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Prevalence and Antimicrobial Resistance of *Klebsiella pneumoniae* among neonates with sepsis in Ethiopia: A Systematic Review and Meta-Analysis

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Abstract

Background: Neonatal sepsis remains a leading cause of morbidity and mortality in Ethiopia. *Klebsiella pneumoniae* is its leading cause. Evidence on its prevalence and resistance patterns among septic neonates in Ethiopia is limited. This systematic review and meta-analysis aimed to estimate the pooled prevalence and antimicrobial resistance profile of *K. pneumoniae* in neonates.

Methods: Following PRISMA 2020 guidelines, the study was registered in PROSPERO (CRD420251116707). PubMed, Hinari, African Journals Online, EMBASE, and Google Scholar were used. STATA version 17 software was used for statistical analysis. A random-effects model was used to estimate pooled effect sizes. Heterogeneity among the included studies was assessed

using Galbraith, Cochran's Q test, and I^2 statistic. Subgroup analysis, sensitivity analysis, and meta-regression were conducted to identify the source of heterogeneity. Publication bias was evaluated using a funnel plot and Egger's test.

Results: Twenty-three studies including 6,679 culture-confirmed neonatal sepsis cases were analyzed, the pooled prevalence of *K. pneumoniae w*as 24.93% (95% CI:19.82, 30.04) with high heterogeneity (I^2=96.25%). Prevalence was reported Amhara (20.80). Cohort studies reported higher prevalence than cross-sectional studies. Studies published after 2021 reported a pooled prevalence of *(*27.77%). Resistance was observed to commonly used antibiotics, including ampicillin, cefotaxime, ceftazidime, ceftriaxone, and gentamicin, which may indicate the presence of extended-spectrum β-lactamase (ESBL)-producing strains. In addition, resistance to meropenem was reported in some studies, raising concern about the possible emergence and spread of carbapenem-resistant *K. pneumoniae*. No strong evidence of publication bias, although Egger's test was borderline, and interpretation is limited due to high heterogeneity

Conclusion: *K. pneumoniae* is a major cause of neonatal sepsis in Ethiopia with high resistance to commonly used antibiotics, highlighting the need for strengthened surveillance, antimicrobial stewardship, and targeted treatment strategies. Future research should explore heterogeneity drivers, resistance mechanisms through molecular characterization, and the clinical impact of resistance on neonatal outcomes such as mortality and treatment failure.

Keywords: Bacteria, Drug Resistance, Gram-negative bacteria, Antibiotic susceptibility

1. Background

Neonatal sepsis is a clinical syndrome characterized by a systemic inflammatory response to suspected or confirmed infection, which may present with bacteremia, pneumonia, meningitis, or urinary tract infections (1) .It remains a major cause of neonatal mortality due to an increased

vulnerability to infection (2).Globally, neonatal sepsis remains one of the leading causes of morbidity and mortality in newborns, particularly in low- and middle-income countries (3).

In Ethiopia, neonatal sepsis is a significant public health problem. This is supported by a systematic review and meta-analysis yielding a pooled prevalence of 45% in neonatal sepsis (4). A recent Ethiopian based meta-analysis also revealed a bacteremia prevalence of 40.0% (5).

Bacterial pathogens represent primary pathogens of neonatal sepsis (6). *Klebsiella pneumoniae* stands out as a gram-negative pathogen playing a major role in hospital- and NICU-acquired infections and resistance to first-line antibiotics (7, 8). This rising antimicrobial resistance (AMR) is a major concern in Ethiopian neonatal units, where limited diagnostic capacity and widespread empirical antibiotic use may exacerbate treatment challenges (9, 10).

Studies in Ethiopia have reported a wide variation of prevalences of *K. pneumoniae* among neonates with sepsis, ranging from approximately 8% to 62% (11-13). This variation reflects differences in study populations, healthcare settings, diagnostic methods, and study designs. Therefore, pooled national-level evidence is needed to generate a more precise and generalizable estimate.

Despite available primary studies, national-level evidence on the pooled prevalence and antimicrobial resistance patterns of *K. pneumoniae* among neonates with sepsis in Ethiopia remains limited. Given the clinical significance, it is imperative to obtain a thorough understanding of its prevalence and AMR status in this population to enhance healthcare practices patient outcomes. Therefore, this systematic review and meta-analysis (SRMA) aimed to synthesize a comprehensive overview of *K. pneumoniae* prevalence and AMR status among neonates with sepsis in Ethiopia based on the existing literatures. The findings may support antimicrobial

stewardship programs, strengthen diagnostic capacity, and inform infection prevention and control strategies, particularly in neonatal intensive care units.

2. Methods

2.1. Protocol registration and searching strategy

The Preferred Reporting Items for Systematic review and Meta-analysis (PRISMA) 2020 guidelines was be used to develop the systematic review and meta-analysis to report the search process (14). The protocol was registered on the International Prospective Register of Systematic Reviews (PROSPERO) database with registration identification number of CRD420251116707. A thorough search of articles published until March 22 ,2026, was conducted using online databases such as PubMed, HINARI, African Journals online database, Cochrane, EMBASE and Google Scholar. The databases were searched by combining different MeSH terms and keywords, including: Condition (outcome of interests) (: studies reported the Prevalence and Antimicrobial Resistance of *Klebsiella pneumoniae* 1) population (septic neonates), 2) outcome (Prevalence and Antimicrobial Resistance of *Klebsiella pneumoniae*, 3) context (Ethiopia and different regions of Ethiopia) both in separation and in combination using Boolean Operator (OR, AND) as shown in the supplementary file 1 table 1. As an example, the following search strategy were entered in google scholar. Bacteria OR "*Klebsiella pneumoniae*" OR *"K. pneumoniae*" AND "neonatal Sepsis" AND Ethiopia.

To make sure that all pertinent studies carried out in the field are found, we also looked over the reference lists of the included studies. In addition, a manual search and a review of grey literature were conducted to find unindexed research publications in repositories.

