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REVIEW

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Dominance of antimicrobial resistance bacteria and risk factors of bacteriuria infection among pregnant women in East Africa: implications for public health

Molla Getie Mehari[1†], Almaw Genet Yeshiwas[2], Dereje Esubalew[3], Yehzibalem Azmeraw[4], Amare Mebrat Delie[5], Liknaw Workie Limenh[6], Nigus Kassie Worku[7], Mickiale Hailu[8], Mihret Melese[9], Alemwork Abie[10], Tenagnework Eseyneh Dagnaw[5], Eneyew Talie Fenta[5], Abraham Teym[11], Rahel Mulatie Anteneh[12] and Chalachew Yenew[13*†]

Abstract

Background Bacterial infections in pregnancy pose significant health risks in East Africa. This study estimates pooled prevalence and identifies key risk factors, addressing limited data to improve maternal health outcomes in the region.

Methods This study employed a systematic review and meta-analysis, analyzing data from eight East African studies (2016–2021). Searches spanned PubMed, Embase, Scopus, and more, with manual reference checks. Data quality was assessed via the Newcastle-Ottawa Scale. RevMan software with a random-effects model estimated pooled prevalence and hazard ratios for risk factors.

Results A pooled analysis of antimicrobial resistance (AMR) bacterial isolates from pregnant women in East Africa highlights concerning prevalence rates of various pathogens. *Escherichia coli* emerged as the most common pathogen, present in 43% (95% CI: 37–48%) of cases, followed by *Staphylococcus aureus* at 20% (95% CI: 0.12, 0.29) and *Corynebacterium*, *Enterococcus*, and *Nocardia* species (*CONs*) in 16% (95% CI: 10–23%) and 16% (95% CI: 12–21%) (Prevalence of *K. pneumoniae)*. A very small proportion 6% (95% CI: 2 – 11%) was found to be infected with *Pseudomonas aeruginosa*. The forest plot highlights risk factors for infections in pregnant women in East Africa: antibiotic use (HR: 2.0, 95% CI: 1.5–2.6), smoking (HR: 1.3, 95% CI: 1.0–1.6), poor sanitation (HR: 1.8, 95% CI: 1.2–2.4), diabetes (HR: 2.1, 95% CI: 1.5–2.8), and age > 30 years (HR: 1.5, 95% CI: 1.1–2.0).

Conclusions This analysis reveals a significant prevalence of bacterial infections, particularly *Escherichia coli*, among pregnant women in East Africa, with antimicrobial resistance (AMR) complicating treatment. The study identified several key risk factors, including antibiotic use, smoking, poor sanitation, diabetes, and age over 30, which are associated with higher rates of infection. While these findings emphasize the need for further research, the results suggest that routine bacterial screening, AMR surveillance, improved sanitation, and antibiotic stewardship are

[†]Molla Getie Mehari and Chalachew Yenew has equal contribution.

*Correspondence:
Chalachew Yenew
chalachewyenew50@gmail.com

Full list of author information is available at the end of the article

important steps in mitigating the impact of these infections. Public health strategies should prioritize high-risk groups, encourage hygiene practices, and continue to guide policy and interventions through ongoing studies.

Keywords Antimicrobial Resistance (AMR), Bacterial infections, Pregnant women, *Escherichia coli*, Public Health interventions

Introduction

Infections caused by bacterial pathogens are a significant concern in pregnant women, especially in low-resource settings like East Africa. Pregnant women are particularly vulnerable to infections due to physiological changes during pregnancy, which can lead to severe maternal and fetal outcomes [1]. Bacterial pathogens such as *Escherichia coli (E. coli)*, *Staphylococcus aureus* (*S. aureus)*, *Coagulase-negative staphylococci* (CoNS), *Klebsiella spp.*, and *Pseudomonas aeruginosa* are commonly implicated in urinary tract infections (UTIs) and other complications in pregnant women. The prevalence of these infections varies across regions, and the associated risk factors are not well understood in many East African countries. While some studies have examined bacterial infections in pregnancy, there remains a lack of comprehensive data on the pooled prevalence of these pathogens in the East African context [2].

The relationship between bacterial infections and adverse pregnancy outcomes such as preterm labor, low birth weight, and maternal sepsis has been well-documented in global literature. Pathogens like *E. coli* and *S. aureus* are commonly identified as major causes of infections in pregnant women, and factors such as poor sanitation, inadequate antenatal care, and the overuse of antibiotics have been recognized as contributing risk factors [3].

Antimicrobial resistance (AMR) is a growing concern in East Africa, with rising resistance to common antibiotics, particularly in hospital settings. However, antimicrobial stewardship (AMS) practices are often poorly implemented due to challenges such as inadequate infrastructure, insufficient funding, and a lack of trained personnel. Some countries have AMS guidelines, but they are not consistently enforced, and the overuse and misuse of antibiotics persist, especially in rural areas. This study will examine the prevalence of bacterial infections among pregnant women and explore how AMS practices impact infection control, with the goal of identifying gaps and recommending strategies to improve antimicrobial use in healthcare and community settings across the region [4].

By synthesizing data from various countries—of east Africa including Ethiopia, Kenya, Tanzania, and Uganda—this study aims to provide a more accurate and comprehensive estimate of the prevalence of bacterial pathogens in the region. Additionally, it will explore the associated risk factors, which are often inadequately addressed in individual studies. Understanding the prevalence of these pathogens and the risk factors that contribute to infections in pregnant women is crucial for public health initiatives [5]. Despite the increasing recognition of the problem, there are still significant gaps in the available data, particularly with regard to the region-specific risk factors, diagnostic challenges, and the influence of antimicrobial resistance.

The findings of this study have significant policy implications [6]. First, understanding the prevalence and risk factors of bacterial infections can guide the development of targeted interventions in East Africa. Health policies could focus on improving maternal health care, enhancing sanitation facilities, and promoting awareness about the importance of early screening and treatment for bacterial infections. Policymakers could also consider implementing antimicrobial stewardship programs to mitigate the growing threat of antimicrobial resistance, which is increasingly recognized as a challenge in managing infections in pregnant women. The data from this pooled analysis could serve as a basis for advocacy to improve maternal health infrastructure, access to diagnostics, and quality of antenatal care in East Africa [7].

The primary aim of this study is to estimate the pooled prevalence of key bacterial pathogens—*E. coli*, *S. aureus*, *Coagulase-negative staphylococci* (CoNS), *Klebsiella spp.*, and *Pseudomonas aeruginosa*—in pregnant women from East Africa. Additionally, the study aims to identify and assess the risk factors associated with these infections. By addressing these aims, the study hopes to provide a more robust understanding of the scope of bacterial infections during pregnancy in the region. Furthermore, it seeks to inform evidence-based policy recommendations that can help improve maternal health outcomes and reduce the burden of bacterial infections in East Africa [8].

The importance of this study lies in its potential to contribute to the reduction of maternal morbidity and mortality related to bacterial infections in East Africa. With high rates of preventable infections in pregnant women, a better understanding of the prevalence and risk factors can lead to more effective health interventions [9]. In addition, the study's findings could serve as a baseline for future research in the region, facilitating the development of targeted interventions and better healthcare management practices. This study will also fill the gaps in knowledge by providing a pooled prevalence estimate, which will be invaluable for health authorities in the region to allocate resources effectively. While this study aims to provide critical insights into bacterial infections

among pregnant women in East Africa, it also lays the foundation for further research in this field. Future studies could explore more granular data on specific bacterial strains, their resistance patterns, and their clinical outcomes. Additionally, research on the effectiveness of interventions designed to mitigate these infections could be explored. In conclusion, this study provides a much-needed comprehensive overview of bacterial infections in pregnant women in East Africa, offering vital information that can influence public health policies and practices in the region [10].

Methods

Study design and setting

This study utilized a pooled analysis of eight peer-reviewed studies conducted from 2016 to 2021 across Ethiopia, Kenya, Tanzania, and Uganda. The included studies employed cross-sectional, cohort, or case-control designs to investigate bacterial isolates and associated risk factors for infections among pregnant women.

