboratory testing facilities[18].

The direct medical expenditures of *C. trachomatis* infections were estimated at $516.7 million in 2008 [19]. Additionally, the direct expenses associated with *C. trachomatis* infections and their sequelae have declined in recent years because sequelae have been handled in a less costly way and ectopic pregnancies have been increasingly controlled medically [20]. Also, significant are the intangible expenses, such as the psychological and emotional harm brought on by ectopic pregnancy and infertility, as well as the concrete costs, such as lost productivity [21].

The trachoma denouement depends on the capacity to effectively identify possible sites of continued transmission for follow-up surveys and more extensive treatments. However, to the best of our knowledge, no systematic review and meta-analysis has been conducted on *C. trachomatis* prevalence in Ethiopia. Therefore, stakeholders, public health specialists, and clinicians utilize this study as input for potential interventions. We provide a thorough analysis that draws on carefully gathered data from English-published publications published over the last period in Ethiopia. As a result, this systematic review and meta-analysis sought to establish the pooled magnitude of *C. trachomatis* in Ethiopia from 2014 to 2024.

Method

Design and protocol

This study was conducted out following the Preferred Reporting Item for Systematic Reviews and Meta-analyses Protocol (PRISMA-P 2020) standards. The four steps of the PRISMA flow chart were documented in the findings, and they show the process of choosing studies from the first identified records to the studies included. The review protocol was established prior to conducting a literature search and registered under the CRD42024612251 registration number in the International Prospective Register of Systematic Reviews (PROSPERO) database..

Database and search strategy

The systematic search was conducted from November 4, 2024 to November 30, 2024. The systematic review and meta-analyses covered studies conducted in the Ethiopia and published in English until October 30, 2024. An extensive literature search was conducted to locate studies on the prevalence of *C. trachomatis* reported in the population of various study subjects in Ethiopia. Systematic searches of the gray and electronic literature were conducted. The data was retrieved using PubMed, Science Direct, and Google Scholar. Boolean operators such as "OR" and "AND" were used to combine and utilize search keywords individually. The followings are the main search terms/words/ phrases/ a set of keywords that were utilized to find pertinent studies: [“Prevalence’’ OR ‘‘Incidence’’ OR Epidemiology’’ AND ‘‘*Chlamydia trachomatis’’* OR ‘‘*C. trachomatis’’* AND "Ethiopia" 2014-2024]. Additionally, the reference lists of the listed studies were searched using a snowball search.

Eligibility criteria

Articles from the aforementioned databases were imported into Thomson Reuters' EndNote version 7 reference management systems in New York, NY. The included articles in this systematic review and meta-analysis were: (a) Observational studies that reported the prevalence of *C. trachomatis* in the Ethiopia, including cross-sectional (retrospective and prospective) and case-control studies. (b) Publications that have been published in grey literature or peer-reviewed journals; and (c) Publications that have been published in English between 2014 and October 30, 2024. The following criteria were used to reject studies: (a) lack of complete accessibility; (b) low quality score according to specified criteria; (c) case series, letters, comments, and editorials; and/or (d) inability to quantify the intended result. (e) The article does not mention the prevalence of *C. trachomatis*.

Outcome of interest

The prevalence of *C. trachomatis*, which was presented in the original article as a percentage and the number of cases (n)/total number of participants (N), were the main finding of interest.

Study selection and quality assessment

The studies' quality was assessed using Joanna Briggs Institute quality assessment criteria (JBI), and studies scoring 50% or above on the quality scale were regarded to be of good quality. The titles in the aforementioned databases were reviewed by (W.A. and M.T.A.). Following this, two reviewers (W.A. and T.E.) independently screened eligible studies for the abstract. Finally, full-text screening was conducted by three reviewers (W.A., A.S., and Y.A.D.).

Data extraction

A consistent data extraction form in Microsoft Excel 2010 was utilized to collect or record relevant data from each identified studies. The extraction technique included a variety of categories, such as first author, year of publication, study population, study design, number of participants, study area/region, and *C. trachomatis* prevalence. The two reviewers (T.E. and Y.A.D.) checked the extracted data for accuracy and consistency. The third reviewer (A.S.) was also participated where necessary.

Statistical analysis

The retrieved data was imported into Microsoft Excel and analyzed using STATA version 17 (Stata Corp. Stata Statistical Software; College Station, TX: Stata Corp LP). A random-effects model was used to get a summary estimate of prevalence across trials. A point estimate with a confidence interval of 95% was used. A funnel plot and Egger's test were used to assess the presence of publication bias. The study's heterogeneity was assessed using the inverse of variance (I^2) statistic. A I^2 score of 50% or higher indicated significant heterogeneity. We performed subgroup analysis to investigate the causes of heterogeneity in studies with significant differences ($I^2 \geq 50\%$).

Results

Selection and characterization of included studies

A total of 279 English-published papers and one unpublished papers on the prevalence of *C. trachomatis* in Ethiopia were found through the electronic searches. A total of 252 studies were identified, after which 28 duplicates were removed. A total of 252 studies were screened to remove studies by title, abstract, and full-text articles, with 10 studies retained after the screening and eligibility process. Finally, 10 studies were included for both qualitative and quantitative analyses **(Figure.1)**. Five studies utilized Polymerase Chain Reaction (PCR) for the diagnosis of *C. trachomatis* [22-26]. This study encompasses participants of all ages and genders. All studies were conducted within health institutions. Among these, five studies focused on female subjects [26-30], while four studies targeted children [22-24, 31]. A notably high prevalence of *C. trachomatis*, at 43%, was identified in the Amhara Region of Ethiopia [31]. Furthermore, *C. trachomatis* frequently co-occurs with *Neisseria gonorrhoeae*, *Trichomonas vaginalis*, and human papillomavirus[26, 27]. A total of 10 studies were included in this meta-analysis [22-31] (**Table.1).**