2.2. Eligibility criteria

We used the CoCoPop approach (condition, context, and population), which is used for systematic reviews of prevalence studies, to define the criteria for including and excluding studies (15). Following a careful review of the articles' content, studies that satisfied the following requirements were included.

Population (Study participants): neonates with sepsis

Context: Ethiopia

Condition (outcome of interests) (: studies reported the Prevalence and Antimicrobial Resistance of *Klebsiella pneumoniae* Studies that included mixed populations but clearly provided sufficient information on the number of neonates with sepsis and clear report of number of *K. pneumoniae* isolates , Whereas**,** studies published in languages other than English, studies that did not use culture to confirm sepsis, reviews, editorial opinions, case reports, letters to the editor, hypotheses, and abstracts from conferences were excluded.

2.3. Study outcome(s)

The primary outcomes of this study were (1) the pooled prevalence of *Klebsiella pneumoniae* and (2) the antimicrobial resistance (AMR) patterns of *K. pneumoniae* isolates.

For prevalence estimation, the numerator was the number of *K. pneumoniae* isolates identified from clinical specimens, and the denominator was the total number of culture-confirmed neonatal sepsis cases in Ethiopia.

For antimicrobial resistance outcomes, the numerator was the number of *K. pneumoniae* isolates classified as resistant to a specific antibiotic based on antimicrobial susceptibility testing, and the denominator was the total number of *K. pneumoniae* isolates tested for that antibiotic.

2.4. Study selection and Data extraction

The studies were independently assessed by two authors (YE and MSA) in compliance with the inclusion and exclusion criteria. The relevant articles with the full text were further screened for quality appraisal. We contacted the authors of any articles that weren't open access; the articles whose authors didn't respond were excluded. Following the identification of all eligible articles, two independent reviewers (YE and MSA) extracted the pertinent information using an organized standard data extraction form by Microsoft Excel spreadsheet. The following data items were taken out of each article. Author name, study participants, Study area, Publication year, Study design, Sample size, number of patients with *K. pneumoniae* and its AMR status. Any disagreement between the reviewers was resolved by discussion.

2.5. Risk of biases

The methodological quality of the included papers were evaluated using the Joanna Briggs Institute's critical evaluation instrument (JBI) for studies (16). Studies with an average quality score higher than seventy five percent (75%) were considered to be high quality and added to the final analysis.

2.6. Data synthesis and analysis

Data were extracted using extraction format in excel and were exported in to STATA version 17 for final analysis. A narrative synthesis was used to present the data, and tables and figures were also used to present the findings. A random effect model was used to estimate the pooled effect prevalence accompanied by a corresponding 95% CI. we used the Freeman–Tukey double arcsine transformation to stabilize variances and account for studies reporting extreme proportions (i.e., 0% or 100%) to pool AMR proportions. A random-effects model was applied to estimate pooled

resistance, considering anticipated between-study variability. Pooled resistances were then transformed back to percentages with corresponding 95% confidence intervals. Although studies differed in design, setting, and antimicrobial susceptibility testing criteria, all reported resistance prevalence for specific pathogen–antibiotic combinations, permitting synthesis of a common outcome. Heterogeneity was assessed by graphical methods using Galbraith plot and forest plot as well as statistically using I^2 test statistics and Cochran's Q test. A pre-defined subgroup analysis was performed to identify the source of heterogeneity. Additionally, sensitivity analysis and meta-regression were also considered to investigate the source of heterogeneity. Publication bias was checked by observation using funnel plots and statistically by Egger's tests.

3. Results

3.1. Selection of studies

Initially, 1051 studies were identified from database searches and other sources. Of these, 243 were removed due to duplication. The remaining 808 articles were screened based on title and abstract, and 696 were excluded. Ultimately, 112 articles were thoroughly evaluated against the eligibility criteria, and 23 of them were found to be potentially eligible for inclusion in this systematic review and meta-analysis (Fig. 1).