Review question

The review question seeks to determine the pooled prevalence and distribution of bacterial pathogens, including *E. coli*, *S. aureus*, *Coagulase-negative staphylococci (CoNS)*, Klebsiella *spp*., and *Pseudomonas aeruginosa*, isolated from pregnant women in East Africa. Additionally, it aims to identify the key risk factors associated with these infections. Using the PICO framework, the population of interest is pregnant women in East Africa, while the intervention involves assessing the prevalence of these bacterial pathogens and their associated risk factors. The comparison focuses on differences in risk factors between infected and non-infected pregnant women, with the outcome being the prevalence, distribution, and identification of significant risk factors. This question is designed to be clear, focused, and actionable, addressing a critical public health concern in the region.

Databases searched

Comprehensive searches were performed across multiple electronic databases to identify relevant studies, including PubMed/MEDLINE, Embase, Scopus, Web of Science, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and Google Scholar for grey literature and supplementary sources. To ensure a thorough search, manual searches of reference lists from identified studies and related review articles were also conducted. The PRISMA guidelines for reporting protocols and the PRISMA checklist were employed to guide the search and screening process. The inclusion criteria were limited to studies published in English between January 2016 and December 2021, focusing on capturing the most recent and relevant literature. This comprehensive approach ensures the robustness and completeness of the evidence base.

Search strategy

A combination of medical subject headings (MeSH) and keywords was employed to ensure a comprehensive search. Key terms included "Bacterial pathogens," "Pregnant women," "East Africa," as well as specific bacterial pathogens such as "*E. coli*," "*S. aureus*," "*Coagulase-negative staphylococci*," "*Klebsiella*," and "*Pseudomonas*." Additional terms like "Prevalence" and "Risk factors" were also included. Boolean operators (AND, OR) were used to refine the search, and filters were applied to restrict the results to studies published in English. This strategy aimed to capture all relevant literature within the specified time frame.

Inclusion and exclusion criteria

The inclusion criteria for this study were as follows: studies that examined bacterial isolates from pregnant women using microbiological culture methods, reported the prevalence of bacterial pathogens such as *E. coli*, *S. aureus*, Coagulase-negative staphylococci (CoNS), *Klebsiella spp.*, or *Pseudomonas aeruginosa*, and were conducted in East Africa, published in English between 2016 and 2021. Only English-language studies were considered for inclusion. Studies were excluded if they lacked detailed microbiological data, did not differentiate between symptomatic and asymptomatic bacteriuria, or focused exclusively on non-bacterial pathogens or animal studies.

Data collection and extraction

Data were extracted from full-text articles using a standardized form. Key variables included the study location and design, year of publication and study period, sample size, prevalence of bacterial pathogens, and reported risk factors. These variables were systematically recorded to facilitate comparison and analysis across the included studies.

Statistical analysis

Data analysis was conducted using RevMan software. A random-effects meta-analysis was performed to calculate pooled prevalence estimates with 95% confidence intervals (CIs) for each bacterial isolate, including E. coli, S. aureus, *Coagulase-negative staphylococci (CoNS)*, *Klebsiella spp*., and *Pseudomonas aeruginosa*. This approach was chosen to account for variability between studies and provide a more accurate overall estimate of the bacterial prevalence. The degree of heterogeneity among the studies was assessed using the I^2 statistic, with values less than 25% indicating low heterogeneity, suggesting a relatively high level of consistency in the findings.

In addition, associations between identified risk factors—such as poor sanitation, antibiotic use, and smoking—and bacterial infections were analyzed using hazard ratios (HRs) with 95% CIs. These estimates were pooled using a fixed-effects model, assuming that the studies shared a common effect size.

Quality assessment

Study quality was evaluated using the Newcastle-Ottawa Scale (NOS), focusing on selection, comparability, and outcome domains. Studies scoring ≥ 6 were considered high quality.

Results and discussion

Key study characteristics

The systematic review and meta-analysis included observational studies from Ethiopia, Sudan, Tanzania, and Uganda, with sample sizes ranging from 169 to 587 participants. Prevalence rates varied widely, from 3.75% in Uganda to 28% in Tanzania. The studies reported different numbers of isolates and methodological quality scores based on the JBI checklist, ranging from 5 to 8 (Table 1).

Prevalence and types of bacterial isolates in urinary tract infections among pregnant women in East Africa

A pooled analysis of 2,611 urine samples from eight studies conducted in four East African countries identified five major bacterial isolates, with *E. coli* being the most prevalent at 43% (95% CI: 37–48%). This was followed by S. aureus at 20% (95% CI: 12–29%), *coagulase-negative staphylococci* at 16% (95% CI: 10–23%), *Klebsiella* species at 16% (95% CI: 12–21%), and *Pseudomonas aeruginosa* at 0.1% (95% CI: 2–11%). These isolates were identified in both asymptomatic and symptomatic bacteriuria cases, with *E. coli* being the dominant pathogen. The findings reveal a significant public health challenge, as *E. coli* is a leading cause of urinary tract infections (UTIs) that can result in severe maternal complications, including preterm labor, low birth weight, and neonatal sepsis. Despite a low heterogeneity (I^2 = 21.88%, p = 0.26) (Figs. 1, 2, 3, 4 and 5), the variability in prevalence rates (27–54%) reflects disparities in geographic settings, healthcare access, and diagnostic practices. Additionally, the high prevalence of antimicrobial resistance (AMR), particularly among *E. coli* strains, exacerbates treatment challenges, prolongs illnesses, and increases healthcare costs. To address these issues, routine bacterial screening and AMR surveillance should be integrated into antenatal care programs. Public health strategies must also prioritize improving water, sanitation, and hygiene (WASH) practices, expanding diagnostic and laboratory capacities, and implementing effective antimicrobial stewardship programs. Raising community awareness and tailoring interventions to reduce AMR risks are essential for mitigating the burden of bacterial infections and safeguarding maternal and neonatal health in East Africa [19].

Forest plot analysis of each bacterial prevalence

The forest plot presents a meta-analysis of the prevalence of *E. coli* among pregnant women in East Africa, based on data from multiple studies. Each study's prevalence estimate is represented by a black square and a horizontal line, indicating the 95% confidence interval (CI). The size of the square reflects the study's weight in the analysis, with larger weights typically corresponding to larger sample sizes or more precise estimates. For instance, *Joshua et al. (2019)* has the largest weight (22.18%), while *Nteziyaremye et al. (2020)* contributes the least (8.01%). The pooled prevalence of *E. coli* is estimated at 43% (95% CI: 37–48%), as depicted by the diamond at the bottom of the plot. The heterogeneity among studies is low, as indicated by an I^2 statistic of 21.88% and a p-value of 0.26, suggesting minimal variation between the studies' results (Fig. 1). These findings underscore the significant prevalence of *E. coli* infections among pregnant women in East Africa and highlight the need for targeted public health interventions in this population [20]. These findings highlight the pressing need for targeted interventions to prevent and manage *E. coli* infections in pregnant women, particularly in East Africa. Strengthened antenatal care programs, improved hygiene education, and enhanced access to diagnostic and treatment facilities are critical. Moreover, AMR surveillance and antimicrobial stewardship programs should be prioritized to mitigate the risk

Table 1 Baseline characteristics observational studies included in systematic review and meta-analysis

Author	Publication year	Country	Sample size	Number of isolates	Prevalence	JBI score	Citation
Hamdan et al.,	2011	Sudan	235	33	14.70%	8	[11]
Alemu et al.,	2012	Ethiopia	385	40	10.40%	7	[12]
Abu et al.,	2021	Ethiopia	283	39	13.78%	5	[13]
Tadesse et al.,	2018	Ethiopia	259	55	21.20%	6	[14]
Taye et al.,	2018	Ethiopia	169	44	26.00%	6	[15]
Gessese et al.,	2017	Ethiopia	300	56	18.70%	8	[16]
Joshua et al.,	2019	Tanzania	393	110	28%	7	[17]
Nteziyaremye et al.,	2020	Uganda	587	28	3.75%	6	[18]

