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Review Article

Prevalence and Characterization of *Escherichia coli* and *Salmonella spp.* in Layer Hen Eggs in West Africa: A Comprehensive Review of Laboratory-Based Evidence

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Abstract

Layer hen eggs are an essential source of affordable animal protein for many populations in West Africa. However, their microbiological safety is frequently compromised by contamination with pathogenic Salmonella and Escherichia coli, two major agents of foodborne infections. This literature review, covering the period 2000–2025, draws upon international databases (PubMed, ScienceDirect, Google Scholar, and AJOL) to analyze studies conducted in several countries across the subregion, including Nigeria, Ghana, Côte d'Ivoire, Mali, Benin, and Burkina Faso. Findings indicate that the prevalence of E. coli in eggs is generally higher than that of Salmonella, with rates exceeding 20% in certain contexts. Observed variations are influenced by several factors, including production system (intensive, semi-intensive, or backyard), the level of biosecurity implementation, and flock health management. Moreover, the emergence of antimicrobial-resistant strains, particularly to fluoroquinolones and cephalosporins, poses an increasing threat to both animal and human health by limiting available therapeutic options. A major concern also lies in disparities in diagnostic capacities: while some laboratories employ advanced techniques such as PCR or molecular serotyping, others still rely on conventional culture methods, potentially leading to an underestimation of contamination rates. This review highlights the urgent need to strengthen microbiological surveillance of eggs through harmonized regional programs. The development of reference laboratories, improvement of farm biosecurity practices, and strict quality control of eggs are identified as priority measures to mitigate health risks, protect public health, and ensure food safety across the region.

Keywords

Layer Hen Eggs, *Salmonella*, *Escherichia coli*, Food Safety, West Africa

1. Introduction

Layer hen eggs are a major source of high-quality protein and essential micronutrients for populations across West Africa, playing a crucial role in food security and nutrition [13, 14]. According to [17], egg production in Africa has grown by

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approximately 2% annually since 2013, reaching about 4 million tons in 2023. This trend reflects the increasing importance of poultry farming in the region's economic development, driven by rapid urbanization and population growth [7].

However, egg production is not without public health risks. Eggs can serve as vehicles for major foodborne pathogens such as *Escherichia coli* and *Salmonella spp*., which are responsible for severe foodborne illnesses [24, 28]. Several studies have shown that hatcheries and production systems characterized by inadequate hygiene practices significantly increase the risk of contamination [2]. Egg production systems in West Africa range widely from small traditional farms to semi-industrial operations, yet they often face challenges related to poor biosecurity and insufficient sanitary control, which facilitate bacterial contamination [10, 29].

Moreover, these bacteria frequently exhibit alarming antimicrobial resistance (AMR) profiles, complicating treatment and raising major concerns for food safety [10, 30]. Recent studies indicate that AMR in E. coli and Salmonella in this region is likely exacerbated by the misuse of antibiotics in poultry farming [30]. The inappropriate use of antimicrobials often driven by weak regulatory frameworks and limited farmer awareness has further contributed to the emergence of resistant strains [1, 30]. These issues highlight the urgent need for improved surveillance and responsible livestock management to minimize risks to public health.

Food safety and public health in West Africa are thus increasingly threatened by the growing prevalence of antimicrobial-resistant *E. coli* and *Salmonella* strains. Initiatives aimed at strengthening biosecurity practices, improving farmer education, and ensuring stricter monitoring of antibiotic use are essential [21].

Accordingly, this review aims to provide a comprehensive synthesis of laboratory-based evidence on Salmonella and E. coli in layer hen eggs across West Africa. Specifically, it seeks to assess their prevalence, characterize their antimicrobial resistance profiles, and propose evidence-based strategies to enhance food safety and protect public health in the region.

2. Manuscript Formatting

This systematic review was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [26].

2.1. Inclusion Criteria

Eligibility criteria for study selection were established based on the PICOS methodology [11]. to define specific inclusion and exclusion parameters. Studies were included if they presented laboratory-based analytical data using methods such as culture, PCR, serotyping, or antibiotic susceptibility testing to determine the contamination of layer hen eggs by *Escherichia coli* and *Salmonella spp*. Eligible studies had to be conducted in at least one West African country namely Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, or Togo and published between January 1, 2000, and September 30, 2025. Publications were required to appear in peer-reviewed journals**,** scientific conference proceedings, or academic theses accessible in full text.