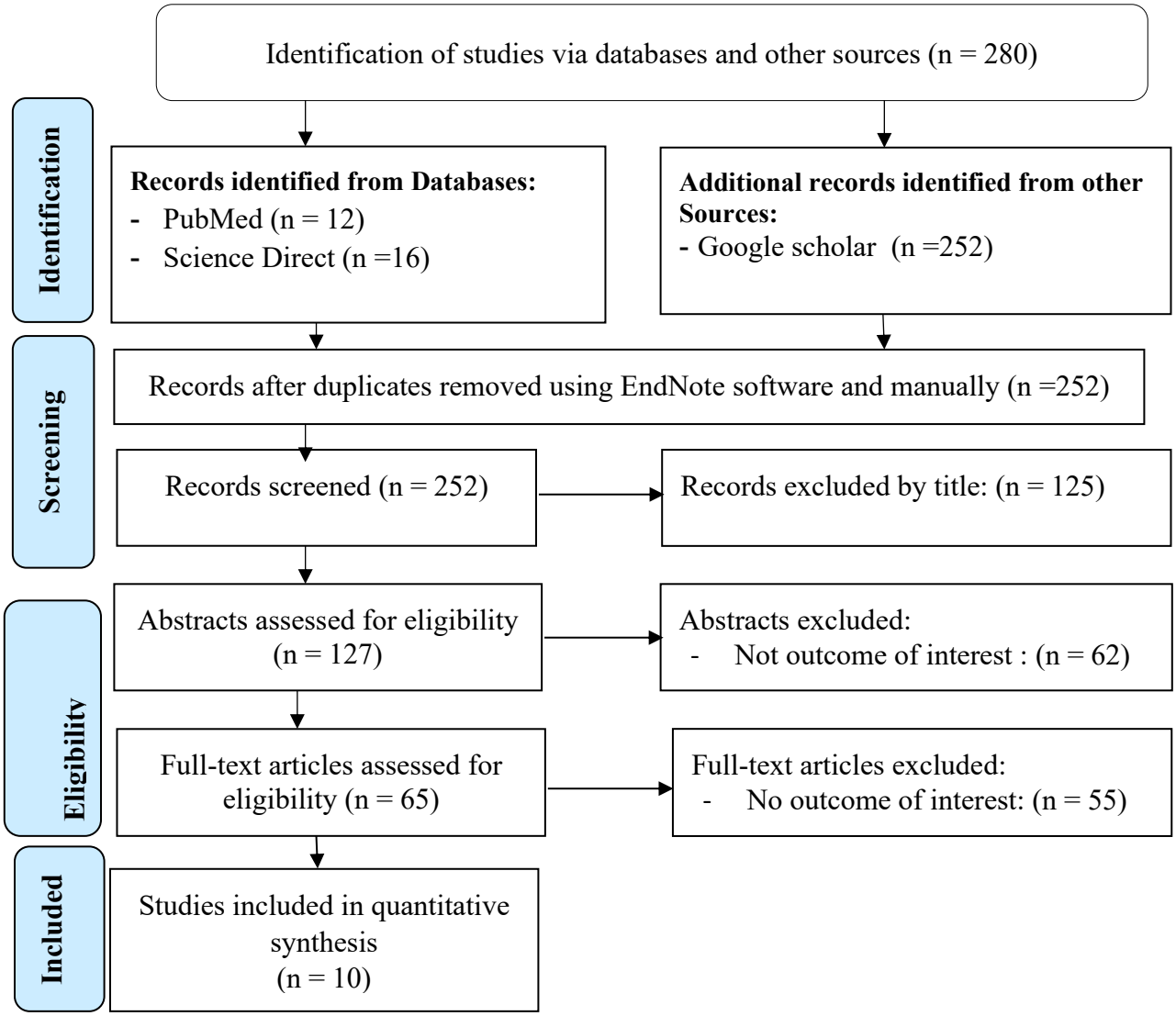


Figure 1: Prisma flow diagram shows the results of the search and reasons for exclusion.

Table.1 Summary of included studies in systematic review and meta-analysis.

Author	Year of publication	Country	Study design	Study populations	Type of disease	Diagnostic technique	Sample size	Prevalence (%)	Quality score/9
Scott D *et al* [22]	2020	Ethiopia	Cross sectional study	Children	Trachoma	PCR	7,441	6.0	9
Endale T *et al* [29]	2016	Ethiopia	Cross sectional study	Reproductive age women	STI	SD BIOLINE rapid antigen test kit	329	18.9	9
Mengistu H *et al* [27]	2021	Ethiopia	Cross sectional study	Pregnant Women	STI	Xpert Assays	350	8.3	9
Alelign T *et al*[28]	2019	Ethiopia	Cross sectional study	Female commercial sex workers	STI	Chlamydial rapid test kit	338	6.8	9
Scott D *et al* [23]	2022	Ethiopia	Cross sectional study	Infants	Trachoma	PCR	464	0.2	9
Scott D *et al* [24]	2018	Ethiopia	Cross sectional study	Children	Trachoma	PCR	15,632	5.7	9
Dagnamyelew T et al [30]	2014	Ethiopia	Cross sectional study	Reproductive age group	STI	Chlamydial rapid test kit	159	16.4	9

				women					
Anna L et al [25]	2024	Ethiopia	Cross sectional study	General population	Trachoma	PCR	1,220	1.7	9
Kristen A et al [31]	2020	Ethiopia	Cross sectional study	Children	Trachoma	Multiplex Sero MAP microsphere	2,267	43	9
Johanna M et al [26]	2024	Ethiopia	Cross sectional study	Asymptomatic women	STI	PCR	779	0.6	9

Abbreviations: PCR = Polymerase Chain Reaction, STI = Sexually Transmitted Infection

Pooled prevalence of *C. trachomatis* in Ethiopia from 2014 to 2024

Ten articles were selected for this systematic review and meta-analysis,which were used to estimate the pooled prevalence of *C. trachomatis*. The minimum prevalence of *C. trachomatis* was 0.2 % (95% CI: 0.0–1.5) [23], also the maximum prevalence of *C. trachomatis* was 43 % (95% CI: 38, 48.4) [31]. The pooled prevalence of *C. trachomatis* in Ethiopia was 10.70 % (95 % CI:2.65-18.74). High heterogeneity (I^2=99.92 % and p value =0.01) across studies was observed in the analysis **(Figure 2)**.

