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SEROPREVALENCE OF SMALL RUMINANT BRUCELLOSIS IN ETHIOPIA: SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT: Brucellosis is considered a neglected zoonotic bacterial disease by the World Health Organization and has been identified as having the highest public health burden across all sections of the community. The aim of this study is to conduct a systematic review and Meta analysis on the seroprevalence of small ruminant brucellosis in Ethiopia. The data searching journal like PubMed, Science Direct, Scopus, Embase an d Google Scholar was used to search the articles. All articles are screened, which was rep orted seroprevalence of small ruminant brucellosis in Ethiopia to be included in the study. Meta-analysis are declared by the effect size by prevalence and standard error of the prevalence which had been analyzed using random-effects models was used to calculate the pooled seroprevalence of small ruminant brucellosis in Ethiopia. The estimated pooled seroprevalence of brucellosis was found to be 3.0% (95% CI: 0.02, 0.03). The sub group analysis showed that there was a statistically significant association between the disease and study region, publication year, laboratory technique employed and study years. Also, there was some evidence of publication bias (Egger's test, p = 0.001) on studies reporting the prevalence of brucellosis in Ethiopia. This review proves a high seroprevalence of brucellosis in the country and the need for appropriate intervention measures, including vaccination and enhanced public awareness, and further surveillance for the control and prevention of brucellosis in livestock husbandry practices. Further studies that are aimed at evaluating the risk factors associated with the spread of brucellosis in domestic animals and sufficient epidemiological data are crucial to the exploration of the epidemiology of the disease throughout the country.
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1. INTRODUCTION

Brucellosis is considered a neglected zoonotic bacterial disease by the World Health Organization (WHO) and has been identified as having the highest public health burden across all sections of the community (Hegazy *et al*., 2011).This is due to lack of effective control and proper disease surveillance (Terefe *et al*., 2017, McDermott *et al*., 2013). In many developing countries like Ethiopia, brucellosis remains endemic and continues to be a major public and animal health problem (Asmare *et al*., 2013a).

The currently recognized species includes *Brucella abortus*, *B. Melitensis*, *B. Suis*, *B. Ovis*, *B. Canis*, *B. Ceti*, *B. Pinnipedialis*, *B. Neotomae*, *B. Microti* and *B. Inopinata* (Mustefa *et al*., 2019). *Brucella melitensis* and *B. Ovis* are the two important Brucella species known to affect sheep and goats, however; *B. Abortus* is also been incremented occasionally in sheep and goats (Radostits *et al*., 2007, Akhvlediani *et al*., 2010). In human, Brucellosis is always caused by *B. melitensis* (cause Undulant or Malta fever) followed by *B. suis*, *B. abortus* and *B. canis* (Dungan, 2010).The disease is transmitted to humans mainly by direct contact with infected livestock or through consumption of raw or uncooked animal products. It causes a systemic infection with clinical manifestations such as fever, sweats, fatigue and joint pain (Mohammed *et al*., 2017). The prevalence of brucellosis is affected by several risk factors such as production system, host and environmental factors (Radostits *et al*., 2007). In sexually mature sheep and goats, brucellosis restricts to the reproductive tract and typically causes placentitis and abortion in pregnant. *Brucella melitensis* and *B. abortus* are zoonotic pathogens that cause disease in humans ((Pappas *et al*., 2006, Radostits *et al*., 2007).Brucellosis causes considerable economic

losses such as a barrier to trade of animals and animal products, an impediment to free animal movement (Thrusfield, 2008). It also causes losses due to abortion of fetus or breeding failure (culling) in the affected animal population and diminished milk production. The disease is often prevalent in traditional pastoral communities both in animals and humans but, due to lack of awareness the disease is not diagnosed and treated (Addis, 2013).

Generally, poor hygiene, prevalence of the disease in animals that expose humans from infected animals or their products influence the occurrence of the disease in humans. Occupational groups at higher risk of infection include cattle producers, veterinarians, animal health personnel, abattoir workers, laboratory personnel and those amongst the general public who are a consumer of animal product (Adesokan *et al*., 2013).