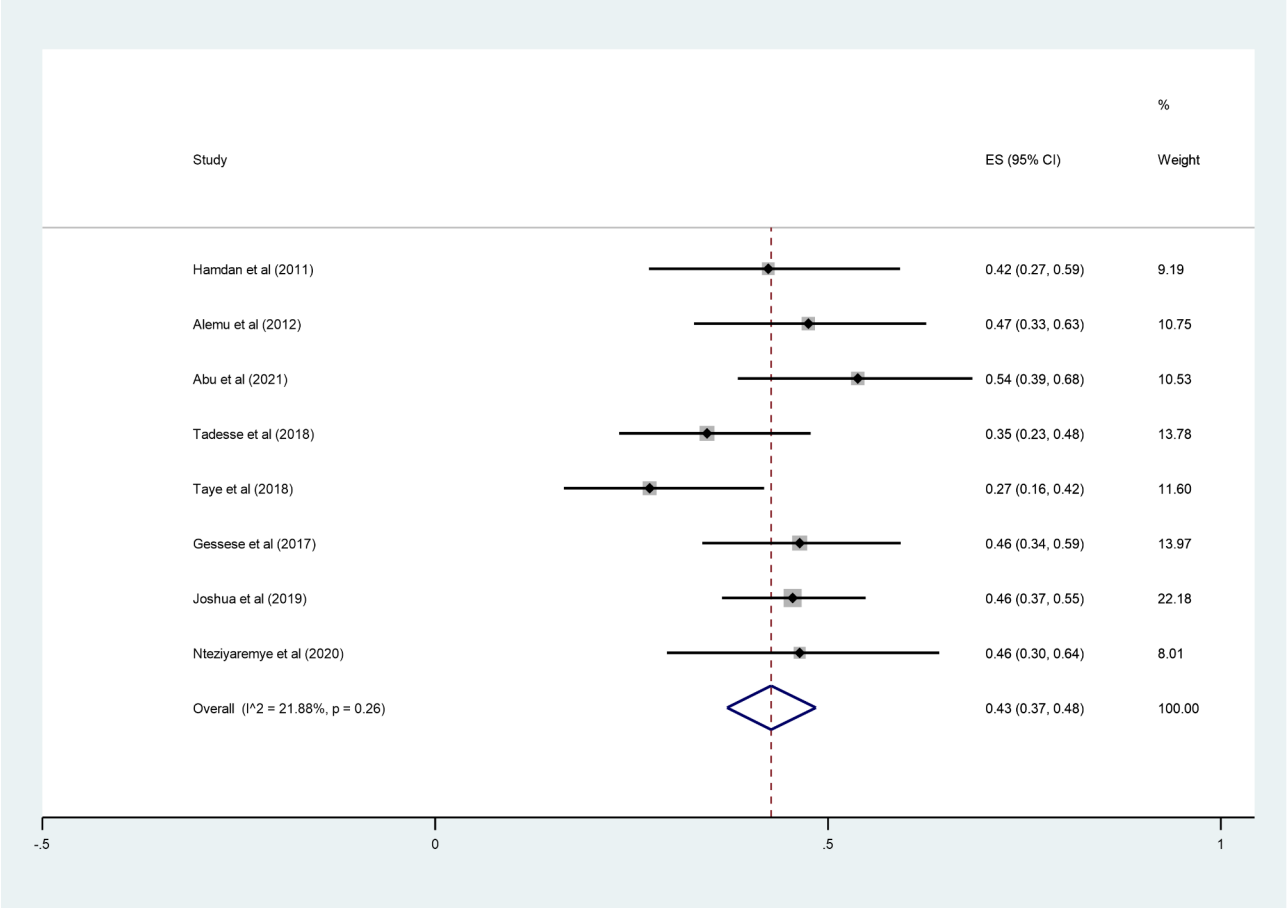

Fig. 1 Forest plot showing the prevalence of *E. coli* among pregnant women in East Africa, 2024

of resistant *E. coli* strains. Future research should focus on understanding the underlying drivers of infection and AMR, with a particular emphasis on regional variations, healthcare access disparities, and effective prevention strategies [21].

Figure 2 presents a forest plot showing the prevalence of *S. aureus* among pregnant women in East Africa, based on data from several studies. The effect sizes (ES) and 95% confidence intervals (CI) are listed for each study, along with their respective weights, which are based on sample size. For instance, the study by Alemu et al. (2012) has the largest weight at 16.62%, while Nteziyaremye et al. (2020) has the smallest weight at 14.22%. The overall pooled effect size for the prevalence of *S. aureus* is 0.20 (95% CI: 0.12, 0.29), indicating a moderate prevalence across the studies. However, there is a significant level of heterogeneity ($I^2 = 60.75\%$, $p = 0.03$), suggesting variability in the results across the different studies. The diamond shape at the bottom of the plot represents the overall effect size, with the dashed vertical line indicating no effect (ES = 0). This high heterogeneity indicates that the prevalence of *S. aureus* varies between studies, highlighting the need for further research to explore the factors contributing to this variability (Fig. 2). The findings of this meta-analysis underscore the moderate prevalence of *S. aureus* among pregnant women in East Africa, highlighting it as a significant public health concern. The presence of substantial heterogeneity suggests that the burden of *S. aureus* infections varies across settings, potentially due to differences in healthcare access, hygiene practices, socioeconomic conditions, or regional variations in antimicrobial resistance [22].

These results call for targeted public health interventions, such as strengthening antenatal care programs to include regular screening for *S. Aureus* and providing timely treatment to reduce the risk of complications. Improved hygiene education and awareness campaigns tailored to pregnant women can mitigate infection risks. Additionally, addressing the variability in prevalence through region-specific studies can help identify high-risk populations and factors driving the disparities [23]. Policymakers and healthcare providers should prioritize investments in diagnostic facilities and antimicrobial stewardship programs to monitor and manage *S. aureus*, especially given its potential role in maternal and neonatal infections. Future research should explore the