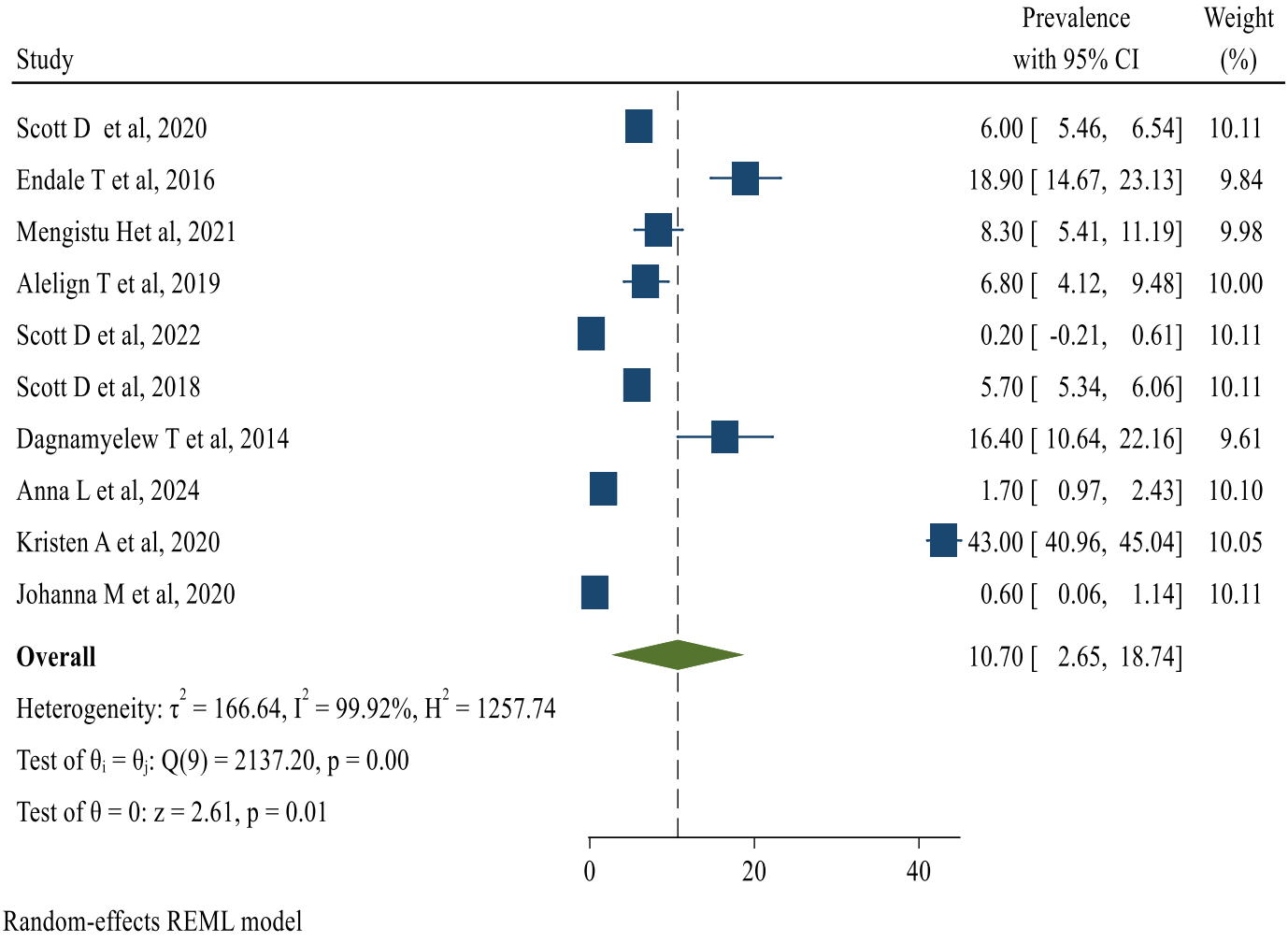


Figure 2: Forest plot showing the pooled prevalence of *C. trachomatis.*

Subgroup analysis based on type of disease, year, and study design

Subgroup analysis based on type of disease showed that the prevalence of Trachoma and sexually transmitted diseases causing *C. trachomatis* was 11.30 % (95 % CI: -4.35–26.95) and 9.91 % (95 % CI: 3.36–16.45), respectively, **(Figure 3)**. Subgroup analysis based on year of publication showed that the prevalence of *C. trachomatis* was 13.36 % (95 % CI: 5.07–21.65) from 2014-2018 and 9.50 % (95 % CI: -1.69–20.68), from 2019-2024. Consequently, the meta-analysis showed no signifcant difference in frequency of *C. trachomatis* among studies on year of publication **(Figure 4)**. Also, the meta-analysis showed signifcant difference in frequency *C. trachomatis* among studies on diagnostic technique **(Figure 5)**.