The traditional life style, beliefs and poor knowledge of the disease create favorable conditions for the spread and transmission of Brucellosis. The risks associated with these practices are difficult to control because of a lack of alternatives and simple and affordable solutions. The control of brucellosis is likely to be cost effective. Good quantitative information on brucellosis in livestock and the human population is essential for demonstrating the benefits of intervention (Teshome *et al*., 2018).The prevention and control of brucellosis in small ruminants will contribute to reduce human brucellosis incidence, especially in the endemic regions of Ethiopia. Therefore, adequate knowledge of the epidemiology of Brucellosis is of great public health importance, particularly amongst livestock workers and animal product consumers, as this will greatly assist in mapping out strategies for its control. The objective of this study was to undertake systematic review and Meta-analysis to estimate the pooled seroprevalence of small ruminant brucellosis in Ethiopia.

2. METHODS

The systematic review and Meta-analysis were performed according to the Preferred Reporting Items for Systematic r eview and Meta-Analysis (PRISMA) flow chart guideline (Moher *et al*., 2010).The STROBE checklist was used to ensure the inclusion of relevant information from the selected articles in the analysis. The outcome of interest was the proportion for small ruminant brucellosis.

2.1 Literature Search Strategy and Eligibility Criteria

This systematic review and meta-analysis were aimed to determine the weighted seroprevalence of small ruminant brucellosis. Literature was searched in Pub Med, Science Direct, Scopus, African Journal Online and Google Scholar databases until July 18, 2022 to September 27, 2022. A Boolean operator and/or was used during an online article search by combining topic related key words.

The key search terms were: “Brucellosis” OR “Brucella” AND “Seroprevalence” OR “Prevalence” OR “Seroepidem iology” AND “Risk factors” OR “Potential factors” AND “Sheep AND Goat” OR “Ovine AND Caprine” OR “Small Ruminants” AND “Ethiopia”. We use “OR” and “AND” Boolean operators to identify studies with any of the keywords in their titles, abstracts and full texts. Moreover, unpublished thesis manuscripts were also accessed from University of Gondar library and College of Veterinary Medicine and Animal Sciences.

2.2 Inclusion and Exclusion Criteria

We used the following inclusion criteria to confirm the eligibility of the searched papers: 1) original peer reviewed research articles and thesis conducted in Ethiopia; 2) cross sectional studies that reported the seroprevalence of small ruminant brucellosis; 3) studies with full texts; 4) targeted study population included small ruminant within any of the management system (intensive or extensive); in this context intensively managed small ruminants were those cattle which are kept indoor for whole day or that only be out of the house for only few hour in a day for recreation whereas extensively managed small ruminants are cattle that are kept on the grazing pasture and get their feed by grazing with or without supplementation in the early morning and late afternoon; 5) studies were performed using serological
diagnostic tests RBPT for screening and CFT or ELISA for confirmation; 6) studies provided the total sample size and the outcome of interest (number of positive samples); 7) studies published only in English language; and 8) studies published online between 2011 up to 2022.

Papers which did not meet the above-mentioned criteria were excluded. Besides, the references of the selected papers will be check manually to find relevant papers that were not retrieved in the database search (Tewodros and Dawit, 2015).

2.3 Study selection and Data Extraction Procedure

Records identified from various electronic databases, indexing services and directories would be exported to Endnote software version X7. Duplicate records were identified, documented and removed. Two independent researchers were extract full text data and evaluate the eligibility of them for final inclusion. In each case, the rest authors play a critical role in solving discrepancies arose between two authors to come up to consensus. Similarly, data extraction format were prepared based on first author, publication year, study year, geographical location (region), study design, sampling method, sample size, diagnostic test, setting and number of

positive samples among the study groups. Seroprevalence of small ruminant brucellosis would calculate by dividing the number of positive cases by the total number of individuals used for the study in a given population at a given period. The study effect size and their corresponding confidence intervals would be calculated from the extracted data. Microsoft Excel datasheet was used to code and manage all extracted information from all relevant studies.