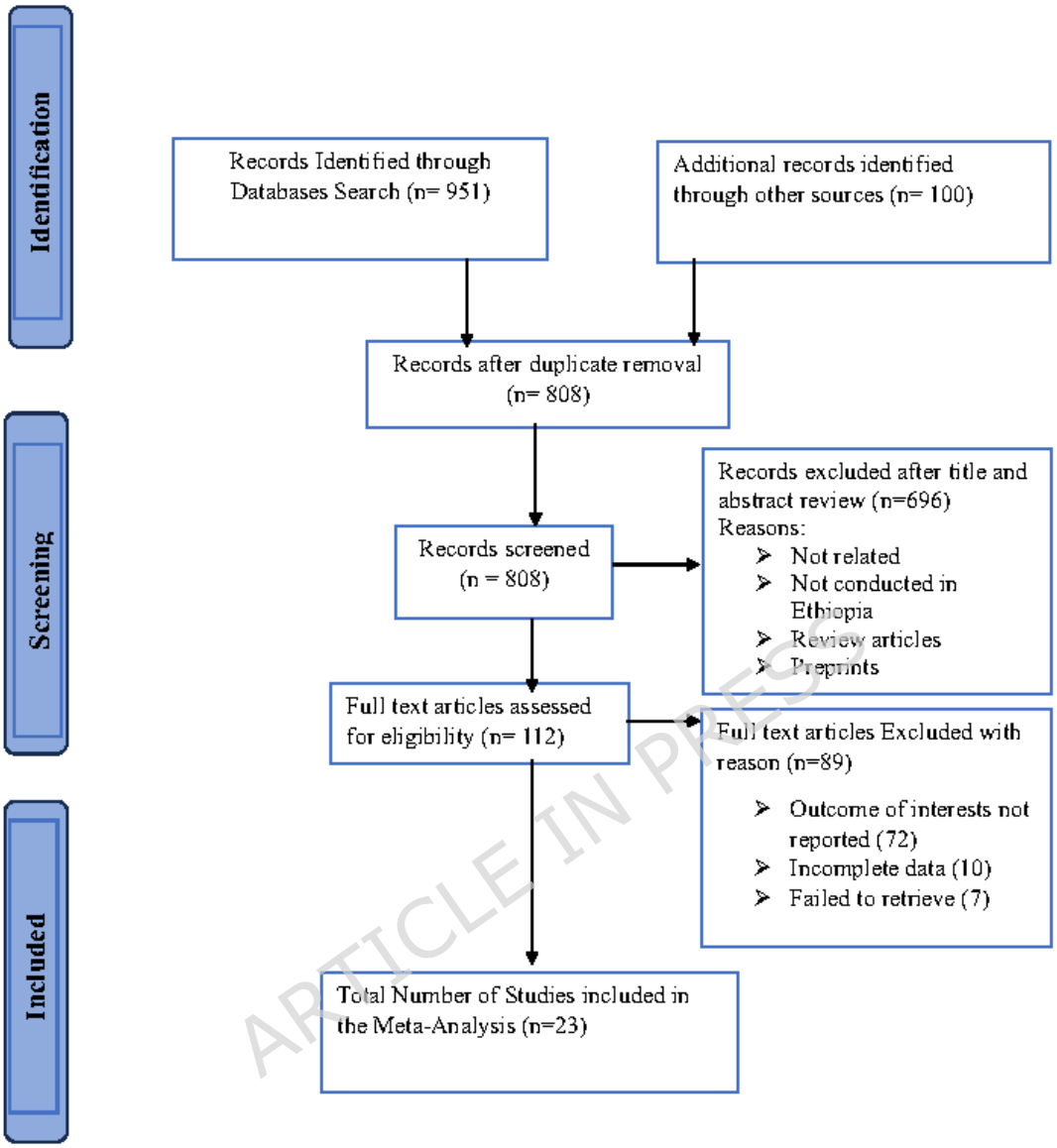

Figure 1 :PRISMA flow diagram illustrating the process of selecting eligible studies for the pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia.

3.2. Study characteristics

This study summarized and analyzed the results of 23 previous research articles from different parts of Ethiopia. All the included studies were scoring over 75% on quality assessments

(Supplementary file 2). The total number of cultures confirmed participants across all the studies was 7179, with 1640 of them reporting *K. pneumoniae* as etiological agent. The highest (62.67%), and the lowest (8.62%) prevalence of *K. pneumoniae* among neonates with sepsis were reported in studies conducted in Addis Ababa and Gondar, respectively. The included studies used a Cohort and cross-sectional designs, where data was collected from healthcare facilities (Table 1 and supplementary file 3).

Table 1: Characteristics of the studied included in the pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

S No	**Author**	**Publication Year**	**Place**	**Region**	**Study Design**	**Sampl**
1	Ali et al. (17)	2025	Hawassa	SNNP	cross-sectional	1324
2	Beshah et. al. (18)	2022	Addis Ababa	Addis Ababa	cross-sectional	107
3	Demissie et. al. (19)	2023	Harar	Harari	Cohort	102
4	Deress et. al. (20)	2025	Gondar	Amhara	cross-sectional	286
5	Deress et.al. (21)	2024	Gondar	Amhara	Cross-sectional	314
6	Dinagde et.al. (22)	2023	Adama	Oromia	Cross-sectional	147
7	Fenta et.al. (23)	2022	Dessie	Amhara	Cross-sectional	67
8	G/eyesus et.al. (24)	2017	Gondar	Amhara	Cross-sectional	117
9	Gadisa et. al. (25)	2024	Multiple	Multiple	cohort	530

10	Gashaw et.al. (26)	2014	Jimma	Oromia	Cross-sectional	313
11	Gebrehiwot et.al. (27)	2012	Gondar	Amhara	Cross-sectional	58
12	Geleta et.al. (28)	2024	Jimma	Oromia	Cohort	138
13	Jemal et.al. (12)	2021	Gondar	Amhara	Cross-sectional	536
14	Kifile et. al. (29)	2020	Debre Markos	Amhara	Cross-sectional	45
15	Solomon et. al. (11)	2021	Addis Ababa	Addis Ababa	Cohort	443
16	Tesema et. al. (30)	2017	Dire Dawa	Dire Dawa	Cross-sectional	127
17	Weldu et. al. (13)	2020	Mekelle	Tigray	Cross-sectional	116
18	Worku et. al. (31)	2022	Hawassa	SNNP	Cross-sectional	143
19	Worku et. al. (32)	2024	Gondar	Amhara	Cross-sectional	455
20	Worku et. al. (33)	2024	Gondar	Amhara	cross-sectional	735
21	Yusuf et. al. (34)	2011	Addis Ababa	Addis Ababa	Cross-sectional	166
22	Zakir et. al. (35)	2021	Arba Minch	SNNP	cross-sectional	240
23	Zenebe et. al. (36)	2021	Bahir Dar	Amhara	cross-sectional	170

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3.2. Prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

The prevalence of *K. pneumoniae* among neonates with sepsis ranged from 8.62% in Gondar, Amhara to 48.98% in Oromia. The random effect model analysis revealed that, the overall pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia was 24.93% (95% CI:19.82, 30.04). However, a high level of statistical heterogeneity was observed among the studies (I^2=96.25%: p<0.001), indicating significant differences in the estimates of *K. pneumoniae* prevalence (Fig. 2).

The graphical assessment of heterogeneity using Galbraith also revealed there is 1 study that is outside of the confidence bound regions, indicating that clear evidence for presence of heterogeneity across the studies report (Fig.3). In the absence of substantial heterogeneity, all the studies to should lie within the 95% CI region (shaded area).