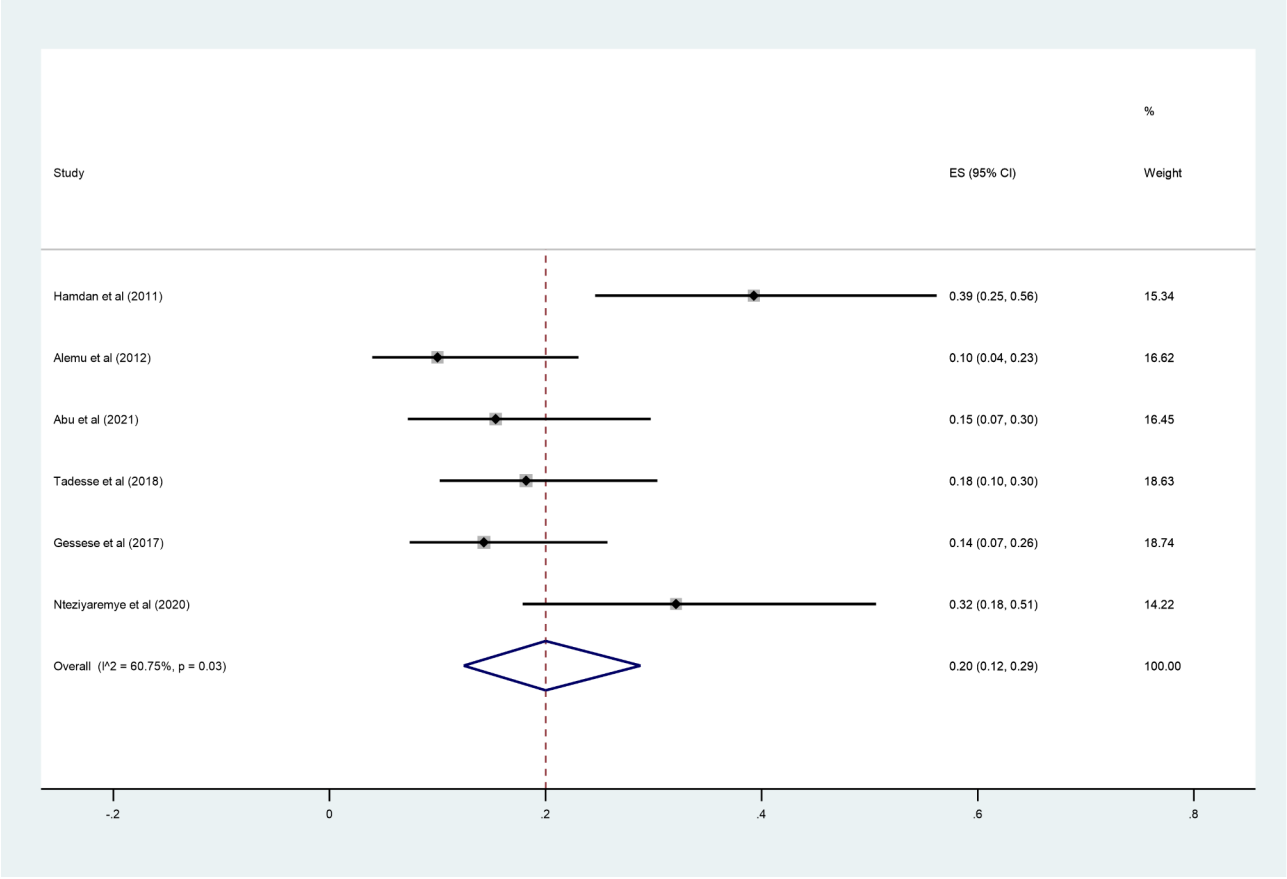

Fig. 2 Forest plot showing the prevalence of *S. aureus* among pregnant women in East Africa, 2024

contextual factors contributing to the observed heterogeneity, focusing on environmental, demographic, and clinical determinants to inform more effective interventions [24].

Figure 3 displays a forest plot that illustrates the prevalence of *Corynebacterium*, *Enterococcus*, and *Nocardia* species (*CONs*) among pregnant women in East Africa, based on data from three studies. The effect sizes (ES) and their 95% confidence intervals (CIs) are shown for each study, representing the estimated prevalence of *CONs* in the sampled populations. The study by Alemu et al. (2012) reported an effect size of 0.22 (95% CI: 0.12–0.36), contributing 29.67% to the overall estimate. Abu et al. (2021) showed a prevalence of 0.13 (95% CI: 0.06–0.27), with a weight of 28.94%, while Gessesse et al. (2017) found a prevalence of 0.14 (95% CI: 0.07–0.26), contributing the largest weight of 41.39%. The overall pooled effect size, representing the combined data from all studies, was 0.16 (95% CI: 0.10–0.23), suggesting a moderate prevalence of *CONs* among pregnant women in East Africa. The diamond at the bottom of the plot indicates the overall estimate, and the vertical dashed line marks the no-effect value (ES = 0). The low heterogeneity (I^2 = 0.00%, $p = 0.48$) signifies minimal variability among the studies, reinforcing the reliability and consistency of the findings (Fig. 3). These pathogens, though less frequently highlighted than common pathogens, represent important contributors to maternal infections that can compromise both maternal and fetal health [25].

The findings highlight the need for routine microbial screening in antenatal care to detect and manage infections caused by *CONs*, especially in resource-limited settings where diagnostic capacity may be restricted. Healthcare providers should integrate awareness and prevention strategies into maternal health programs, including promoting hygienic practices and timely treatment to reduce potential adverse outcomes [26].

Given the relatively moderate prevalence, targeted research should investigate the pathogenicity, antimicrobial resistance patterns, and risk factors associated with *CONs* infections in pregnant women. This will help refine treatment protocols and public health interventions. Furthermore, efforts to strengthen laboratory capacities in the region can enhance the identification and management of these infections, ultimately improving maternal and neonatal health outcomes [27].

Figure 4 presents a forest plot showing the prevalence of *K. pneumoniae* infections among pregnant women in

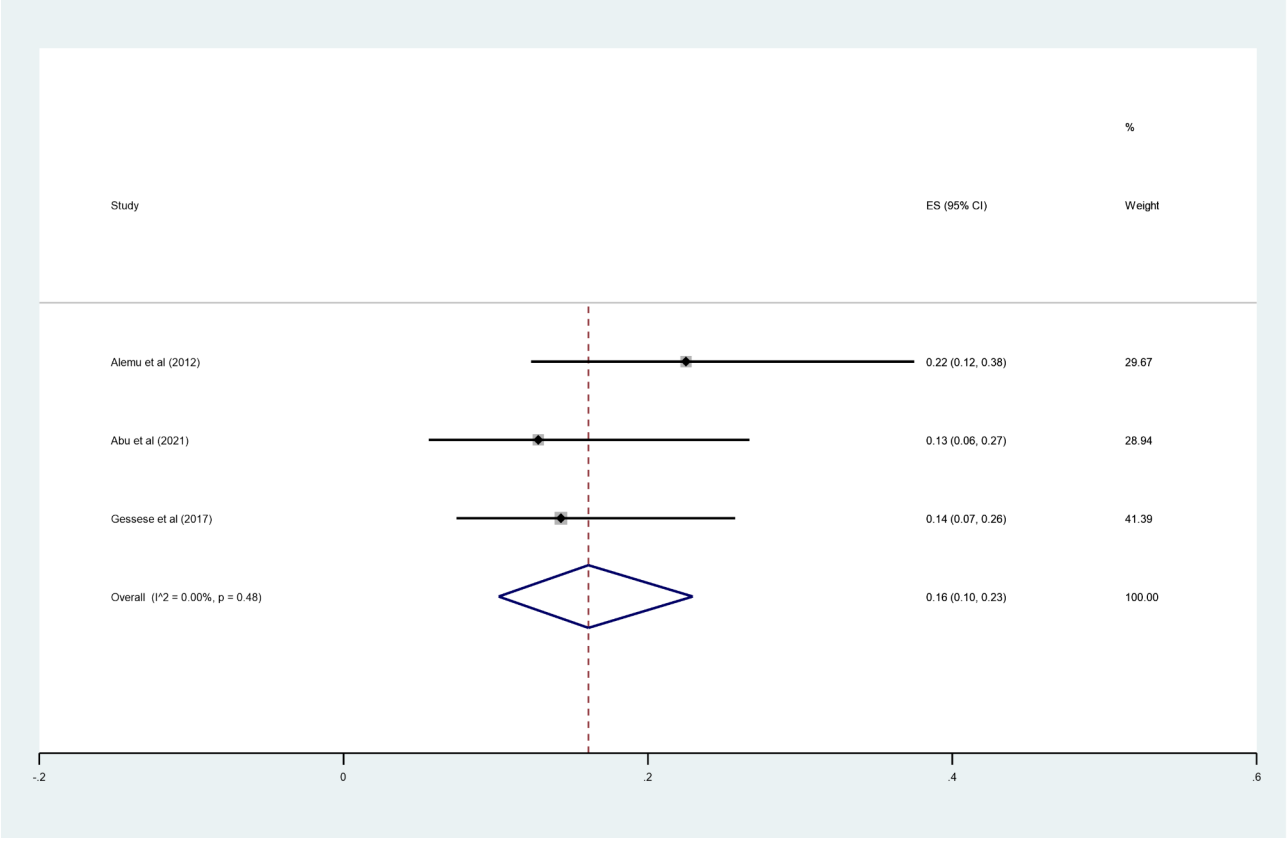

Fig. 3 Forest plot showing the prevalence of *CONs* among pregnant women in East Africa, 2024

East Africa, based on multiple studies. The individual effect sizes (ES) for each study range from 0.07 to 0.24, with corresponding 95% confidence intervals (CIs) varying between 0.02 and 0.23 and 0.11–0.35. The weight for each study reflects its contribution to the overall pooled effect size. The overall pooled effect size is 0.16 (95% CI: 0.12–0.21), suggesting a moderate prevalence of *K. pneumoniae* infections among pregnant women in the region. The I^2 value of 27.63% indicates moderate heterogeneity between the studies, which is further supported by a p-value of 0.22, suggesting that the variation between studies is not statistically significant. This suggests that while there is some variability across studies, the pooled estimate provides a reliable assessment of the prevalence of *K. pneumoniae* in East African pregnant women (Fig. 4). The findings underscore the importance of incorporating *K. pneumoniae* screening in antenatal care, particularly in regions with limited access to healthcare resources. Early detection and appropriate antibiotic treatment are crucial to managing these infections and preventing complications such as preterm birth, low birth weight, and maternal morbidity [28].