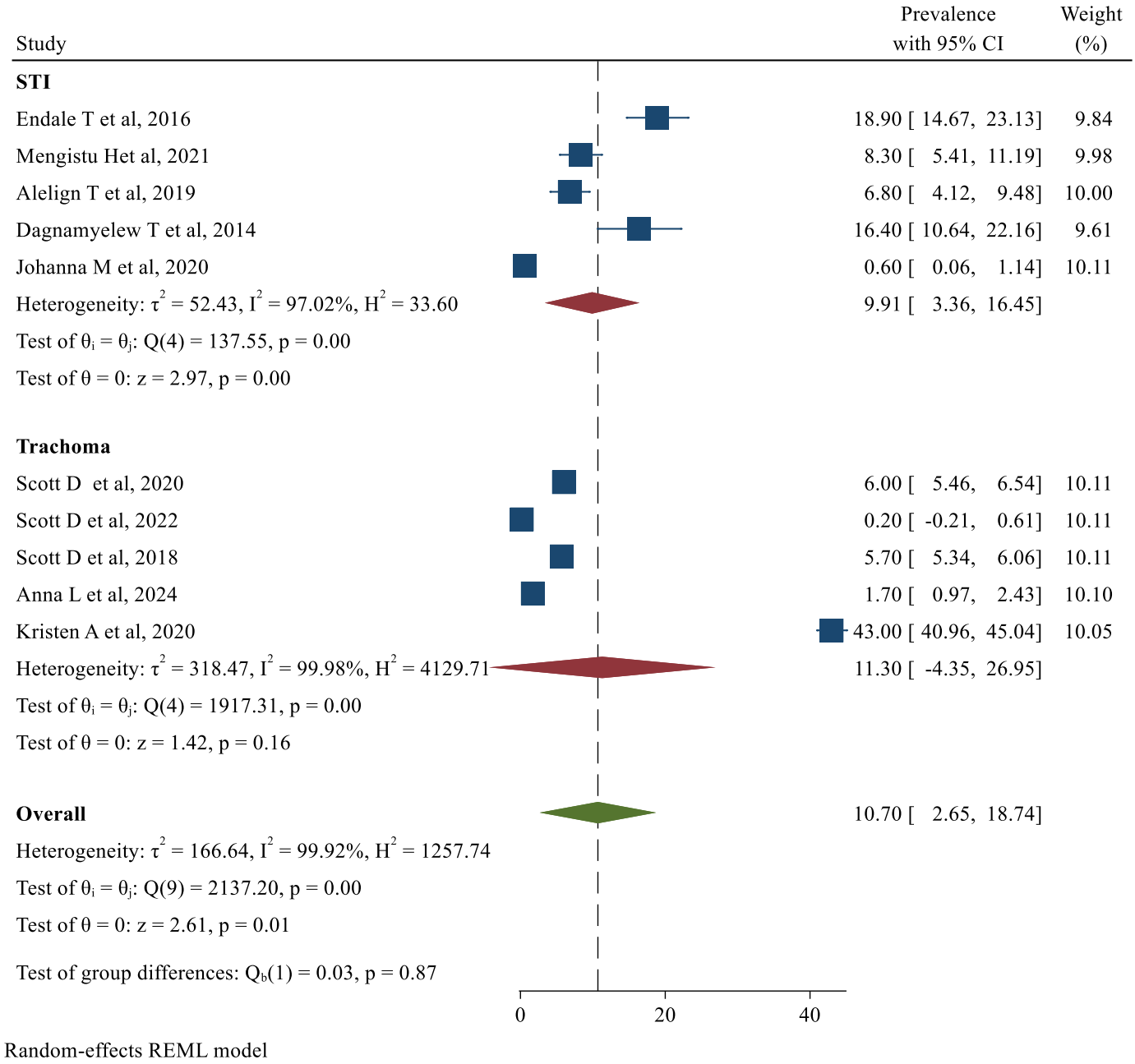


Figure 3. Subgroup analysis for pooled prevalence of *C. trachomatis based* on type of disease.