2.2. Exclusion Criteria

Studies that did not specifically focus on layer hen eggs such as those concerning poultry meat or other avian products were excluded. Likewise, research lacking experimental laboratory data, including consumer surveys or market studies, as well as duplicate publications or incomplete abstracts without usable data, were not considered.

2.3. Information Sources, Search Strategy, and Article Selection

The article selection process was carried out in three distinct phases.

The first phase, identification, involved locating relevant studies through keyword-based searches across selected databases. The search strategy combined carefully chosen keywords with Boolean operators.

In English, search terms included:

"*Escherichia coli*" OR "*E. coli*" AND "*Salmonella*" AND "eggs" AND "West Africa" AND ("microbiological analysis" OR "antimicrobial resistance").

In French, the keywords used were:

"*Escherichia coli*" OR "*E. coli*" ET "*Salmonella*" ET "œufs" ET "Afrique de l'Ouest" ET ("analyse microbiologique" OU "résistance antimicrobienne").

During the screening phase, article titles and abstracts were reviewed to verify compliance with the inclusion criteria. In the eligibility and final inclusion phase, full-text articles were examined to extract relevant information, including publication year, study country, number of samples analyzed, methods used, prevalence results, and antimicrobial resistance profiles.

The synthesis of the publications reviewed for the purpose of this study is presented in Table 1 below.

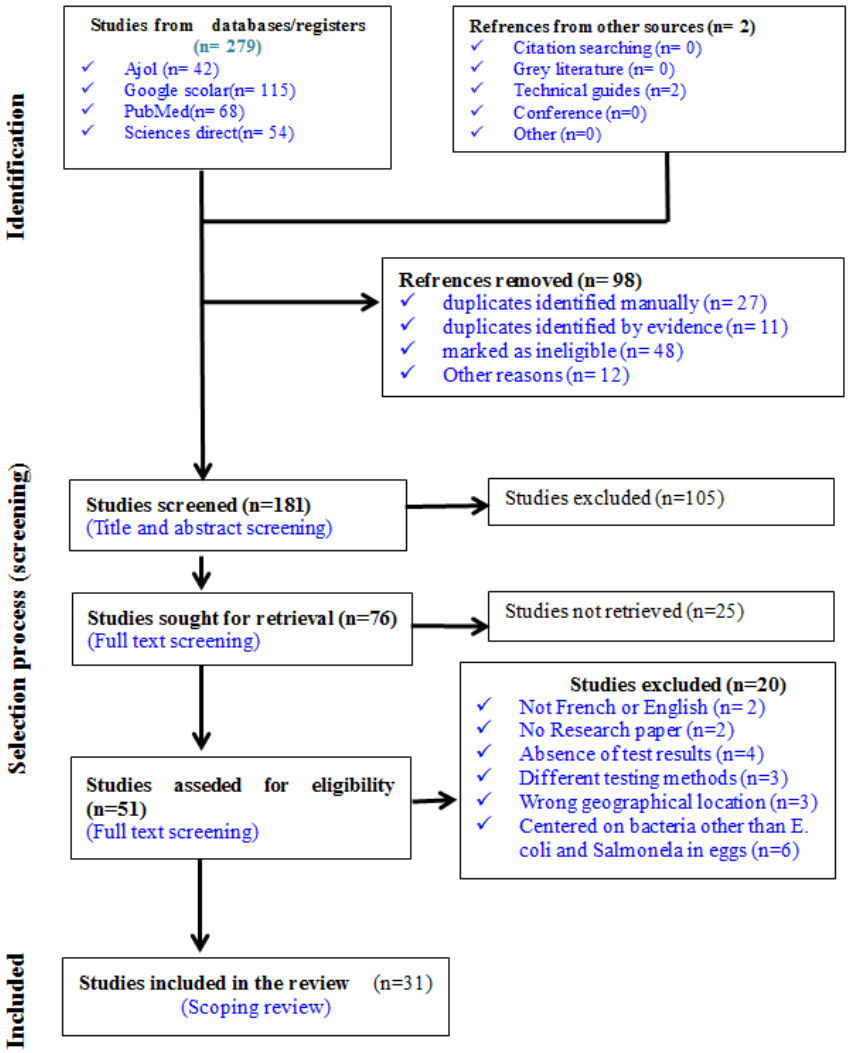

Figure 1. *PRISMA 2020 flow diagram illustrating the study selection process for the systematic review, including identification, screening, eligibility, and inclusion of studies retrieved from electronic databases.*