Additionally, the rising concern of antimicrobial resistance (AMR) in *K. pneumoniae* further emphasizes the need for better stewardship of antibiotics in pregnant women. Public health interventions should focus on improving diagnostic capabilities, enhancing hygiene and infection control practices, and promoting awareness about the risks associated with *K. pneumoniae* infections [29]. Future research should explore the environmental, clinical, and demographic factors contributing to the spread of *K. pneumoniae* in East Africa and assess the role of antimicrobial resistance in complicating treatment regimens. Strengthening maternal healthcare infrastructure to routinely identify and manage *K. pneumoniae* infections can significantly reduce maternal and neonatal health risks in the region [30].

The forest plot in Fig. 5 shows the effect sizes (ES) from three studies, each contributing to the analysis of *Pseudomonas aeruginosa* infections among pregnant women in East Africa. Handan et al. (2011) reports a small effect size (ES = 0.03, 95% CI: 0.01–0.15), while Taye et al. (2018) and Metayemew et al. (2020) both report moderate effect sizes (ES = 0.07, 95% CI: 0.02–0.18 and 95% CI: 0.02–0.23, respectively). The overall combined effect size is 0.06 (95% CI: 0.02–0.11), indicating a small but statistically significant positive effect. The I^2 value of 0% suggests no heterogeneity between the studies, and the p-value of 0.75 supports the consistency of the results. These findings suggest that there is a small but significant

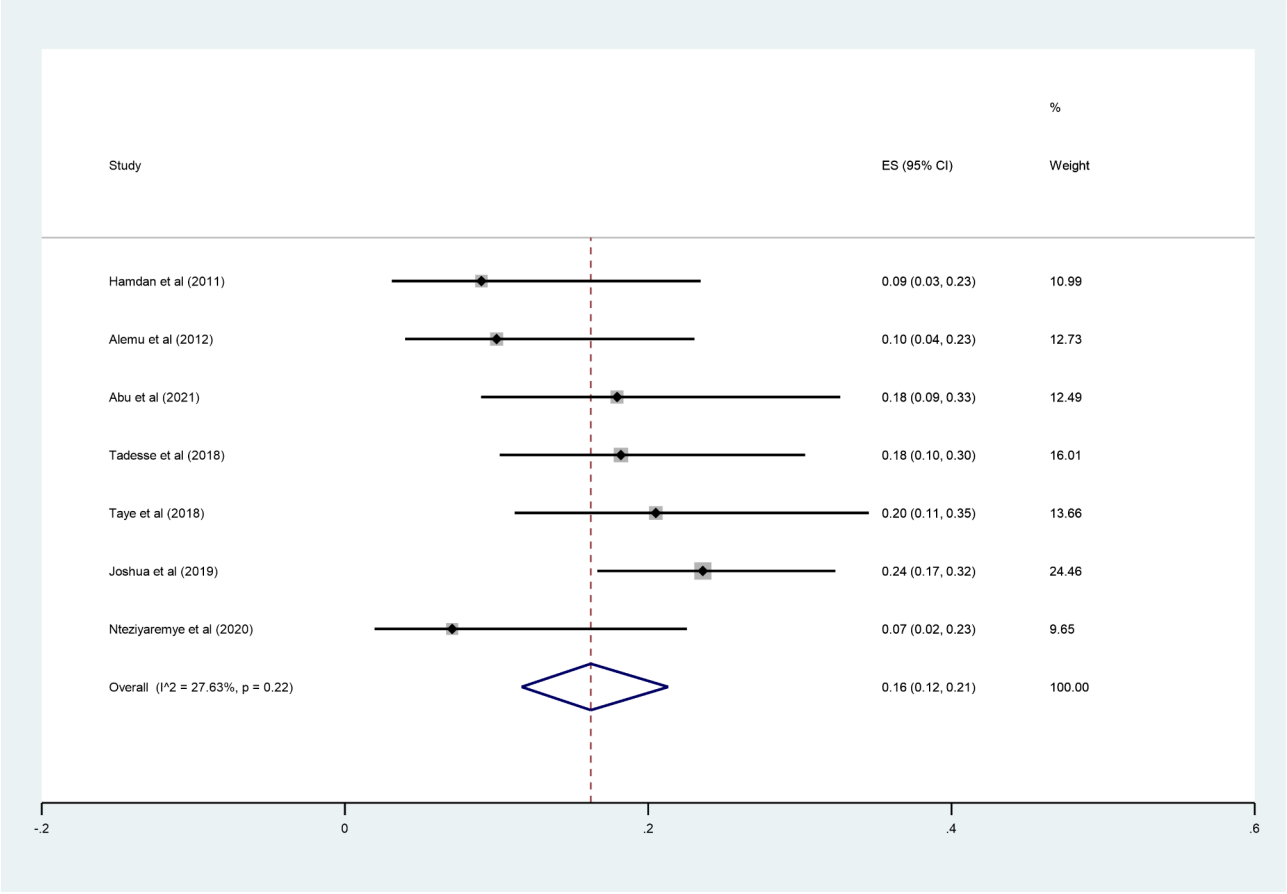

Fig. 4 Forest plot showing the prevalence of *K. pneumoniae* among pregnant women in East Africa, 2024

effect, highlighting the prevalence and potential impact of *P. aeruginosa* on maternal health in the region (Fig. 5). The findings emphasize the need for ongoing surveillance of *P. aeruginosa* infections in maternal health settings. Healthcare providers should be aware of the potential for *P. aeruginosa* infections and consider it in their differential diagnoses, especially for pregnant women presenting with symptoms of respiratory or urinary tract infections. Routine screening and timely treatment of infections can help mitigate the risk of adverse outcomes for both the mother and the fetus [31].

Additionally, the low prevalence does not diminish the importance of infection prevention and control measures, particularly in healthcare settings where *P. aeruginosa* can be opportunistic, especially in immunocompromised individuals such as pregnant women. Implementing strict hygiene practices, improving infection control measures in hospitals, and promoting antimicrobial stewardship can help reduce the burden of this pathogen [32]. Given the increasing global concern about antimicrobial resistance (AMR), it is important for future research to examine the resistance patterns of *P. aeruginosa* in East Africa, as this could impact treatment outcomes. Policymakers should prioritize interventions aimed at improving diagnostic infrastructure and strengthening healthcare systems to address infections caused by *P. aeruginosa* in pregnancy, ultimately improving maternal and neonatal health outcomes in the region [33].