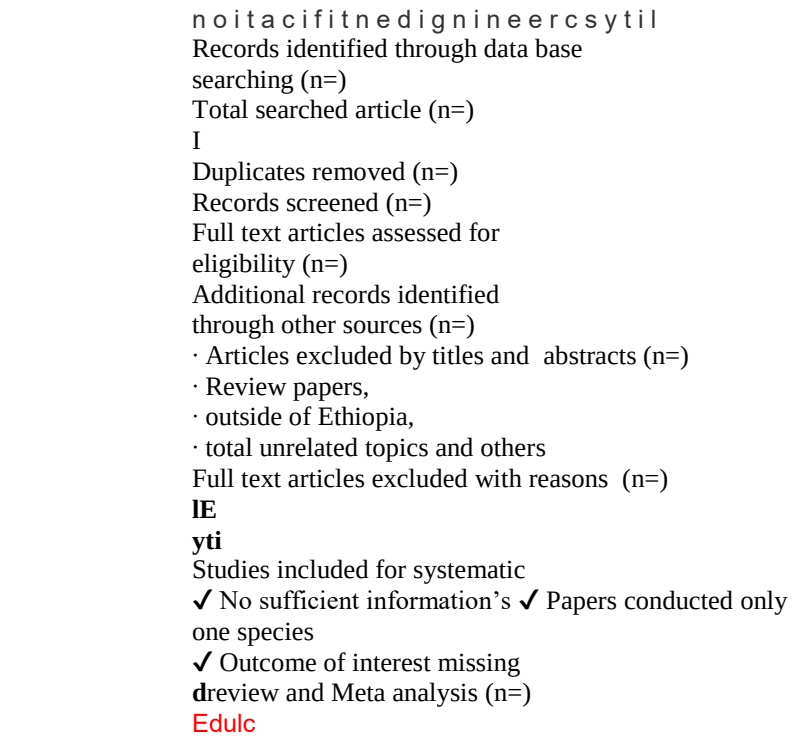

Figure 1: PRISMA guide line flow chart format describing the article selection procedure. (not shown).

2.4 Study Quality Assessment

Two independent researchers were evaluated the quality of the included papers using a quality assessment checklist (standard strengthening the Reporting of Observational Studies in Epidemiology checklist (STROBE). This quality assessment checklist includes 22 items constituting various sections of the articles such as title, abstract, introduction, methods, results, and discussion.

The checklist included items assessing objectives, different components of the methods (eg, study design, sample size, study population, bias, statistical methods), results, limitations, and funding of the studies. The assigned scores were determined from 0 to 44. Following the checklist (STROBE), searched papers were classified into 3 groups: low quality score (<15.50), moderate quality score (15.50- 29.50) and high quality score (30.0-44.0) (Erik von Elm *et al.*, 2007).

Table 1: STROBE Checklist for quality assessment of included studies STROBE Statement Checklist of items that should be included in reports of cross-sectional studies.

Item No	Recommendation
Title and abstract	1 (*a*) Indicate the study's design with a commonly used term in the title or the abstract
	(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction	
Background/rationale	2 Explain the scientific background and rationale for the investigation being reported Objectives 3 State specific objectives, including any pre specified hypotheses
Methods	
Study design	4 Present key elements of study design early in the paper
	6
Setting	5 Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 (*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7 Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8* For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Describe any efforts to address potential sources of bias
Study size	10 Explain how the study size was arrived at
Quantitative variables	11 Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 (*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions
	(*c*) Explain how missing data were addressed
	(*d*) If applicable, describe analytical methods taking account of sampling strategy
	(*e*) Describe any sensitivity analyses
Results	
Participants	13* (a) Report numbers of individuals at each stage of study eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed
	(b) Give reasons for non-participation at each stage
	7

(c) Consider use of a flow diagram
Descriptive data 14* (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
(b) Indicate number of participants with missing data for each variable of interest
Outcome data 15* Report numbers of outcome events or summary measures
Main results 16 (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for
and why they were included
(*b*) Report category boundaries when continuous variables were categorized
(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a
meaningful time period
Other analyses 17 Report other analyses done eg analyses of subgroups and interactions, and sensitivity analyses
Key results 18 Summarize key results with reference to study objectives
Limitations 19 Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation 20 Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability 21 Discuss the generalisability (external validity) of the study results