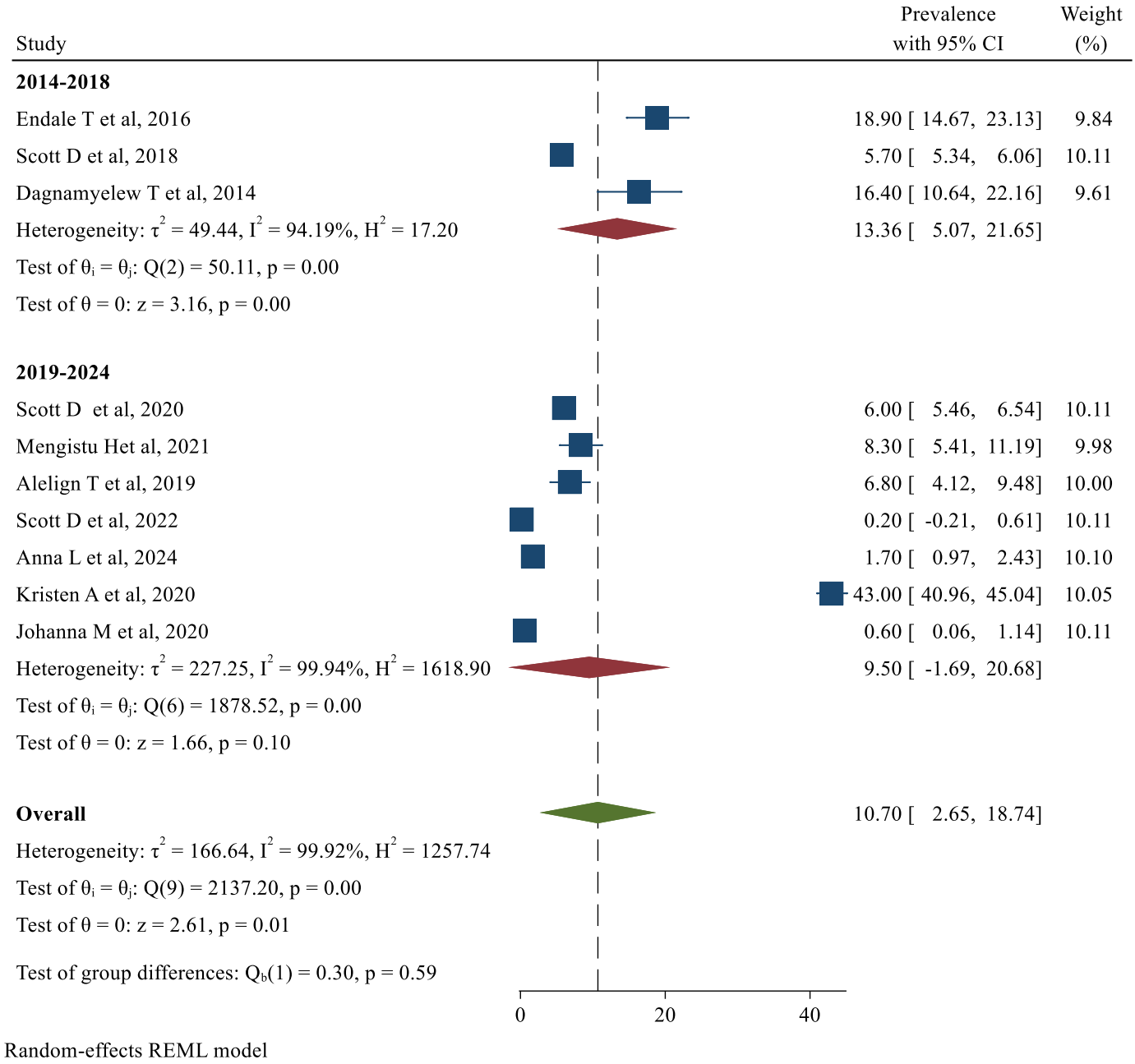


Figure 4. Subgroup analysis for pooled prevalence of *C. trachomatis* from 2014 to 2024.

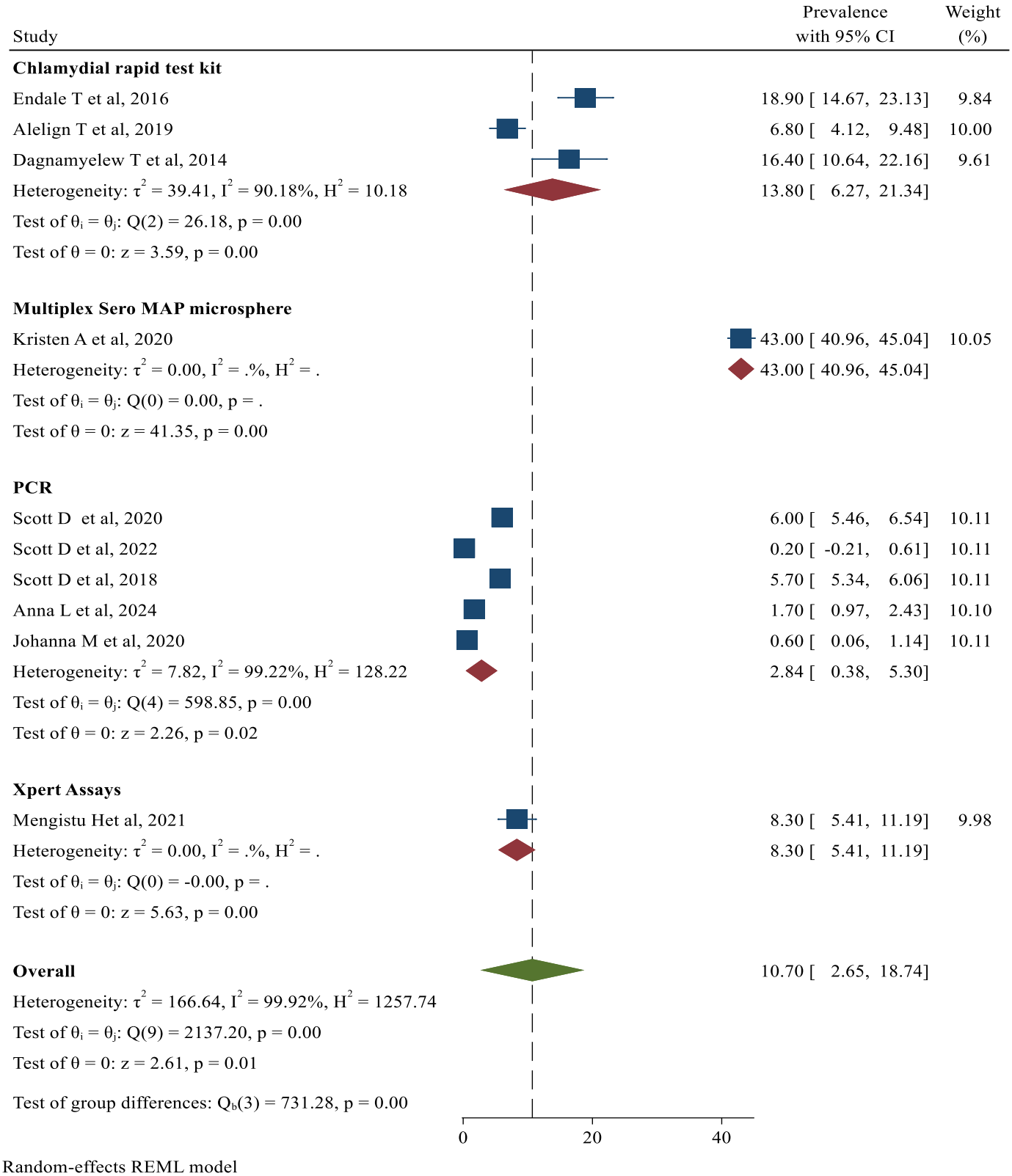


Figure 5. Subgroup analysis for pooled prevalence of *C. trachomatis based* on diagnostic technique.