Risk factors of bacteriuria infection among pregnant women in East Africa

The forest plot illustrates the risk factors associated with infections among pregnant women in East Africa, presented as hazard ratios (HRs) with 95% confidence intervals (CIs). Antibiotic use is associated with a significantly increased risk of infection, with an HR of 2.0 (95% CI: 1.5–2.6), indicating that women who used antibiotics were twice as likely to develop infections compared to those who did not. Smoking shows an HR of 1.3 (95% CI: 1.0–1.6), suggesting a 30% higher likelihood of infection, though the lower CI bound of 1.0 indicates a borderline association. Poor sanitation significantly elevates infection risk, with an HR of 1.8 (95% CI: 1.2–2.4), highlighting the importance of addressing environmental hygiene. A history of diabetes is strongly linked to infection, with an HR of 2.1 (95% CI: 1.5–2.8), demonstrating that women with diabetes are more than twice as likely to experience infections. Age greater than 30 years is also

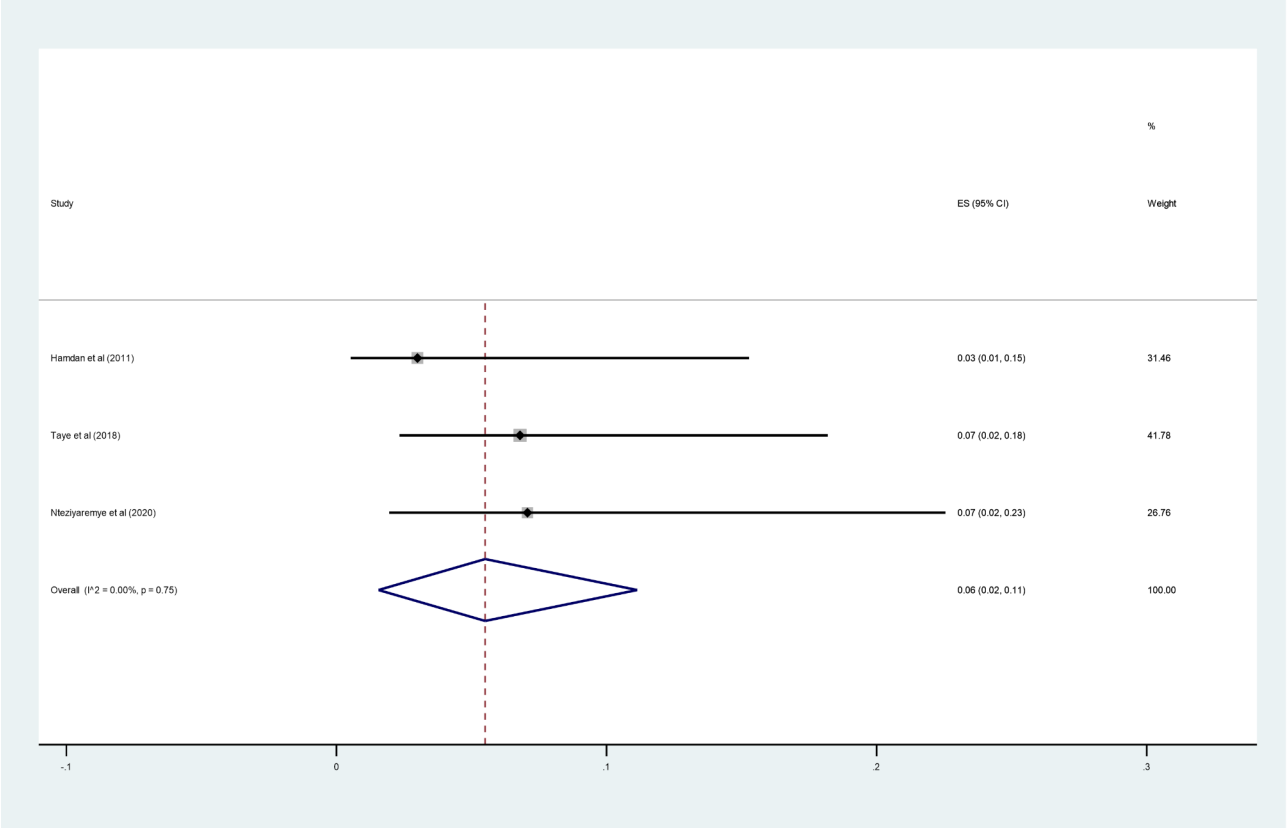

Fig. 5 Forest plot showing the prevalence of *P. aeruginosa* among pregnant women in East Africa, 2024

a significant risk factor, with an HR of 1.5 (95% CI: 1.1–2.0), indicating a 50% higher risk compared to younger women. The overall risk, considering all factors, is summarized as an HR of 1.7 (95% CI: 1.4–2.0), confirming a statistically significant increase in infection susceptibility among this population. These findings emphasize the critical need to address modifiable risk factors such as sanitation, smoking, and proper medical management to reduce infection risks (Fig. 6).

Antibiotic use was found to significantly increase the risk of infection, indicating that women who used antibiotics were twice as likely to develop infections compared to those who did not. This association points to the potential misuse or overuse of antibiotics, which could contribute to antimicrobial resistance (AMR) and complicate the treatment of infections in pregnant women. Public health strategies should focus on promoting responsible antibiotic use, alongside antimicrobial stewardship programs, to reduce unnecessary prescriptions and curb the rise of resistant pathogens [34].

Similarly, smoking was found to be a risk factor for infections, suggesting a 30% increased risk of infection among pregnant women who smoke. Although this association is borderline, smoking during pregnancy is known to impair immune function and increase the likelihood of infections. Public health campaigns aimed at smoking cessation for pregnant women could significantly reduce these risks and improve maternal and fetal health outcomes [35].

Poor sanitation also emerged as a significant risk factor, emphasizing the need to address environmental hygiene. Poor sanitation is a well-established risk factor for a range of infectious diseases, particularly in vulnerable populations like pregnant women. Interventions to improve sanitation infrastructure and hygiene practices, particularly in rural and underserved areas, are essential to reduce infection rates. Additionally, improving access to clean water and sanitation facilities should be a priority in public health planning [36].

A history of diabetes was found to strongly correlate with an increased risk of infection. Diabetes impairs immune function, making pregnant women with diabetes more susceptible to infections. Public health interventions should focus on early screening for gestational diabetes and managing pre-existing diabetes to reduce infection risks. Education on diabetes management, especially during pregnancy, is critical to lowering infection rates in this high-risk group [37].

Lastly, age greater than 30 years was identified as a risk factor, indicating a 50% higher likelihood of infection among older pregnant women. As immune function naturally declines with age, older pregnant women may