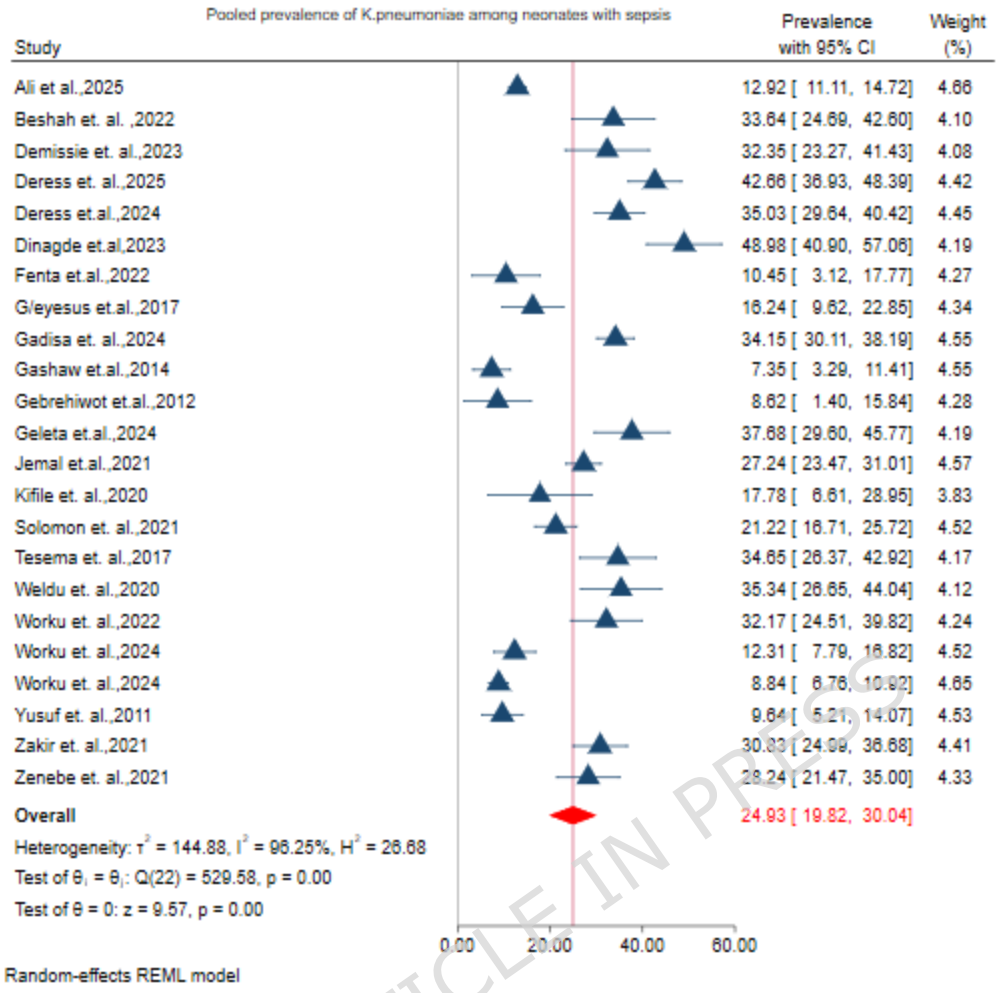

Figure 2: Forest plot showing the pooled Prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia using random-effect model analysis.