Other information
Funding 22 Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

2.5 Meta-Analysis
Data on the seroprevalence and corresponding 95% confidence intervals (CIs) of the disease were calculated for each study. The pooled prevalence estimates would be compute using the formula given by (Barendregt *et al*., 2013). Forest plot diagram was employed to present the heterogeneity among studies, outcomes of meta-analysis that display estimates of the seroprevalence, and their corresponding CIs of all included studies together with the pooled effect size. Similarly, subgroup analyses for the primary outcome (seroprevalence of brucellosis) would be done by study region, publication year, laboratory technique employed (CFT or ELISA) and sample size category.
Cochran's Q-statistics and inverse variance index (I^2) would be computed to determine the heterogeneity and inconsistency (true variation) among studies, respectively. Similarly, we considered the I^2values of 25%, 50% and 75% as low, medium and high heterogeneity respectively (Higgins and Thompson, 2002). The tau statistics (τ^2) was used to assess the variance of the effect size estimates across the population of the study.
Based on the heterogeneity assessment result, we used DerSimonian and Laird's random-effects method (if the p value of the Q test is 5%) or Mantel-Haenszel's fixed effects method to pool the estimations (Tufanaru *et al*., 2017). Small study effects and publication bias presence were then visualized using funnel plot diagrams and, Egger's and Begg's asymmetry tests (Borenstein *et al*., 2009). A funnel plot was computed using effect size and its corresponding standard error of the effect size. STATA software version 17 is used to do the meta-analysis.

3. RESULTS
3.1 Descriptive literature search results
A total of 187 potentially relevant studies were identified from several sources including PubMed, Science Direct, Scopus and Google scholar. From these, 27 duplicated articles were removed with the help of Endnote 7. The remaining 160 records were screened using their titles and abstracts and 137 of them were excluded. Full texts of 26 records were then evaluated for eligibility. From these, 7 articles were excluded due to the outcome of interest was found missing, insufficient and/or ambiguous.
A total of 19 articles were eligible for the final systematic review and Meta-analysis from all screened studies. All of the eligible studies have been used RPBT and ELISA or CFT for antibody detection. These selected eligible articles were conducted namely; Oromia, Tigray, Amhara, Somali and Oromia and Somali. From 19 published articles a total of 10,067 samples of small ruminant (both sheep and goats) were subjected to disease detection. The sample size ofshoat ranges from 226 to 985 in each study area of Ethiopia. The seroprevalence of the disease in the 16 articles was ranges from 1. 40% to 9.1%. The mean sample size from overall report wa s 528.94. Finally, a total of 19 articles fulfilled the eligibilit y criteria and quality assessment and thus included for syste matic review and meta-analysis.
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noitacifitnedIgnineercSytilibigilEdedulcnI
Records identified through data base searching (n= 171)
Total searched article (n=187) Duplicates removed (n=27)
Records screened (n=160)
Full text articles assessed for eligibility (n=26)
Studies included for systematic
review and Meta analysis (n=19)
Additional records identified

through other sources (n=16)
· Articles excluded by titles and abstracts (n=137)
· Review papers (n= 17)
· outside of Ethiopia(n=50)
· total unrelated topics and others (n= 67)
Full text articles excluded with reasons (n= 7)
✓ No sufficient information's(n= 2) ✓ Papers conducted only one species(n=4)
✓ Outcome of interest missing(n=1)
Figure 2: PRISMA guide line flow chart describing the article selection process.