Table 1. *Summary of publications on bacterial pathogens in eggs in West Africa (2000–2025).*

Database	Keywords used	Study period	Countries	Articles identified	Articles sorted after initial screening	Articles retained after final selection
PubMed	("Escherichia coli" OR "E. coli") AND "Salmonella" AND "eggs" AND "West Africa" AND ("microbiological analysis" OR "antimicrobial resistance")	2000–2025	Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, Togo, Guinea	68	24	8
AJOL	("E. coli" OR "Salmonella") AND "œufs" AND "Afrique de l'Ouest"	2000–2025	Bénin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigéria, Sénégal, Togo, Guinée	42	18	7
Google Scholar	("E. coli" + "Salmonella" + "eggs" + "West Africa")	2000–2025	Bénin, Burkina Faso, Côte d'Ivoire,	115	36	9

Database	Keywords used	Study period	Countries	Articles identified	Articles sorted after initial screening	Articles retained after final selection
			Ghana, Mali, Niger, Nigéria, Sénégal, Togo, Guinée			
ScienceDirect	("E. coli" OR "Salmonella") AND "eggs" AND "West Africa"	2000–2025	Bénin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigéria, Sénégal, Togo, Guinée	54	20	7
Total	–	–	–	279	98	31

2.4. Data Extraction and Analysis

Data extraction was carried out systematically and rigorously to ensure the reliability and validity of the information collected. Each article was independently reviewed by at least two members of the research team to minimize extraction bias. In cases of discrepancies in data extraction, group discussions were conducted to reach a consensus. In addition, a quality control check was performed on a subset of studies to verify the accuracy and completeness of the extracted information. Relevant data were collected from the selected articles using a standardized extraction form designed to capture the essential elements of each study. The extracted data included the following:

1) Bibliographic information: year of publication, author(s), article title, and source (journal, conference, thesis).
2) Geographical data**:** study country and specific region of West Africa concerned.
3) Study characteristics**:** study type (e.g., cohort study, case-control study), sample size, and data collection and analysis methods (culture, PCR, serotyping, antibiotic susceptibility testing).
4) Microbiological results: contamination rates of eggs with *Escherichia coli* and *Salmonella* spp., as well as findings related to antimicrobial resistance prevalence.
5) Conclusions and recommendations: main findings regarding food safety and public health implications.

The extracted data were then aggregated and analyzed to enable a comprehensive synthesis of results, facilitating comparison across studies and identification of general trends related to *Escherichia coli* and *Salmonella* contamination in layer hen eggs in West Africa.This methodological approach aimed to provide a solid foundation for the conclusions of the systematic review while adhering to the standards set forth in the PRISMA guidelines.

3. Reported Prevalence by Country

The results presented in Table 2 show that contamination of eggs by pathogenic *E. coli* is generally higher than by *Salmonella* across all West African countries studied. In Nigeria, contamination rates are the highest in the region, averaging around 16% for *Salmonella* and over 22% for *E. coli*. This reflects both the significance of poultry production in the country and the limitations in biosecurity practices in some farms. Ghana also shows high prevalence levels, with approximately 16% for *Salmonella* and 21% for *E. coli*, similar to those observed in Nigeria. These two countries represent the most concerning hotspots for bacterial contamination of eggs in West Africa. In Mali, contamination levels are moderate, with about 11% positivity for *Salmonella* and 17% for *E. coli*. This indicates a worrisome situation, though less critical than in neighboring countries with more intensive production systems. In Côte d'Ivoire and Benin, *Salmonella* prevalence is relatively lower (5–12%), but eggs are still frequently contaminated with pathogenic *E. coli* (up to 17–20%), posing a non-negligible public health risk. Finally, in Burkina Faso, Senegal, Togo, Niger, and Guinea, studies report variable prevalence rates, generally ranging from 10 to 18% for *Salmonella* and 10 to 25% for *E. coli*. These figures confirm that egg contamination is a widespread issue throughout the sub region, regardless of the level of poultry industry development.