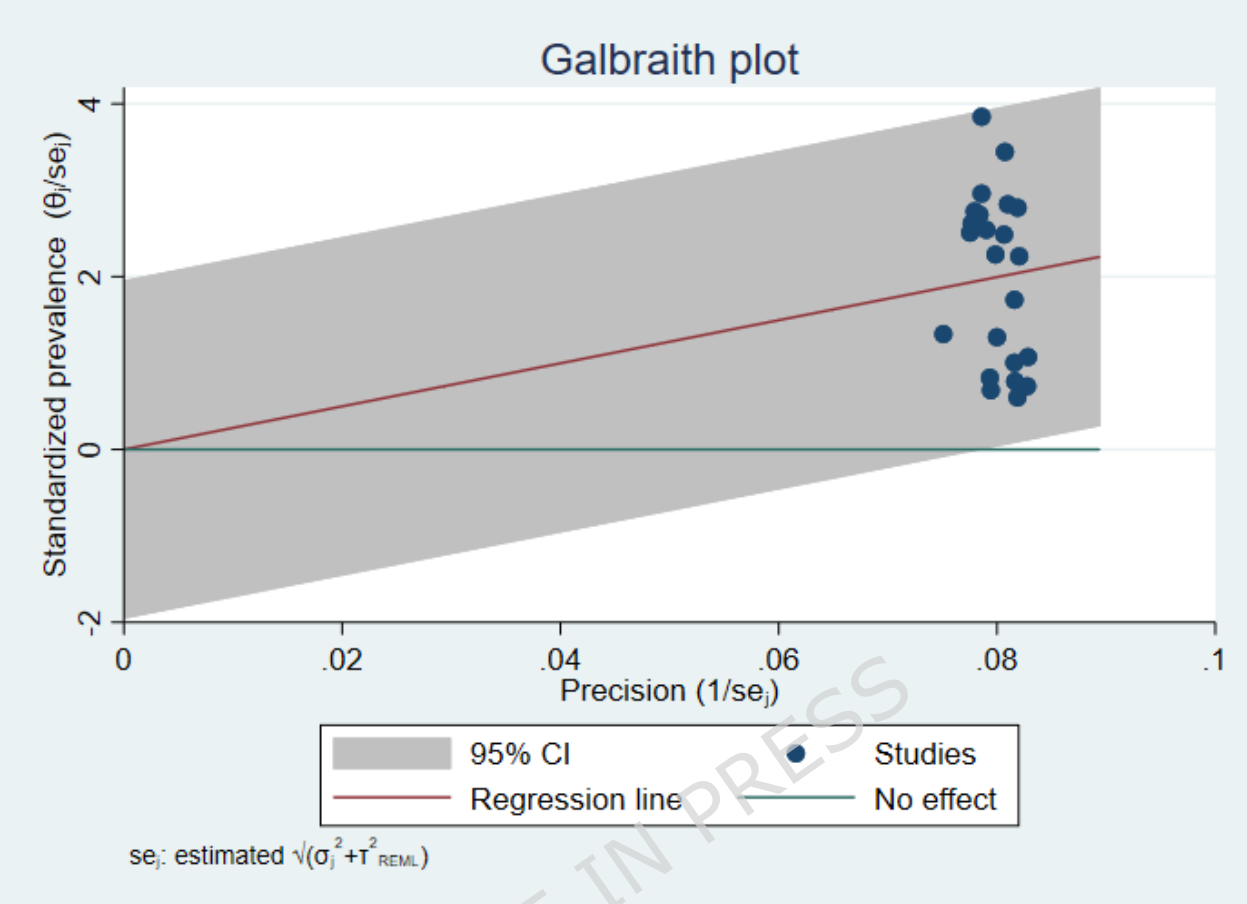

Figure 3: Galbraith plot for heterogeneity assessment of the included studies.

3.3.Antimicrobial Resistance of *K. pneumoniae* among neonates with sepsis in Ethiopia

A total of 17 antibiotics were included in the meta-analysis, with the number of studies per antibiotic ranging from 2 to 12. The pooled AMR estimates showed variability across antibiotics, with generally high levels of heterogeneity.

The pooled resistance status of *K. pneumoniae* showed a wide range of resistance levels across different antibiotics, ranging from 94.27% (95% CI: 88.66–99.88) to 23.46% (95% CI: 9.10–37.82). Notably, highest resistance was observed against ampicillin (94.27%, 95% CI: 88.66–99.88) and cefotaxime (86.83%, 95% CI: 77.66–96.00) notable carbapenem resistance meropenem

(26.62%, 95% CI: 5.46–47.79), whereas comparatively lower resistance levels were reported for nalidixic acid (23.46%, 95% CI: 9.10–37.82) in table 2 and supplementary file 1 fig 1-17.

Heterogeneity was observed across most antibiotics, with I^2 values ranging from 72.92% to 98.71%. The highest heterogeneity was noted for amoxicillin-clavulanate (I^2 = 98.71%), sulfamethoxazole (I^2 = 97.71%), meropenem (I^2 = 96.52%), and ceftazidime (I^2 = 96.15%), while the lowest heterogeneity observed for tetracycline (I^2 = 76.88%) and tobramycin (I^2 = 72.92%) as shown in table 3 below. These findings should be interpreted cautiously, particularly given the limited number of studies reporting on certain antibiotics. Furthermore, subgroup analysis, sensitivity analysis, and meta-regression were conducted (supplementary file 4,5,6) along with publication bias for 13 antimicrobial agents as shown in the Supplementary File 7.

Table 2: Summary of pooled resistance of K. *pneumoniae* isolates among neonates with sepsis in Ethiopia.

S No	Antibiotics	No of Studies	Pooled AMR (%)	95% CI	Heterogeneity	
					I2	P-value
1	Amikacin	6	28.65	[4.81,52.50]	98.06	<0.01
2	Amox-clav	10	78.61	[63.56,93.66]	98.71	<0.01
3	Amoxicillin	4	86.81	[72.10,101.53]	84.39	<0.01
4	Ampicillin	11	94.27	[88.66,99.88]	94.29	<0.01
5	Cefotaxime	5	86.83	[77.66,96.00]	84.08	<0.01
6	Ceftazidime	7	64.8	[43.51,86.10]	96.15	<0.01
7	Ceftriaxone	12	79.76	[70.83,88.68]	91.42	<0.01
8	Chloramphenicol	10	54.28	[42.10,66.46]	88.07	<0.01

9	Ciprofloxacin	12	30.29	[15.97,44.62]	95.15	<0.01
10	Gentamicin	12	73.9	[61.89,85.91]	93.49	<0.01
11	Meropenem	5	26.62	[5.46,47.79]	96.52	0.01
12	Sulf-meth	10	77.64	[63.67,91.61]	97.71	0.01
13	Tetracycline	7	66.82	[54.78,78.86]	76.88	<0.01
14	Erythromycin	2	46.27	[19.31,73.24]	92.49	<0.01
15	Nalidixic acid	2	23.46	[9.10,37.82]	0	0.5
16	Tazobactam	2	53.07	[45.45,60.69]	0	0.38
17	Tobramycin	2	69.7	[58.98,80.42]	72.92	0.05

Amox-clav-Amoxicillin-Clavulanate Sulf-meth- Sulfamethoxazole-trimethoprim

3.4. Subgroup analysis

The subgroup analysis was conducted based on region, year of publication, and study design. By region, the higher pooled prevalence of *K. pneumoniae* was observed in other regions (28.13%, 95% CI: 21.37,34.89). Amhara region had a prevalence of 20.80% (95% CI:13.31,28.29). High heterogeneity was observed in both categories as shown table 3 below.

When sub grouped by year of publication, studies published after 2021 reported the higher pooled prevalence of *K. pneumoniae (*27.77%,95% CI: 21.92,33.62) than those published before 2021 (18.16%,95% CI: 9.35,26.97). In addition, high heterogeneity persisted across both categories. (Table 4)

By study design, based on only four studies, a higher pooled prevalence was found in cohort studies (30.97%,95% CI: 23.59,38.35) compared to cross-sectional studies (23.63%,95% CI: 17.75,29.51). Both categories exhibited substantial heterogeneity as shown in table 4 below.