3.2 Descriptive Study Characteristics

The final 19 eligible studies which were considered for determining the seroprevalence of brucellosis in small ruminants are summarized for systematic review and Meta analysis. The studies were published in the year between 2011 and 2022. All the selected studies were cross sectional study design in nature.
Table 2: Characteristics of selected studies describing the seroprevalence of small ruminant brucellosis in Ethiopia.
Author Publication Year
Study area
Laboratory Techniques
Total Sample
Diseased Prevalence Quality S core
Teshome et al. 2018 Oromia CFT 424 11 0.026 34 Efa et al. 2012 Oromia CFT 384 35 0.091 38 Wubishet et al. 2018 Oromia ELISA 283 23 0.081 37 Muhidin et al. 2021 Oromia CFT 470 14 0.030 32
Abiot et al. 2015 Oromia ELISA 840 39 0.046 36 Lemu et al. 2014 Oromia RBPT 384 6 0.016 28.5 Mulalem et al. 2017 Tigray CFT 558 10 0.018 29
Tsehay et al. 2014 Oromia and
Somali
CFT 420 15 0.036 30.5
Dabassa et al. 2013 Oromia CFT 384 9 0.023 31 Mustefa et al. 2019 Oromia CFT 762 11 0.014 27.5 Bekele et al. 2011 Somali CFT 730 11 0.015 28 Mohammed et al. 2017 Somali CFT 291 4 0.014 27.5 Tewodros and Dawit 2015 Amhara CFT 714 5 0.007 27 Ahad. 2021 Somali CFT 226 4 0.018 30 Teklue et al. 2013 Tigray CFT 985 15 0.015 29 Sintayehu et al. 2015 Somali CFT 285 6 0.021 30 Tsegaye et al. 2015 Oromia CFT 853 15 0.018 29.5
12
Yune et al 2022 Oromia CFT 384 6 0.016 31 Dosa et al 2022 Oromia CFT 690 23 0.033 35

3.3 Meta-analysis

Table 3: Summary of selected studies with its Author and Publication year.
3.3.1 Pooled prevalence estimate
Author with Publication year
Effect size
(95% conf. interval)
% Weight
Due to the expected variation between studies, random effects meta-analyses were employed using the total sample size and number of positives (effect size and standard error of the effect size). An overall pooled prevalence of the disease was estimated to be 3% (0.02 to 0.03 of 95% CI).

3.4 Summary of Meta-analysis

Teshome et al., 2018 0.026 0.011 - 0.041 5.17 Efa et al., 2012 0.091 0.062 – 0.120 3.27 Wubishet et al., 2018 0.081 0.049 - 0.113 2.94 Muhidin et al.,2021 0.030 0.014 - 0.045 5.13 Abiot et al., 2015 0.046 0.032 – 0.061 5.30 Lemu et al., 2018 0.016 0.003 - 0.028 5.57 Mulalem et al., 2012 0.018 0.007 - 0.029 5.77 Tsehay et al.,2014 0.036 0.018 - 0.053 4.77 Debassa et al., 2014 0.023 0.008 - 0.039 5.17 Mustefa et al., 2017 0.014 0.006 - 0.023 6.09 Bekele et al., 2015 0.015 0.006 - 0.024 6.05
Random-effects meta-analyses were employed using the prevalence and standard error of prevalence for effect size
Mohammed et al., 2011
Tewodros and Dawit, 2015
0.014 0.000- 0.027 5.43 0.007 0.001 - 0.013 6.34
and standard error of the effect size and using author and publication year for the study label of the Meta-analysis.
Ahad, 2021 0.018 0.001 - 0.035 4.85 Teklue et al., 2018 0.015 0.008 - 0.023 6.19 Sintayehu et al., 2021 0.021 0.004 - 0.038 4.93 Tsegay et al., 2013 0.018 0.009 - 0.026 6.05 Yune et al., 2022 0.016 0.003 – 0.028 5.57 Dosa et al., 2022 0.033 0.020 – 0.047 5.43 Theta 0.025 0.018- 0.032
13
14

3.5 Forest Plot

Due to the expected variation between studies, random effects meta-analyses were carried out using the prevalence and standard error of prevalence (effect size and standard error of the effect size). (τ^2 = 0.00; I^2 = 85.65%, DF = 18,
H^2 =6.96, Q - test = 82.72 and P - value 0.00). Individual study prevalence estimates ranged from 1.40% to 9.1% with the overall random pooled prevalence of 3% (95% CI: 0.02, 0.03). Studies weighted approximately equal with weights on individual studies ranging from 2.94% to 6.19% due to high heterogeneity between studies.
15
Figure 3: Forest Plot depicting the seroprevalence of small ruminant brucellosis in Ethiopia.
16

3.6 Subgroup Meta-Analysis

3.6.1 Subgroup Analysis by study Regions

Subgroup analyses were done for study Regions (Oromia, Somali Oromia and Somali, Amhara and Tigray regions of Ethiopia). Thus, high seroprevalence was observed in Oromia region 3% (95% CI: 0.02 - 0.05), whereas the same prevalence was observed in both Somali and Tigray region 2% (95% CI: 0.01– 0.02).