Table 2. Laboratory findings on E. coli and Salmonella in layer hen eggs in West Africa (2000–2025).

Contry	Prevalence		Isolation	Serotypes/	Antimicrobial
	Salmonella	coli	Methods	Pathotypes	Resistance
Benin	8–15	12–20	Selective culture, PCR	*S. Enteritidis, S. Typhimurium*; EPEC, EHEC	β-lactams, tetracyclines, genes ESBL (bla_CTX-M)
Burkina Faso	10–18	15–22	Culture, serotyping, PCR	*S. Enteritidis*, *S. Typhimurium*; EPEC	Fluoroquinolones, tetracyclines, bla_TEM, tetA
Côte d'Ivoire	5–12	10–17	Culture, multiplex PCR	*S. Enteritidis*; EPEC, EAEC	Aminoglycosides, penicillins, multidrug resistance
Ghana	12–20	18–25	Culture, serotyping, PCR	*S. Typhimurium*, *S. Enteritidis*; EHEC, EPEC	Tetracyclines, sulfonamides, tetA, sul1, sul2
Mali	8–15	14–21	Culture, PCR, serotyping	*S. Enteritidis*; EPEC	β-lactams, tetracyclines, aminoglycosides, bla_TEM, tetA
Nigeria	10–22	16–28	Culture, multiplex PCR	*S. Enteritidis*, *S. Typhimurium*; EPEC, EHEC	multidrug resistance β-lactams, tetracyclines, fluoroquinolones, ESBL, tetA
Senegal, Togo, Niger, Guinea	5–18	10–25	Culture, PCR	*S. Enteritidis, S. Typhimurium*; EPEC	Tetracyclines, aminoglycosides, β-lactams (variable)

4. Comparison of Prevalence and Regional Trends

The graph below presents a comparison of the average prevalence rates of *E. coli* and *Salmonella* spp. in eggs across ten West African countries.

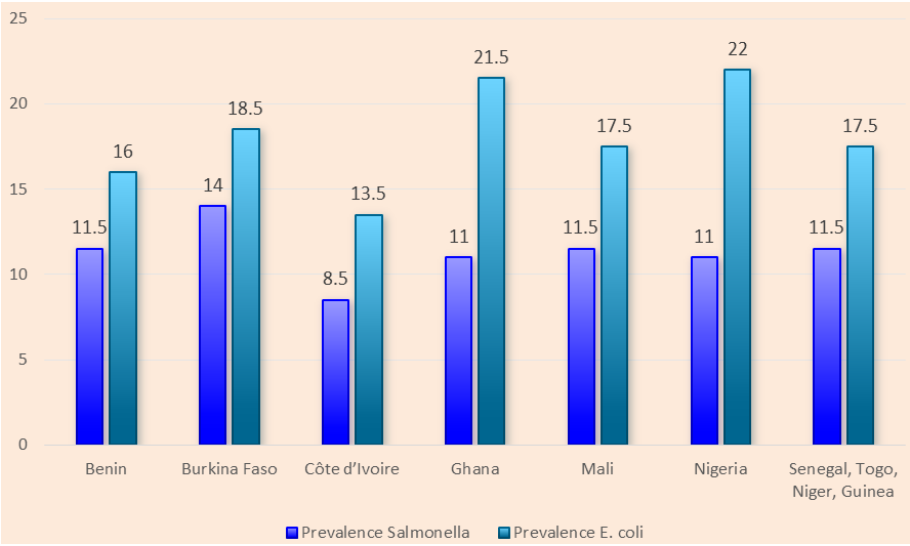

Figure 2. Graph of Average Prevalence Rates of E. coli and Salmonella spp. in Eggs in West Africa.

The results presented in Figure 2 highlight notable variations among West African countries, depending on their levels of poultry production and the implementation of biosecurity measures. Countries with large-scale poultry industries, such as Nigeria and Ghana, show higher prevalence rates of *Salmonella* and *E. coli* in layer hen eggs, reflecting both the intensification of production systems and the challenges in enforcing strict biosecurity practices.