3.6. Heterogeneity and publication bias

The heterogeneity was evaluated for *C. trachomatis* used in various studies on prevalence of *C. trachomatis*. There was significant heterogeneity on *C. trachomatis* prevalence, with I^2 statistics indicating values greater than or equal to 99.92 % at P = 0.01. A funnel plot was used to evaluate the potential publication bias in the included studies. As a result, the funnel plot seems asymmetric, revealed that publication bias among studies was observed **(Figure 6)**. An Egger's test was used to evaluate the potential publication bias in the included studies. However, an Egger's test of *C. trachomatis* prevalence indicated that there was no publication bias with a p-value= 0.1745.

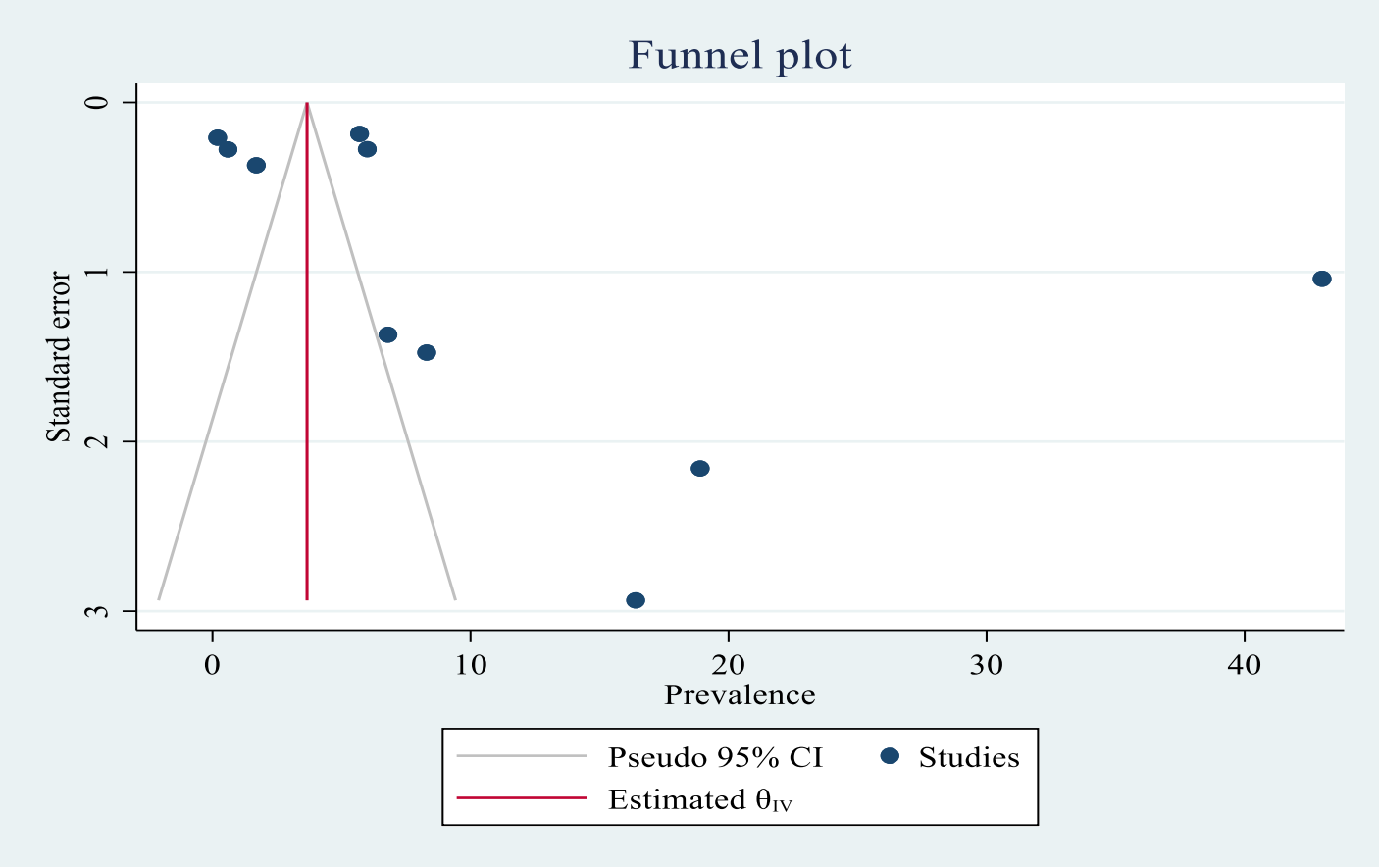


Figure 6. Funnel plot for pooled prevalence of *C. trachomatis*.

Sensitivity: In sensitivity analyses using the leave-one-out technique, removing none of the studies had a significant effect on pooled burden estimates and heterogeneity measures among review papers. As a result, sensitivity analysis using the random-effects model revealed that no single study affected the overall prevalence of *C. trachomatis* **(Figure 7)**.