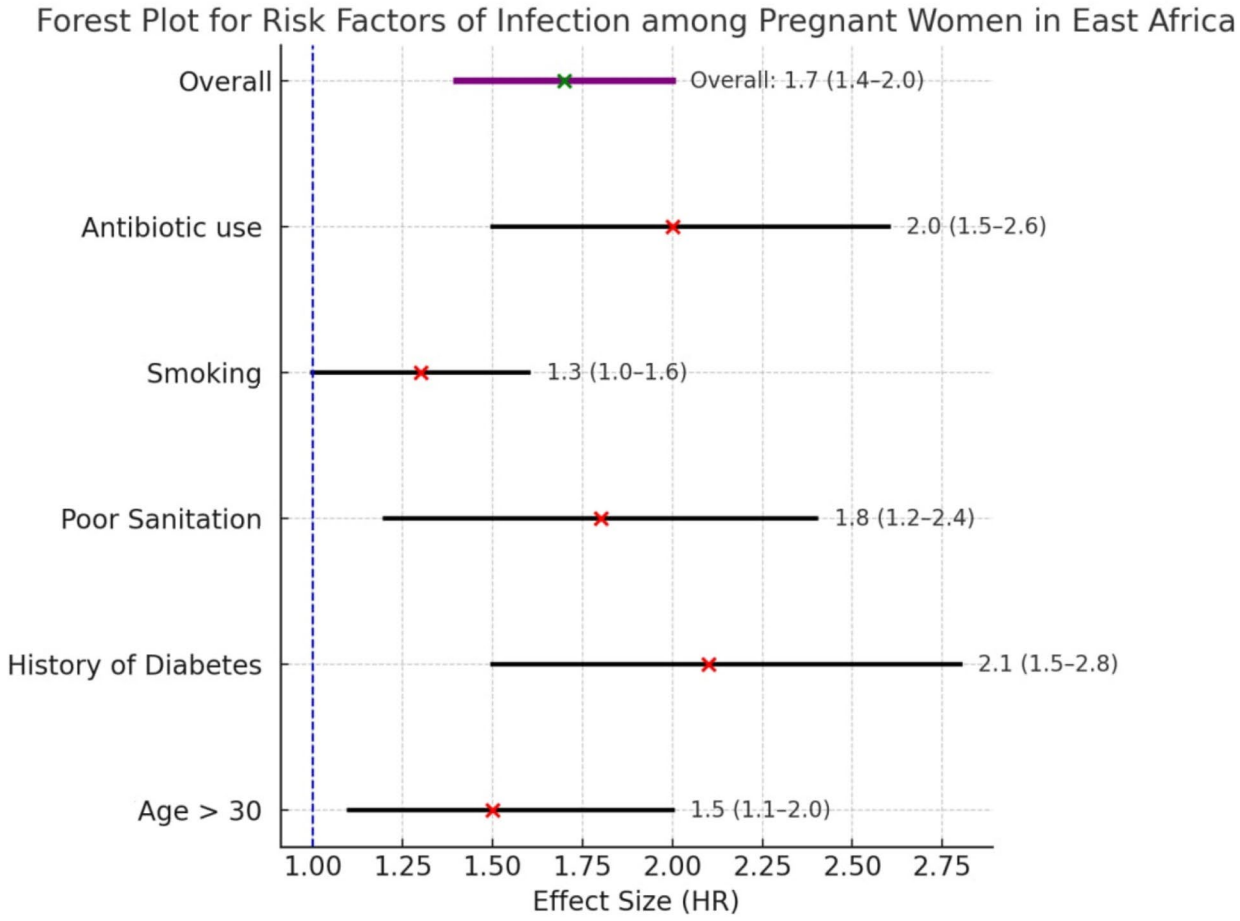

Fig. 6 Forest Plot of Risk Factors Associated with Infections among Pregnant Women in East Africa, Showing Hazard Ratios (HRs) with 95% Confidence Intervals

be more vulnerable to infections. Targeted healthcare interventions for this group, including regular screenings for infections and preventive care such as vaccinations, could help mitigate these risks [38].

Together, these findings highlight the need for public health initiatives that address modifiable risk factors such as antibiotic misuse, smoking, poor sanitation, and diabetes management. By focusing on these factors, it is possible to reduce the risk of infections among pregnant women in East Africa, ultimately improving maternal and neonatal health outcomes. Public health programs should also incorporate age-specific care and interventions for older pregnant women to further enhance maternal health [39].

A limitation of this review is that it only focuses on studies conducted in East Africa, which may limit the generalizability of the findings to other regions with different environmental, social, and health contexts. To address this, future research should incorporate broader geographical regions to compare and contrast findings, and consider including studies from other parts of Africa or globally to enhance the robustness and applicability of the results.

Conclusion and recommendations

Conclusion

The pooled analysis of bacterial isolates among pregnant women in East Africa highlights a high prevalence of bacterial infections, particularly *E. coli*, followed by *S. aureus*, *coagulase-negative CONs*, *K. pneumoniae*, and *P. aeruginosa*. The prevalence of *E. coli* ranged from 27 to 54%, with significant regional variations, reflecting a major public health concern. The study emphasizes the growing challenge of antimicrobial resistance (AMR), which complicates treatment strategies and contributes to increased maternal and neonatal morbidity. These infections, particularly urinary tract infections (UTIs), are linked to severe maternal complications such as preterm labor, low birth weight, and neonatal sepsis. Risk factors including antibiotic use, smoking, poor sanitation, diabetes, and maternal age were found to significantly increase the likelihood of infections. These findings highlight the importance of addressing modifiable risk factors and

strengthening diagnostic capacity. To mitigate the burden of these infections, it is critical to improve water and sanitation practices, adopt effective antimicrobial stewardship, and implement region-specific interventions. Further research is needed to explore the underlying causes of regional disparities in infection prevalence and resistance patterns. The results underscore the urgent need for routine bacterial screening, AMR surveillance, and comprehensive public health strategies to improve maternal and neonatal health outcomes in East Africa.

Recommendations

To address bacterial infections among pregnant women in East Africa, routine bacterial screening should be integrated into antenatal care programs, focusing onE. coliand other common pathogens. Strengthening AMR surveillance and enhancing sanitation and hygiene, especially in rural areas, is vital to reduce infection rates. Antibiotic stewardship programs should be established to minimize unnecessary antibiotic use. Public health interventions should target high-risk groups with tailored monitoring and treatment. Community awareness campaigns should emphasize proper hygiene, early detection, and safe antibiotic use. Further research on environmental and socioeconomic factors will guide future health policies and interventions.

Author contributions

M.G.M., A.G.Y., D.E., A.T., R.M.A., and C.Y. contributed to writing the main manuscript text. Y.A., A.M.D., L.W.L., N.K.W., M.H., M.M., A.A., T.E.D., and E.T.F. Prepared Figs. 1, 2, 3, 4, 5 and 6. All authors reviewed and approved the final manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

The analysis used publicly available data from published studies. As no new data collection was performed, ethical approval was not required.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Medical Laboratory Science, College of Medicine and Health Sciences, Injibara University, Injibara, Ethiopia
[2]Department of environmental health, college of medicine and health science, Injibara University, Injibara, Ethiopia
[3]Department of Human Physiology, College of Medicine and Health Science, Ambo University, Ambo, Ethiopia
[4]Department of plant science, College of agriculture, food and climate Sciences, Injibara University, Injibara, Ethiopia
[5]Department of Public Health, College of Medicine and Health Sciences, Injibara University, Injibara, Ethiopia
[6]Department of Pharmaceutics, School of Pharmacy, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia
[7]Department of public health, college of Medicine and health science, Dire Dawa University, Dire Dawa, Ethiopia
[8]Department of Midwifery, College of Medicine and health science, Dire Dawa University, Dire Dawa, Ethiopia
[9]Department of Human Physiology, School of Medicine, College of Medicine and Health Science, University of Gondar, Gondar, Ethiopia
[10]Department of Midwifery, College of Medicine and Health Science, Bahir Dar University, Bahir Dar, Ethiopia
[11]Department of Environmental Health, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia
[12]Department of Public Health, College of Health Sciences, Debre Tabor University, Debre Tabor, Ethiopia
[13]Department of Environmental Health Sciences, Public Health, College of Health Sciences, Debre Tabor University, Debre Tabor, Ethiopia