Conversely, in countries such as Mali, Côte d'Ivoire, and Benin, contamination rates are intermediate, reflecting more diversified production systems that range from smallholder farms to semi-intensive operations. The impact of biosecurity and hygiene practices is a key factor influencing contamination dynamics. Studies indicate that farms implementing regular cleaning, veterinary supervision, and strict feed management tend to have lower contamination rates.

In contrast, farms characterized by high animal density, poor hygiene, and uncontrolled antibiotic use report much higher prevalence rates, along with the worrying emergence of antimicrobial-resistant strains. Finally, it is important to note that data remain fragmented and insufficient in several countries particularly Niger, Guinea, and Togo where studies are scarce or based on small sample sizes. This lack of comprehensive data prevents an exhaustive comparison and underscores the need to strengthen regional microbiological surveillance of table eggs in West Africa.

5. Food Safety and Public Health Aspects

The results presented in Table 2 above raise several important points concerning food safety and public health in West Africa. The following key interpretations were identified:

From the standpoint of prevalence and diversity, contamination of eggs by pathogenic *E. coli* is generally higher than that by *Salmonella*. This may indicate a more complex issue, as *E. coli* contamination is often associated with poor hygiene conditions along the production chain. This highlights the urgent need to improve biosecurity and hygiene practices within poultry farms.

Nigeria and Ghana, as the region's leading poultry producers, exhibit alarmingly high contamination rates. This situation can be attributed to production pressure and insufficient implementation of biosecurity measures appropriate for their intensive systems. These countries should be prioritized for targeted interventions aimed at reducing contamination particularly through farmer training programs and the strengthening of food safety standards.

Although Mali shows intermediate levels of contamination, the situation remains concerning. This may indicate increasing vulnerability as poultry production expands. Further studies are needed to identify the underlying factors driving this contamination and to develop preventive measures accordingly.

The lower prevalence of *Salmonella* in Benin and Côte d'Ivoire compared to *E. coli* may reflect differences in production systems or farm management practices. However, the significant presence of pathogenic *E. coli* still represents a health risk, suggesting that control measures should target both types of contamination.

The diversity of contamination rates reported in countries such as Burkina Faso, Senegal, and Togo indicates a heterogeneous situation across the region, calling for a coordinated regional approach to surveillance and risk management.

Overall, these findings underscore the urgent need for targeted interventions to improve egg safety in West Africa. This includes establishing comprehensive monitoring systems, educating farmers on best practices in hygiene and biosecurity, and strengthening regulations governing poultry production.

6. Discussion

The findings of this review indicate that contamination of layer hen eggs by *Salmonella* and pathogenic *Escherichia coli* remains a major public health concern in West Africa. Both bacterial genera are leading causes of foodborne illnesses worldwide, often linked to inadequate handling, poor hygiene, or consumption of raw or undercooked eggs [14, 18, 30]. The risk is further exacerbated in the sub region, where temperature, humidity, and weak food safety infrastructures promote bacterial survival and transmission [4].

A critical issue emerging from this synthesis is antimicrobial resistance (AMR). Many isolates of *E. coli* and *Salmonella* recovered from eggs demonstrated resistance to critical antibiotic classes such as fluoroquinolones, third-generation cephalosporins, and tetracyclines [6, 19, 22]. This widespread resistance pattern reflects the frequent and sometimes unregulated use of antimicrobials in poultry production systems, a practice that accelerates the emergence of extended-spectrum β-lactamase (ESBL) genes such as *bla_{CTX-M}* and *bla_{TEM}* [5, 23]. These findings underscore the urgency of adopting One Health–based surveillance programs that integrate animal, human, and environmental health perspectives [16, 29, 31].

However, diagnostic capacities across West Africa remain uneven. While a few laboratories employ advanced techniques such as PCR and molecular serotyping [7], many still rely solely on conventional culture methods, leading to potential underestimation of contamination rates [20, 27]. These methodological disparities hinder data comparability and impede accurate regional risk assessments.

In terms of country-specific trends, the highest contamination rates were recorded in Nigeria and Ghana, where *E. coli* prevalence exceeded 20% and *Salmonella* prevalence averaged around 16%. These figures are consistent with previous studies that documented similar contamination levels in eggs and poultry environments [15, 19, 25]. The high prevalence in these countries likely reflects the scale and intensification of

poultry production combined with gaps in biosecurity implementation. Conversely, intermediate contamination rates in Mali (approximately 11% for *Salmonella* and 17% for *E. coli*) may indicate a transitional phase of production intensification, accompanied by emerging biosafety challenges [12, 27].