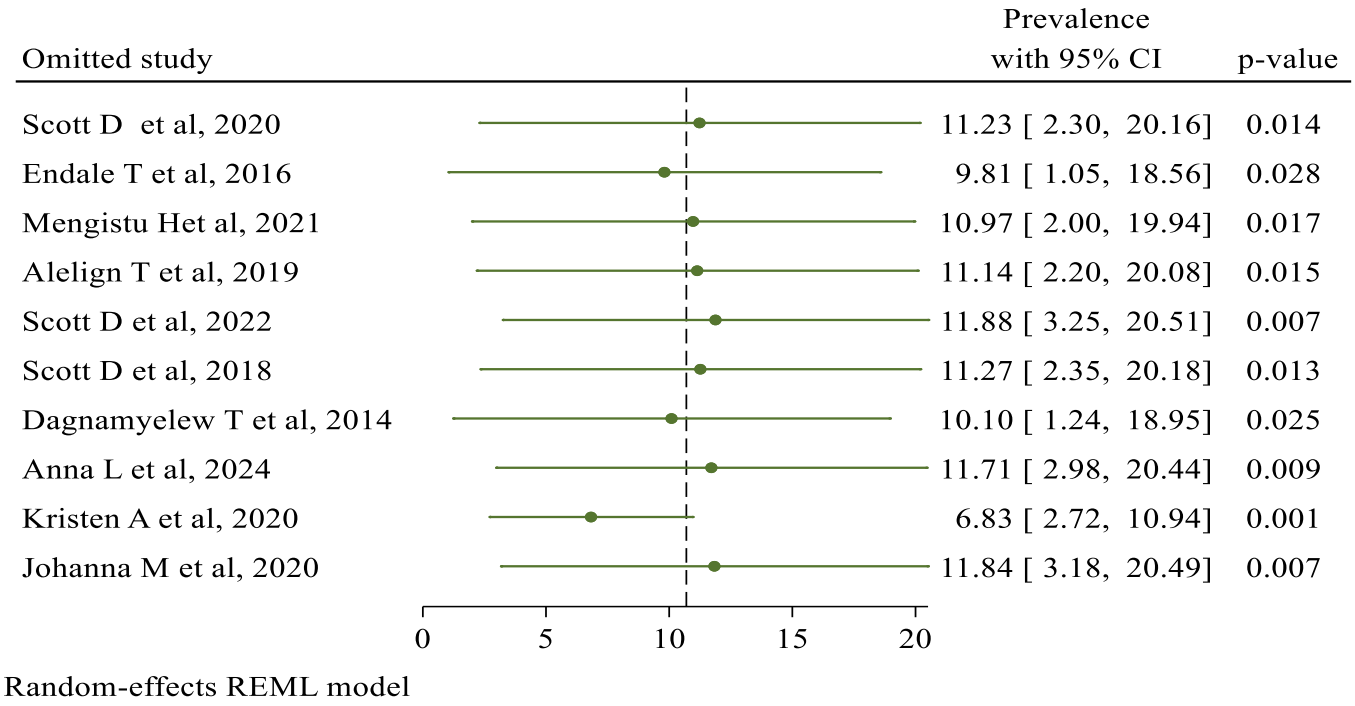


Figure: 7 Sensitivity analysis results of included studies on prevalence of *C. trachomatis*.

Discussion

Chlamydia trachomatis is a major public health issue worldwide, including in Sub-Saharan Africa. To address the issue, the majority of developed nations have put in place specific programs to control chlamydial infection, ranging from case management to opportunistic screening of high-risk groups and an annual screening program for sexually active women aged 25 years. These countries have reduced chlamydial infection and its complications, while developing nations continue to use a syndromic approaches to management. In Sub-Saharan Africa, the infection and its complications continue to be a significant burden due to the asymptomatic nature of the infection, which leaves most patients undiagnosed and untreated for extended periods of time, allowing the infection to spread [32].This systematic review and meta-analysis showed the pooled prevalence of *C. trachomatis* in Ethiopia.

In this systematic review and meta-analysis, the pooled prevalence of *C. trachomatis* was 10.70 % (95 % CI:2.65-18.74). This finding was lower than that reported in Tanzania (36.21 %) [33], and Ghana (19.0%) [34]. This might be due to differences in the study groups' age, gender, sexual behavior, and environmental factors. For example, research that focus on high-risk populations, such as teenagers or sex workers, may indicate a greater incidence than general population study. Additionally, this difference could be associated with a number of influencing factors, including social, cultural, and economic circumstances [35].

However, this finding was higher than that reported in Nigeria (0.7 %) [36]. This might be due to variations in access to healthcare services, diagnostic techniques, study design, sample size, population characteristics, and public health initiatives, such as sexually transmitted infections screening, treatment, and educational campaigns. Furthermore, epidemiological factors such as increasing rates of unprotected sexual behaviors, multiple sexual partners, and a lack of sexual health education may lead to an increase in infection rates [37]. This higher incidence in Ethiopia may indicate a greater public health concern with *C. trachomatis* infections.

Furthermore, this finding was inline with that reported in Iranian (8.74 %) [38], Uganda (18.2 %) [39], and China (7.1 %) [40]. This might occur because *C. trachomatis* is impacted by comparable risk factors over the world, such as age (especially among young people), sexual conduct, and socioeconomic status.

This review showed that the pooled prevalence of trachoma causing *C. trachomatis* was 11.30 % (95 % CI: -4.35–26.95). This finding was inline with that reported in Egypt (10.8%)[41] and low-income countries of Africa (21.93 %) [42]. This demonstrated that comparable patterns were seen in low-income African nations.

These results highlight the continued difficulties in trachoma control, especially in areas with poor sanitation and access to healthcare. According to the statistics, focused interventions are necessary to address this avoidable cause of blindness, particularly in communities that are at risk [43].

However, this finding was lower than that reported among female study subject in the world (60.6%) [44]. This significant difference draws attention to a possible disparity in the burden of trachoma, which may be more prevalent in women due to a variety of environmental and socioeconomic variables. The higher incidence in women may be related to variations in living situations, hygiene habits, and access to healthcare. In order to create focused interventions to lower the incidence of trachoma, particularly among disadvantaged populations, it is essential to comprehend these differences [45].