Figure 4: Subgroup analysis by study regions 3.6.2 Subgroup Analysis by publication year category

Subgroup analyses were done by articles publication year category. Thus, the same seroprevalence was observed the publication year category from 2011 – 2014 and 2015 –

2018 with the prevalence 3 %(95% CI: 0.00 - 0.06 and 0.01 - 0.04) and the publication year category from 2019 - 2022 with prevalence of 2% (95% CI: 0.01 - 0.03) respectively.

19

Note: - 1=2011 - 2014, 2=2015 - 2018, 3=2019 - 2022

20

Figure 5: Subgroup analysis by publication year category 3.6.3 Subgroup Analysis by Laboratory techniques

Subgroup analyses were done for laboratory techniques (RBPT, CFT and ELISA). Thus, high seroprevalence was observed in ELISA6% (95% CI: 0.03 - 0.09) followed by CFT and RBPT with both the same seroprevalence of 2% (95% CI: 0.00 - 0.02 and 0.00 – 0.03) respectively.

21

Note: - 1=RBPT, 2=ELISA, 3=CFT

22

Figure 6: Subgroup analysis by Laboratory techniques. 3.6.4 Subgroup analysis by sample size

Subgroup analyses were done for sample size which has been categorized into three parts like <300, 300 - 600 and >600. Thus, high seroprevalence was observed in both sample size category of <300 and 300 - 600 with the seroprevalence of 3% (95% CI: 0.00 - 0.06 and 0.01 - 0.05), whereas the least prevalence was observed in sample size category of >600 with 2% (95% CI: 0.01– 0.03) respectively.

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Note: - 1=<300, 2=300 - 600, 3=>600 Figure 7: Subgroup analysis by Sample size.

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3.7 Publication Bias

3.7.1 Funnel plot for visualizing publication bias

We assessed publication bias and small study effects by funnel plot observation and Egger's test for small study effects. The funnel plot that visually observed there were asymmetry in which the result of effect estimates against its standard error showed that there was some evidence of publication bias and small study effect on studies reporting the seroprevalence of brucellosis in small ruminant in

Ethiopia. Figure 8: Funnel plot that assesses publication bias.

1

3.7.2 Egger test detecting publication bias

Table 4: Egger test that assesses publication bias.

From Egger's test statistics result there was publication bias

Std.Eff Coefficient Std. err

p

value

95% conf. interval

and small study effect since the estimated bias coefficient 4.729 with standard error 0.666 and p - value 0.001.

3.8 Meta-Regression

Meta-regression analysis was done for each variable included in the study separately. The variables coded as categorical variables and those variables included were

Slope -0.0072 0. 004 0.072 -0.015 - 0.0006 **Bias** 4.729 0.666 0.000 3.423 - 6.035

Table 5: Summary of final multivariable Meta-regression analysis.

Variables Coefficient Std. errs. P- value 95% Conf. interval

study regions, publication year, study year, laboratory techniques and sample size were employed. Those variables with p-values <0.05 were used in the multivariable Meta regression analysis. Only laboratory techniques had significant value and retained in the final multivariable Meta regression analysis.

Laboratory techniques

Ref.

2 0.041 0.016 0.009 0.010 - 0 .072 3 0.006 0.012 0.635 -0.018 - 0.03

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4. DISCUSSION

Brucellosis induces considerable human suffering and huge economic losses in animals(B Lopes *et al*., 2010, Tesfaye *et al*., 2021) . It has a significant public health implication for a pastoral community in consequence of lifestyles, feeding habits, close contact with animals, low awareness, and poor hygienic conditions which favors infection(Asmare *et al*., 2013b). Also, it can generally cause significant loss of productivity through abortion, prolonged calving, kidding, or lambing interval, low herd fertility, and comparatively low milk production in farm animals.