Lower *Salmonella* prevalence rates in Côte d'Ivoire and Benin (5-12%), paired with relatively high *E. coli* contamination (up to 20%), suggest differing biosecurity and egg-handling practices. Similar findings were reported by [3, 8], who observed that *E. coli* remains a more persistent contaminant even under moderate biosecurity conditions, emphasizing the need for dual-targeted monitoring programs addressing both pathogens.

Regional variation across countries such as Burkina Faso, Senegal, Togo, Niger, and Guinea (10-25% *E. coli* and 10-18% *Salmonella*) confirms that egg contamination is widespread throughout West Africa, regardless of production intensity or development level. This heterogeneity calls for a coordinated regional framework for microbial surveillance, harmonized laboratory protocols, and stronger enforcement of food safety standards [9, 16, 29].

Overall, these findings highlight the urgent need to:

1) Strengthen laboratory capacities for microbial testing and AMR profiling.
2) Implement continuous farmer education on hygiene and antibiotic stewardship.
3) Establish cross-border surveillance and early-warning systems under a One Health framework.

Such efforts are crucial not only for reducing contamination risks in eggs but also for mitigating the spread of antimicrobial resistance within the broader food chain and human populations.

7. Conclusion and Perspectives

This literature review highlights the high prevalence of *Salmonella* and pathogenic *Escherichia coli* in table eggs consumed in West Africa. The findings reveal that contamination rates vary across countries, but the general trend indicates a more frequent occurrence of *E. coli* than *Salmonella*. These bacteria represent a major public health risk, especially in contexts where eggs are consumed raw or undercooked. The emergence of antibiotic-resistant strains further exacerbates this risk and poses an increasing threat to food safety and human health.

Overall, data on *E. coli* and *Salmonella* contamination in eggs across West Africa confirm concerns similar to those observed in other regions, underscoring an urgent need for targeted interventions to improve food safety and public health. A collaborative and integrated approach involving researchers, producers, and policymakers is essential to address this complex challenge.

The analysis also highlights disparities in diagnostic capacities. While some countries have access to modern tools such as PCR and molecular serotyping, others still rely on conventional culture methods, limiting accurate detection and assessment of pathogens. In this context, the creation and strengthening of regional reference laboratories are crucial to standardize methods, compare data, and guide public health policies.

Looking ahead, several key actions deserve particular attention:

1) Develop harmonized regional surveillance programs that integrate the "One Health" approach;
2) Strengthen biosecurity measures in poultry farms, particularly regarding hygiene and antibiotic management;
3) Establish regular microbiological quality control of eggs throughout the value chain, from production to consumption;
4) Promote collaboration among research institutes, veterinary services, health authorities, and regional organizations to implement coordinated strategies against foodborne zoonoses.

Ultimately, improving the microbiological safety of eggs in West Africa requires a combination of scientific, institutional, and policy efforts. These actions are essential to safeguard public health and strengthen consumer confidence in poultry products across the region.

In conclusion, the results demonstrate that egg contamination by *E. coli* and *Salmonella* remains a significant issue in West Africa. A collaborative approach between governments, producers, and public health agencies is crucial to minimize consumer health risks and enhance food safety across the region.

Abbreviations

AMR	AntiMicrobial Resistance
CTX	Cefotaximane
ECEH	Enterohaemorrhagic Escherichia coli
EPEC	Enteropathogenic Escherichia coli
ESBL	Extrasensitively Beta-Lactamase
FAO	Food and Agriculture Organization
PCR	Polymerase Chain Reaction
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
TEM	Plasmidic Penicillinase
USTTB	University of Sciences, Techniques and Technologies of Bamako
WHO	World Health Organization
WOAH	World Organization of Animal Health

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Author Contributions

Sissoko Aminata: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing

Maiga Boubacar Madio dit Aladiogo: Investigation, Methodology, Validation, Writing – review & editing

Diabate Daouda: Methodology, Supervision, Writing – review & editing

Dicko Amadou Hamadoun: Supervision, Writing – review & editing

Samake Fasse: Supervision, Writing – review & editing

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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