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References

1. Kumar M, Saadaoui M, Al Khodor S. Infections and pregnancy: effects on maternal and child health. Front Cell Infect Microbiol. 2022;12:873253.
2. Derese B, Kedir H, Teklemariam Z, Weldegebreal F, Balakrishnan S. Bacterial profile of urinary tract infection and antimicrobial susceptibility pattern among pregnant women attending at Antenatal Clinic in Dil Chora Referral Hospital, Dire Dawa, Eastern Ethiopia. Therapeutics and clinical risk management. 2016:251 – 60.
3. Gibbs RS. The relationship between infections and adverse pregnancy outcomes: an overview. Annals Periodontology. 2001;6(1):153–63.
4. Walusansa A, Asiimwe S, Kafeero HM, Stanley IJ, Ssenku JE, Nakavuma JL, et al. Prevalence and dynamics of clinically significant bacterial contaminants in herbal medicines sold in East Africa from 2000 to 2020: a systematic review and meta-analysis. Trop Med Health. 2021;49:1–14.
5. Aleinein IA, Sokhn ES. Knowledge and prevalence of urinary tract infection among pregnant women in Lebanon. Heliyon. 2024;10(17).
6. Prestinaci F, Pezzotti P, Pantosti A. Antimicrobial resistance: a global multifaceted phenomenon. Pathogens Global Health. 2015;109(7):309–18.
7. Al-Worafi YM. Infectious Disease causes and Risk factors in developing countries: adults. Handbook of Medical and Health Sciences in developing countries: education, practice, and Research. Springer; 2024. pp. 1–23.
8. Chapuma C, Twabi HH, Monk EJ, Jafali J, Weeks A, Beales E, et al. The aetiology and antimicrobial resistance of bacterial maternal infections in Sub-saharan Africa—a systematic review and meta-analysis. BMC Infect Dis. 2024;24(1):978.
9. Medicine Io. Improving birth outcomes: meeting the challenge in the developing world. 2003.
10. Harun MGD, Anwar MMU, Sumon SA, Hassan MZ, Mohona TM, Rahman A, et al. Rationale and guidance for strengthening infection prevention and control measures and antimicrobial stewardship programs in Bangladesh: a study protocol. BMC Health Serv Res. 2022;22(1):1239.
11. Hamdan HZ, Ziad AHM, Ali SK, Adam I. Epidemiology of urinary tract infections and antibiotics sensitivity among pregnant women at Khartoum North Hospital. Ann Clin Microbiol Antimicrob. 2011;10:1–5.
12. Alemu A, Moges F, Shiferaw Y, Tafess K, Kassu A, Anagaw B, et al. Bacterial profile and drug susceptibility pattern of urinary tract infection in pregnant women at University of Gondar Teaching Hospital, Northwest Ethiopia. BMC Res Notes. 2012;5:1–7.
13. Abu D, Abula T, Zewdu T, Berhanu M, Sahilu T. Asymptomatic Bacteriuria, antimicrobial susceptibility pattern and associated risk factors among pregnant women attending antenatal care in Assosa General Hospital, Western Ethiopia. BMC Microbiol. 2021;21(1):348.
14. Tadesse S, Kahsay T, Adhanom G, Kahsu G, Legese H, G/wahid A, et al. Prevalence, antimicrobial susceptibility profile and predictors of asymptomatic bacteriuria among pregnant women in Adigrat General Hospital, Northern Ethiopia. BMC Res Notes. 2018;11:1–6.
15. Taye S, Getachew M, Desalegn Z, Biratu A, Mubashir K. Bacterial profile, antibiotic susceptibility pattern and associated factors among pregnant

women with urinary tract infection in Goba and Sinana Woredas, Bale Zone, Southeast Ethiopia. BMC Res Notes. 2018;11:1–7.
16. Gessese YA, Damessa DL, Amare MM, Bahta YH, Shifera AD, Tasew FS, et al. Urinary pathogenic bacterial profile, antibiogram of isolates and associated risk factors among pregnant women in Ambo town, Central Ethiopia: a cross-sectional study. Antimicrob Resist Infect Control. 2017;6:1–10.
17. Kaduma J, Seni J, Chuma C, Kirita R, Mujuni F, Mushi MF, et al. Urinary tract infections and preeclampsia among pregnant women attending two hospitals in Mwanza City, Tanzania: a 1: 2 matched case-control study. Biomed Res Int. 2019;2019(1):3937812.
18. Nteziyaremye J, Iramiot SJ, Nekaka R, Musaba MW, Wandabwa J, Kisegerwa E, et al. Asymptomatic bacteriuria among pregnant women attending antenatal care at Mbale Hospital, Eastern Uganda. PLoS ONE. 2020;15(3):e0230523.
19. Berhe DF, Beyene GT, Seyoum B, Gebre M, Haile K, Tsegaye M, et al. Prevalence of antimicrobial resistance and its clinical implications in Ethiopia: a systematic review. Antimicrob Resist Infect Control. 2021;10:1–14.
20. Mohamed F, Dahie H, Mohamoud J, Adam M, Dirie H. Prevalence, antimicrobial susceptibility profile, and associated risk factors of uropathogenic Escherichia coli among pregnant women attending Dr. Sumait Hospital Mogadishu, Somalia. Front public Heal [Internet]. 2023; 11: 1203913. 2023.
21. Post AS, Guiraud I, Peeters M, Lompo P, Ombelet S, Karama I, et al. E scherichia coli from urine samples of pregnant women as an indicator for antimicrobial resistance in the community: a field study from rural Burkina Faso. Antimicrob Resist Infect Control. 2022;11(1):112.
22. Keneh NK, Kenmoe S, Bowo-Ngandji A, Tatah Kihla Akoachere J-F, Gonsu Kamga H, Ndip RN, et al. A mapping review of methicillin-resistant Staphylococcus aureus proportions, genetic diversity, and antimicrobial resistance patterns in Cameroon. PLoS ONE. 2023;18(12):e0296267.
23. Lee BY, Wiringa AE, Mitgang EA, McGlone SM, Afriyie AN, Song Y, et al. Routine pre-cesarean Staphylococcus aureus screening and decolonization: a cost-effectiveness analysis. Am J Manag Care. 2011;17(10):693.
24. Bankar NJ, Ugemuge S, Ambad RS, Hawale DV, Timilsina DR. Implementation of antimicrobial stewardship in the healthcare setting. Cureus. 2022;14(7).
25. MacLean A. Urinary tract infection in pregnancy. Int J Antimicrob Agents. 2001;17(4):273–7.
26. Slezak E, Unger H, Gadama L, McCauley M. Screening for infectious maternal morbidity-knowledge, attitudes and perceptions among healthcare providers and managers in Malawi: a qualitative study. BMC Pregnancy Childbirth. 2022;22(1):362.
27. Chelkeba L, Fanta K, Mulugeta T, Melaku T. Bacterial profile and antimicrobial resistance patterns of common bacteria among pregnant women with bacteriuria in Ethiopia: a systematic review and meta-analysis. Arch Gynecol Obstet. 2022;306(3):663–86.
28. McCartney AL, Hoyles L. The role of Klebsiella populations in preterm infants. Biochem Soc Trans. 2023;51(2):887–96.
29. Yeta KI, Michelo C, Jacobs C. Antimicrobial resistance among pregnant women with urinary tract infections attending antenatal clinic at levy mwanawasa university teaching hospital (LMUTH), Lusaka, Zambia. Int J Microbiol. 2021;2021(1):8884297.
30. Gadisa E, Egyir B, Adu B, Ahmed H, Disasa G, Tessema TS. Epidemiology, antimicrobial resistance profile and management of carbapenem-resistant Klebsiella pneumoniae among mothers with suspected sepsis in Ethiopia. Ann Clin Microbiol Antimicrob. 2024;23(1):85.
31. Reynolds D, Kollef M. The epidemiology and pathogenesis and treatment of Pseudomonas aeruginosa infections: an update. Drugs. 2021;81(18):2117–31.
32. Lopes JA, Rghei AD, Thompson B, Susta L, Khursigara CM, Wootton SK. Overcoming barriers to preventing and treating P. Aeruginosa infections using AAV vectored Immunoprophylaxis. Biomedicines. 2022;10(12):3162.
33. Kariuki S, Kering K, Wairimu C, Onsare R, Mbae C. Antimicrobial resistance rates and surveillance in Sub-saharan Africa: where are we now? Infect Drug Resist. 2022;15:3589–609.
34. Llor C, Bjerrum L. Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. Therapeutic Adv drug Saf. 2014;5(6):229–41.
35. Metzger MJ, Halperin AC, Manhart LE, Hawes SE. Association of maternal smoking during pregnancy with infant hospitalization and mortality due to infectious diseases. Pediatr Infect Dis J. 2013;32(1):e1–7.
36. Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, et al. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low-and middle-income countries. Int J Hyg Environ Health. 2019;222(5):765–77.
37. Yefet E, Bejerano A, Iskander R, Zilberman Kimhi T, Nachum Z. The Association between Gestational Diabetes Mellitus and infections in pregnancy—systematic review and Meta-analysis. Microorganisms. 2023;11(8):1956.
38. Quiros-Roldan E, Sottini A, Natali PG, Imberti L. The impact of Immune System Aging on Infectious diseases. Microorganisms. 2024;12(4):775.
39. Chen Q, Li D, Beiersmann C, Neuhann F, Moazen B, Lu G, et al. Risk factors for antibiotic resistance development in healthcare settings in China: a systematic review. Epidemiol Infect. 2021;149:e141.

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