Likewise, this review indicated that the pooled prevalence of sexually transmitted diseases causing *C. trachomatis* was 9.91 % (95 % CI: 3.36–16.45). This finding was inline with that reported in Australia (11.2%) [46]. This consistency implies that the prevalence of *C. trachomatis* infections is comparatively comparable in many geographic settings, which may point to shared risk factors like sexual behavior, access to healthcare, and public health initiatives. In order to successfully control and lower the prevalence of these illnesses, the results emphasize the significance of continuous surveillance and focused preventative measures in endemic areas[47].

However, this finding was lower than that reported in the world (41.6%) [48]. This disparity reveals notable regional differences in the burden of *C. trachomatis* infections, indicating that socioeconomic circumstances, healthcare access, and sexual health education may be important determinants of prevalence rates. The higher rates seen in West Africa and around the world point to the urgent need for improved public health initiatives and strategies designed to address the unique difficulties encountered in these areas, such as increased knowledge of and access to sexually transmitted disease testing and treatment [49].

There was significant heterogeneity on *C. trachomatis* prevalence, with I^2 statistics indicating values greater than or equal to 99.92%. This variation could be explained by differences in methodologies, sample size, sampling technique, data collection methods, and public health policies. The diagnostic tools that are accessible and available to the target the population have a significant impact on *C. trachomatis* screening. Although laboratory based nucleic acid amplification tests offer a very precise diagnosis, they are typically not accessible or cheap in underdeveloped nations due to their high cost and requirement for laboratory equipment and skilled staff. Furthermore, it may become impossible to give a timely therapy intervention if

test findings are not reported promptly. Point-of-care tests, on the other hand, may be used in both clinic and out of clinic settings. They enable the diagnosis and treatment selections to be made at the same visit, guaranteeing prompt treatment, and avoiding the loss of follow ups [50, 51].

Moreover, in this systematic review and meta-analysis, subgroup analysis based on year of publication showed that prevalence of *C. trachomatis* on 2014-2018 and 2019-2024 year was 12.33 % (95 % CI: 6.30–18.36) and 8.99 % (95 % CI: 0.07–17.91), respectively. According to the data presented, the prevalence of *C. trachomatis* dropped from 12.33% in 2014–2018 to 8.99% in 2019–2024. This decline could be due to several factors which might have contributed to this drop, including the development of more effective public health initiatives that enhanced access to screening and treatment. Enhanced public awareness efforts may have also had a role in encouraging safer sexual habits among the population. However, it is necessary to consider potential drawbacks, such as underreporting or reduced testing in specific groups, which might distort prevalence numbers. Furthermore, changes in sexual behavior over time may alter infection dynamics, emphasizing the need for continued monitoring and investigation. Understanding these trends is critical for assessing the effectiveness of existing health initiatives and making sound judgments regarding future treatments [52, 53].

Furthermore, in this review, subgroup analysis based on diagnostic techniue showed the presence of significant difference on the prevalence of *C. trachomatis*. The finding suggests that the diagnostic techniues used in different studies may influence the reported prevalence rates. This might be due to several factors which could contribute to the change in prevalence of *C. trachomatis* among the diagnostic techniues like variations in the sensitivity and specificity of diagnostic tests, time of study conduct, cultural practices, and targeted populations. These variations might also be due to disparities between geographical locations in terms of socioeconomic status, healthcare access, degrees of urbanization, and population movement extent.

Strength and limitations of the study

The main strength of this study is that it provided a picture of the prevalence of *C. trachomatis* in Ethiopia. Also, as far as we know, this is the first study that has investigated the pooled prevalence of *C. trachomatis*, particularly in Ethiopia. However, the data obtained from this investigation did not contain the pooled associated risk factors that influences the prevalence of *C. trachomatis*. Since there was no indicated associated risk factors in the included studies. This review includes studies from specific region due to a

shortage of literature from other area, which may impact the representativeness of the findings. Additionally, only studies conducted from 2014 to 2024 were considered for this review.

Conclusion and recommendation

The spread of *C. trachomatis* is a worldwide health concern that necessitates an integrated approach that considers environmental, economical, and political developments in Ethiopia. The findings of this systematic review and meta-analysis regarding the prevalence of *C. trachomatis* in Ethiopia revealed a significant high prevalence of *C. trachomatis*. This highlights the major difficulty in controlling infections caused by *C. trachomatis* in the region. As a result, we strongly advocate increasing *C. trachomatis* control surveillance in Ethiopia to prevent future *C. trachomatis* epidemics. Furthermore, this information implies that the government and non-governmental organizations should prioritize primary prevention of this illness. Similarly, in resource limited nations, policymakers, stakeholders, and health care providers' appropriate attention to *C. trachomatis* specific and speedy diagnostic test and treatment in any medical outpatient and inpatient clinics.

Declarations

We declare that this manuscript is review and has not been submitted or published in other journal.

Clinical trial

In this manuscript **clinical trial number: not applicable**.

Availability of data

The data that support the findings of this study are available in the manuscript.

Consent for publication

Not applicable

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This systematic review and meta-analysis was not funded by any organization or individual.

Conflict of interests

The author declares that there is no conflict of interest.

Ethical approval

Not applicable

Author's contribution

W.A. led the review, article selection, data mining, data screening, data extraction, statistical analysis, manuscript preparation, and overseeing the study's conceptualization. **W.A., M.T.A., A.S., T.E.,** and **Y.A.D.** involved in data mining, data extraction, manuscript writing, editing, and ensuring accuracy and completeness. **A.S.** and **T.E.** were involved in statistical analysis consultation of the overall process of this review. Moreover, all authors actively engaged in critically reviewing the study's progress, data analysis, and manuscript preparation, involved in the approval of the final manuscript for submission, thereby affirming their endorsement of its content and findings.

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