Table 3: Subgroup analysis of *K. pneumoniae* among neonates with sepsis in Ethiopia using Region, Publication Year and Study design

Subgroups	**Category**	**No of studies**	**Pooled prevalence of *K. pneumoniae***	**95% CI**	**Heterogeneity Statistics**	
					I^2	**p-value**
Region	Amhara	10	20.80	(13.31,28.29)	95.63	<0.001
	Other	13	28.13	(21.37,34.89)	95.75	<0.001
Publication Year	≤2020	7	18.16	(9.35,26.97)	92.39	<0.001
	> 2021	16	27.77	(21.92,33.62)	96.47	<0.001
Study Design	Cross-sectional	19	23.63	(17.75,29.51)	96.71	<0.001
	Cohort	4	30.97	(23.59,38.35)	84.09	<0.001

3.5. Sensitivity analysis

We also conducted a leave-one-out sensitivity analysis to evaluate whether the exclusion of any single study alter the statistical result of pooled resistance of *K. pneumoniae* among neonates with sepsis in Ethiopia. This analysis involved sequentially omitting each individual study and recalculating the overall pooled effect size. However, a few studies resulted in a noticeable shift in the pooled estimate when omitted, with estimates moving toward higher values. This indicates that these studies may have a relatively stronger influence on the overall effect size. The pooled estimated prevalence ranged from 17.29% (95% CI: 16.34,18.24) to 20.07% (95% CI:18.98,21.14) after deletion of a single study (Figure 4).

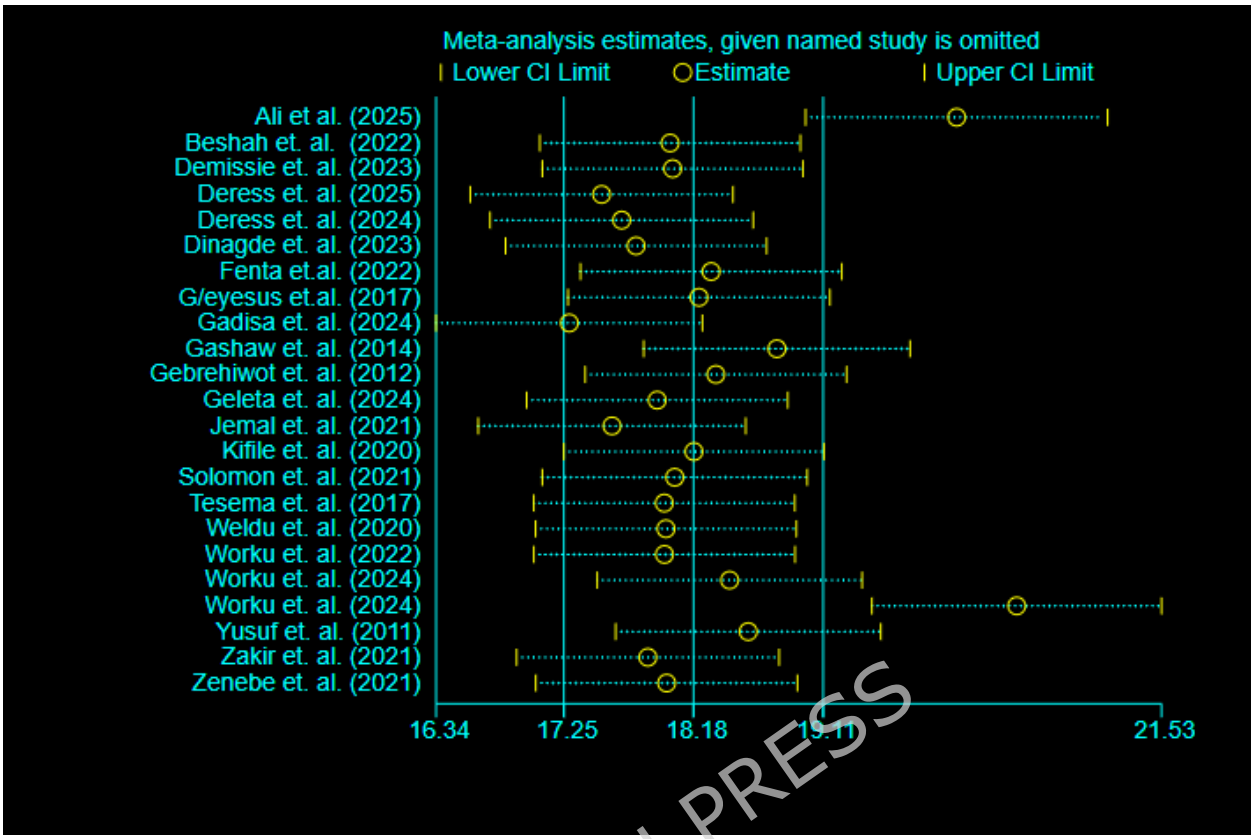

Figure 4: Result of the sensitivity analysis of studies included in the meta-analysis of pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

3.7.Meta-regression

We further conducted a meta-regression analysis to explore potential sources of heterogeneity among the studies included in the meta-analysis. It incorporated study characteristics, such as publication year, sample size, Region and study design as covariates in the meta-regression model. The meta-regression analysis revealed that Region, sample size and publication year were the variable statistically associated with the observed heterogeneity among the studies, as indicated by the statistically significant results in Table 4 below.

Table 4: Meta-regression analysis result of for the prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

Moderator	**Coefficient**	**SE**	**p-value**	**[95% CI]**	
Region					
Amhara	1				
Other	10.33	4.1009	0.021	1.71	18.94
Study Design					
Cohort	1				
Cross-sectional	3.81	5.5482	0.501	-7.84	15.49
Publication Year	2.38	0.5322	0.001	1.26	3.50
Sample Size	-0.03	0.0068	0.002	-0.04	-0.01

3.8.Publication bias

Publication bias was examined by observation using funnel plots and shows substantial symmetry, suggesting absence of small study effect (Fig.5). It was also statistically checked by Egger's tests and the result indicated that there was no evidence of publication bias, with a p-value of 0.08. This suggests that the included studies in the systematic review and meta-analysis were not significantly influenced by the selective publication of studies based on the direction or magnitude of their findings (Table 5).