The disease impairs socio-economic development for livestock owners, which represents a vulnerable sector in rural populations in general and pastoral communities in particular. Even though, most reports have made either limited geographic coverage or are relatively confined to a single agro ecology, these stated evidences strongly suggest that brucellosis might be a widespread problem in Ethiopia(Terefe *et al*., 2017).

But the seroprevalence of the disease is affected by different factors like, environmental factors, the number of samples, type of strains, stage of infection and type of diagnostic techniques used. The approaches of Meta analysis allow identifying the role of such factors, by combining results of different reports, with different designs, agro ecology and locations. Good meta-analysis outputs are relevant for the management and control of an infectious disease like Brucellosis that could not be identified by individual studies alone (Dohoo *et al*., 2009). This is the first quantitative meta-analysis on the sero prevalence of small ruminant brucellosis in Ethiopia to the best of our knowledge for evidence based decision.

We have used 19 cross sectional studies with 10067 serum samples that have been undertaken between years from 2011 to 2022 in Ethiopia were included in this study; the pooled seroprevalence of small ruminant brucellosis was 3.0%. This result is higher than the meta-analysis report of (Ran *et al*., 2018) from sheep and goat in China where the pooled prevalence was 2%. Similarly, the current finding was higher than the reports of (Tsegay *et al*., 2015, Mulalem *et al*., 2017) who reported prevalence of 1.80% from small ruminant selected in different area in Oromia region in Ethiopia. The current finding is in line with the report of (Dosa *et al*., 2022, Muhidin *et al*., 2021) from small ruminant brucellosis in Oromia region in Ethiopia where the pooled prevalence was 2.97 and 3.30% respectively.

Mean while, the current finding was lower than the reports in (Abiot *et al*., 2015, Efa *et al*., 2012, Wubishet *et al*., 2018) from small ruminant brucellosis in different districts of Oromia region in Ethiopia where the pooled seroprevalence was 4.64%.8.13% and 9.1% respectively. The difference in the seroprevalence of small ruminant brucellosis in the different studies could be due to differences in the geographical location and animal husbandary practice between the different study areas. Therefore, information on the actual seroprevalence of the small ruminant brucellosis in the country helps the policymakers to develop appropriate strategies regarding prevention and control protocols. In the present study, the subgroup analysis showed that there was a statistically significant association between the disease and study regions, publication year, laboratory technique employed and study years. Also, there was evidence of publication bias and small study effects (Egger's test, p = 0.001) on studies reporting the seroprevalence of small ruminant brucellosis in Ethiopia.

5. LIMITATIONS

The study has some limitations; an overall analysis of the study showed a large degree of heterogeneity among studies and within subgroup analysis. The studies used in this analysis were RBPT for screening diagnosis which has low precision for detection of antibody as compared to CFT and ELISA. The absence of unpublished data in the Meta

analysis also limits the reflection on the real epidemiology of the disease in the country. Some studies not include in the meta-analysis due to using key searching terms like the truncation and Boolean operators. Therefore, the study may not necessarily reflect the real situation of the country dise ase status.

6. CONCLUSION AND RECOMMENDATIONS

We conduct a systematic review and meta-analysis to assess the seroprevalence of brucellosis in small ruminant in Ethiopia. The seroprevalence of brucellosis in small ruminant is different in different parts of Ethiopia. There is a limited knowledge and studies about the systematic review and Meta-analysis in many regions of the country and the findings are heterogeneous. The result of this meta analysis shows that the pooled prevalence estimate of the disease in the country is 3.0%. Therefore, the pooled

Data Sharing Statement

All data generated during this study are included.

Author Contributions

Seroprevalence of small ruminant brucellosis is used for evidence-based disease control in Ethiopia.

Based on the above conclusions the following recommendations are forwarded;

· The overall data demands intervention measures, including vaccination and enhanced public awareness, and further surveillance for the control and prevention of brucellosis in livestock husbandry practices.

·Further studies that are aimed at evaluating the risk factors associated with the spread of brucellosis in domestic animals and sufficient epidemiological data are crucial to the exploration of the epidemiology of the disease throughout the country.

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All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval.

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Disclosure

The authors declare that they have no competing interest.

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