Table 5: Egger's test statistics of the prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

Beta1	**SE**	**t**	**P-value**

4.42	2.028	2.18	0.09

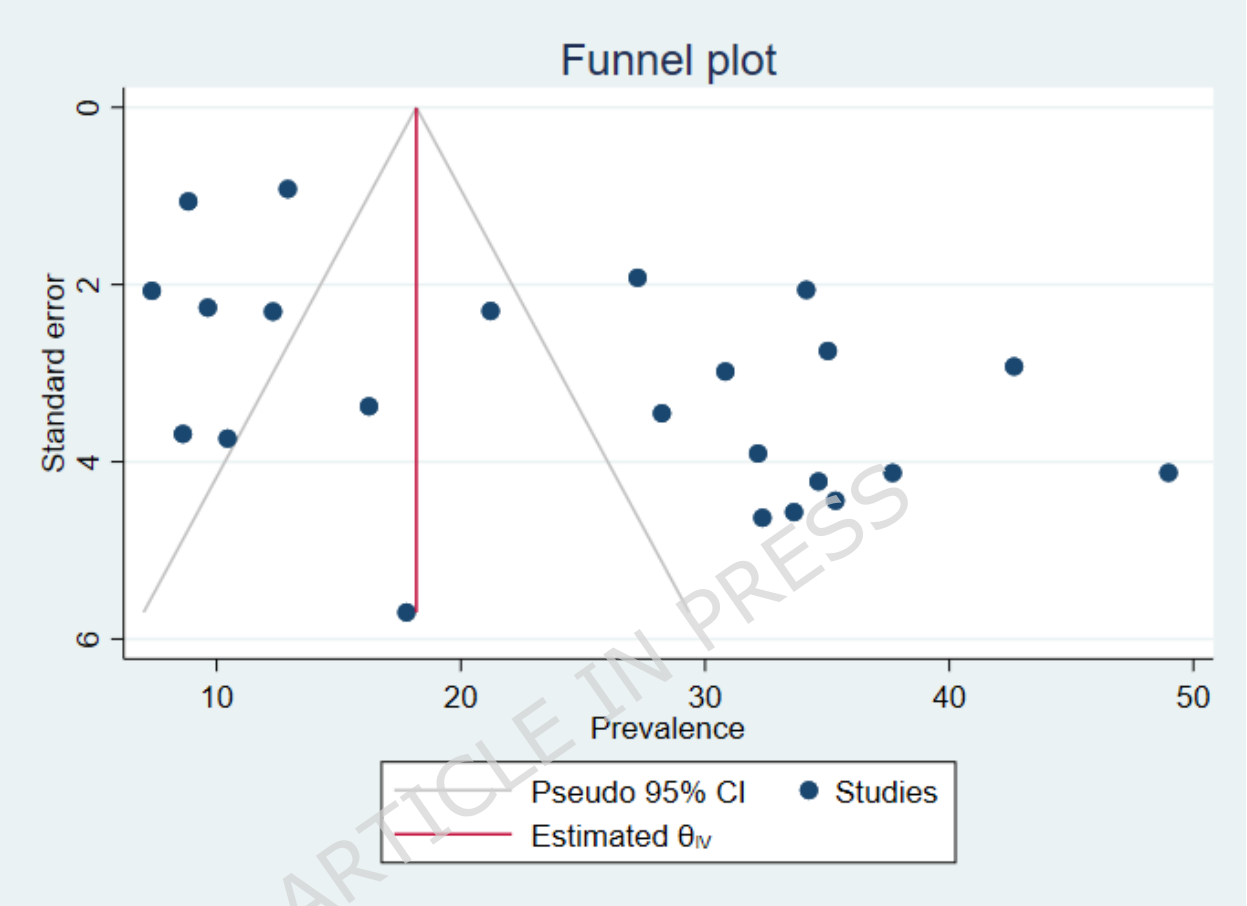

Figure 5: Funnel plot on the prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia

4. Discussion

Unlike previous systematic reviews that evaluated the overall bacterial causes of neonatal sepsis or antimicrobial resistance patterns, our review specifically focuses on *Klebsiella pneumoniae* among culture-confirmed neonatal sepsis cases in Ethiopia. By providing pooled estimates of both prevalence and antimicrobial resistance, this review offers updated evidence that may help inform empirical treatment strategies and antimicrobial stewardship efforts. 23 articles that fulfilled the

eligibility criteria were included and enrolled for the final analysis. Accordingly, the overall pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia was found to be was 24.93% (95% CI:19.82, 30.04), with significant heterogeneity. Although most included studies were of moderate to high methodological quality, variations in study design, sampling methods, and reporting may have contributed to the observed heterogeneity; therefore, the pooled estimates should be interpreted with caution. This finding is higher than a study done in Ethiopia (5) and sub-Saharan Africa (37) which may be attributed to differences in study period, sample size and detection capability. The inclusion of larger sample size and more recent studies in this study make it more advantageous. However, the finding was in line with reports from Iran (38) and other countries (39-41).

According to the subgroup analysis, Amhara region reported a lower pooled prevalence of *K. pneumoniae* 20.80% compared to studies from other regions 28.13%. This may be due to the differences in healthcare service quality, availability of neonatal intensive care resources, and diagnostic capacity.

According to publication year, with the studies conducted from 2021 showed a higher prevalence 27.77% compared to studies published before 2020 with a prevalence of 18.16%. This variation may be influenced by differences in study periods, settings, and diagnostic practices. These potential explanations have been suggested in previous literature (42, 43), but were not directly examined in this analysis.

Cohort studies reported a higher prevalence of *K. pneumoniae* 30.97% compared with cross-sectional studies 23.63%. This difference may be related to the prospective nature of cohort designs, which allows better identification of hospital-acquired and nosocomial infections during

follow-up (44, 45). these indicate the importance of improving surveillance, antimicrobial stewardship, and infection prevention and control practices in neonatal care settings in Ethiopia.

This review also revealed a high level of AMR among *K. pneumoniae* isolates causing neonatal sepsis in Ethiopia.

The pooled AMR pattern of *K. pneumoniae* among neonates with sepsis showed high resistance, particularly to commonly used first-line antibiotics. Ie. ampicillin 94.27%, amoxicillin 86.81%, cefotaxime 86.83%, ceftriaxone 79.76%, and amoxicillin-clavulanate 78.61%. These findings are consistent with reports from other low- and middle-income countries (46) . this likely reflects widespread empirical use, limited antimicrobial stewardship, and the emergence of ESBL-producing organisms.

Our study also found a pooled resistance for gentamicin 73.90%, tetracycline 66.82%, ceftazidime 64.80%, chloramphenicol 54.28%, erythromycin 46.27%, and tazobactam 53.07%. These findings indicate a concerning public health issue.

Although relatively lower resistance was observed for antibiotics such as amikacin, ciprofloxacin, and meropenem, these findings have a significant clinical concern. Meropenem is considered a last-resort (carbapenem) antibiotic, and the presence of emerging resistance. This may indicate the emergence of carbapenem-resistant *K. pneumoniae*.

Antimicrobial resistance is often driven by a combination of microbial and healthcare-related factors. ESBL-producing *Klebsiella pneumoniae* and other Gram-negative organisms are frequently implicated in neonatal sepsis and are known for their ability to acquire and disseminate resistance. Transmission within NICUs may occur through cross-contamination via healthcare workers, medical equipment, or environmental reservoirs, facilitating outbreaks of multidrug-

resistant organisms. In addition, frequent empirical use of broad-spectrum antibiotics in critically ill neonates may exert selective pressure, promoting the emergence and persistence of resistant strains (47, 48). These mechanisms likely contribute to the high burden of antimicrobial resistance observed in neonatal populations.

Overall, the subgroup analysis showed variation in AMR estimates across region and publication year, along with the sensitivity analysis. However, these findings should be interpreted with caution due to high heterogeneity and the small number of studies.

Implications for public health and clinical practice

The high prevalence and antimicrobial resistance of *K. pneumonice* among neonates with sepsis in Ethiopia poses a major challenge to effective treatment, particularly given the markedly high resistance rates to commonly used antibiotics. Resistance to commonly used first-line antibiotics limits treatment options and may necessitate the use of broader-spectrum or reserve antibiotics, which are often costly and less readily available in resource-limited settings. This increases the risk of treatment failure, prolonged hospitalization, and adverse neonatal outcomes. This underscores the need to integrate routine antimicrobial susceptibility testing (AST) into neonatal sepsis management. Strengthening infection prevention and control (IPC) measures in neonatal care units. Furthermore, the observed regional variations in resistance patterns highlight the importance of implementing locally tailored antibiotic stewardship programs, rather than relying solely on uniform national treatment guidelines.

Limitations and Future Research

Despite its strengths, this study has several limitations. The consistency and generalizability of the pooled estimates are questioned by the heterogeneity seen among the included studies, even though

it can be partially attributed to regional and methodological variations. Furthermore, the results might have been affected by the use of observational studies, which are biased. The results may overestimate the burden of resistance and may not accurately reflect its magnitude in community settings because all of the studies were conducted in hospitals. Only English-language studies were included, which may introduce language bias. We failed to retrieve some potentially available studies. This exclusion may have introduced availability bias. In addition, relevant grey literature, such as Ministry of Health reports, was not included due to incomplete reporting. the quality assessment threshold of 75% on the JBI checklist was based on commonly used practice and may be considered arbitrary. Inconsistencies in AMR reporting across studies contributed to challenges in pooling estimates, and no subgroup analysis for AMR was feasible in some cases. Moreover, certain antibiotic-specific resistance estimates were based on a limited number of studies and should therefore be interpreted with caution. this study does not provide sufficient evidence to recommend specific alternative empirical regimens. However, the findings underscore the need for continuous local AMR surveillance to inform treatment decisions. Future studies should explore sources of heterogeneity, including variations in laboratory diagnostic techniques, infection control practices, antibiotic prescribing patterns, and neonatal demographics. In addition, molecular characterization of resistance mechanisms is needed to understand the genetic drivers of antimicrobial resistance in *K. pneumoniae*, and studies linking resistance patterns to clinical outcomes such as neonatal mortality, length of hospital stay, and treatment failure are essential to clarify its clinical impact.

5. Conclusion

This SRMA analyzed the pooled prevalence of *K. pneumoniae* among neonates with sepsis in Ethiopia, in addition to high levels of AMR. Several widely used antibiotics were found to be

resistant, suggesting that the number of effective treatment options is decreasing. Notably, resistance to last-line medications like meropenem was also found, indicating a significant risk to the ability to manage neonatal sepsis in the future. These results highlight the critical need for timely revision of local treatment guidelines, routine surveillance of antibiotic resistance and proper antimicrobial stewardship. Furthermore, Future research should focus on addressing the limitations of the current study and exploring additional factors contributing to AMR.

Abbreviations

- AMR: Antimicrobial Resistance
- CI: Confidence Interval
- MSA: Mikiyas Shemelis Achame
- YE: Yonas Erkihun

Declaration

Ethics approval

This systematic review and meta-analysis was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. It was done based on available papers on different databases and it was registered on Prospero with registration identification number of CRD420251116707.

Consent for publication

Not Applicable

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Competing Interests

The authors declared that there was no conflict of interest in this work.

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Authors' contributions

All authors made a substantial contribution to the study on design, methodology, and data analysis. MSA wrote-up the draft manuscript. YE was involved in data extraction and All authors read, revised the draft critically for important intellectual content, and gave the final approval of the manuscript.

Clinical trial number not applicable

Consent to Participate

Informed consent was not required because this study was a systematic review and meta-analysis that utilized data extracted from previously published studies.

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