Antibiotic Resistance of *Escherichia coli* Bacteria in Cattle: Challenges to Food Self-Sufficiency in Indonesia

Antibiotic Resistance of Escherichia coli Bacteria in Cattle: Challenges to Food Self-Sufficiency in Indonesia

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Abstrak

Resistensi antibiotik pada sektor peternakan, khususnya peternakan sapi di Indonesia, perlu memperoleh perhatian khusus karena merupakan isu kesehatan masyarakat yang cukup mengkhawatirkan. Penggunaan antibiotik yang tidak rasional untuk terapi, profilaksis, maupun growth promotor telah berkontribusi pada meningkatnya keberadaan bakteri resisten pada sapi potong dan sapi perah. Tantangan utama dalam pengendalian AMR meliputi kurangnya regulasi penggunaan antibiotik di lapangan, keterbatasan fasilitas diagnostik, rendahnya kesadaran peternak, serta kurang optimalnya program surveilans nasional. Tinjauan ini mensintesis temuan mengenai kejadian resistensi antibiotik bakteri *Escherichia coli* (*E. coli*) yang diisolasi dari sapi di Indonesia. Berbagai studi menunjukkan isolat bakteri *E. coli* dari sapi di Indonesia telah menunjukkan resistensi terhadap antibiotik penting, termasuk tetracycline, penicillin, dan beberapa antibiotik golongan β-laktam. Keberadaan bakteri resisten ini tidak hanya berdampak pada penurunan efektivitas pengobatan hewan, tetapi bakteri yang resisten tersebut juga berpotensi berpindah ke manusia melalui rantai pangan, kontak langsung, serta mencemari lingkungan. Berdasarkan temuan ini, upaya pengendalian perlu dilakukan secara terpadu melalui pendekatan One Health, mencakup peningkatan biosekuriti peternakan, penguatan kebijakan penggunaan antibiotik, edukasi peternak, serta pengembangan program surveilans AMR yang konsisten dan berstandar nasional. Hasil surveilance dari data penelitian terkait resistensi bakteri *E. coli* di Indonesia dapat digunakan untuk menekan risiko penyebaran resistensi antibiotik dari sektor sapi ke manusia secara signifikan.

Kata kunci: Antimicrobial resistance, *Escherichia coli,* sapi, Indonesia, One Health.

Abstract

Antimicrobial resistance (AMR) in the livestock sector, particularly in cattle farming in Indonesia, requires special attention as it is a rather concerning public health issue. The irrational use of antibiotics for therapy, prophylaxis, or as growth promoters has contributed to the increasing presence of resistant bacteria in beef and dairy cattle. The main challenges in controlling AMR include the lack of regulation on antibiotic use in the field, limited diagnostic facilities, low farmer awareness, and suboptimal national surveillance programs. This review synthesizes findings on the incidence of antibiotic resistance in *Escherichia coli* (*E. coli*) bacteria isolated from cattle in Indonesia. Various studies have shown that *E. coli* isolates from cattle in Indonesia have exhibited resistance to important antibiotics, including tetracycline, penicillin, and several β-lactam antibiotics. The presence of these resistant bacteria not only affects the effectiveness of veterinary treatments but also has the potential to transfer to humans through the food chain, direct contact, and environmental

contamination. Based on these findings, control efforts need to be conducted in an integrated manner through a One Health approach, including improving farm biosecurity, strengthening antibiotic use policies, educating farmers, and developing a consistent, nationally standardized AMR surveillance program. The surveillance results from research data on E. coli bacterial resistance in Indonesia can be used to significantly reduce the risk of the spread of antibiotic resistance from the cattle sector to humans.

Keywords: Antimicrobial resistance, *Escherichia coli,* cattle, Indonesia, One Health.

Introduction

Escherichia coli is a commensal bacterium of the digestive tract that plays an important role in maintaining the microbiota of warm-blooded animals, including cattle (Dewi et al., 2021). In addition to being a normal flora bacterium, some strains of *E. coli* are pathogenic and can pose risks when present outside their normal habitat (Nanlohy et al., 2021). *Escherichia coli* bacteria is always present in the body of an individual, serves as an indicator bacterium for antibiotic resistance because the use of antibiotics for therapy, prophylaxis, and as growth promoters in cattle farming leads to significant selection pressure, thereby promoting the emergence and increasing prevalence of E. coli resistance in livestock products such as beef and cow's milk (Amalo et al., 2020).

Antibiotic resistance in *Escherichia coli* in the livestock sector has become a global concern because this bacterium has a high ability to transfer various resistance genes, including genes encoding extended-spectrum β-lactamases (ESBL), AmpC, and resistance genes against tetracyclines, aminoglycosides, and fluoroquinolones (Agustin et al., 2025). Studies show that ESBL-carrying plasmids in livestock *E. coli* can simultaneously carry multiple resistance genes and easily transfer through conjugation to other strains, thereby accelerating the emergence of multidrug resistance (Chen et al., 2023). Genomic analysis of *E. coli* plasmids from various animal sources shows that mobile genetic elements such as integrons and insertion sequences—particularly IS26—accelerate the accumulation and spread of antimicrobial resistance genes in livestock environments (Liu & Ma, 2022). The mechanism of antimicrobial gene transfer can occur through plasmids, transposons, and integrons, allowing high levels of horizontal gene transfer and directly contributing to the increase of antimicrobial resistance in bacterial populations within animal production systems (Martins & Brown, 2020).

Antimicrobial resistance in *E. coli* bacteria from livestock is not only a concern for animal health but also has the potential to transfer to humans through food consumption, direct contact, or the environment (Pfeifer and Webb, 2021). Several studies have shown the presence of resistant pathogens from animals that reappear in humans, supporting the idea that animal production serves as a reservoir for resistance (Smith et al., 2017). Recent surveillance reports from European Food Safety Authority (EFSA) and European Centre for Disease Prevention and Control (ECDC) confirm that resistant *E. coli* is still routinely found in animals and animal products, making the food chain an important route of transmission (EFSA & ECDC, 2025).

In many developing countries, including regions with intensive livestock systems such as in Indonesia, the challenges of controlling resistance include the use of antibiotics without veterinary supervision, suboptimal farm biosecurity, limited diagnostic facilities, and uneven implementation of antimicrobial resistance surveillance programs (Maron et al., 2013). This situation underscores the importance of an integrated One Health-based approach, involving the animal health, human health, and environmental sectors, to ensure that AMR monitoring and mitigation efforts are carried out effectively and sustainably (Van Boeckel et al., 2019).

With the growing evidence of E. coli's role as an important indicator of antimicrobial resistance in livestock, a comprehensive literature review is needed to understand the emerging resistance patterns, the factors influencing its spread, and effective control strategies in the cattle farming sector, particularly in Indonesia.

Material and Methodes

The literature for the review in this manuscript was obtained through searches in several major databases, namely PubMed, Scopus, ScienceDirect, Google Scholar, and the Garuda Portal. The search was conducted for publications from 2010 to 2025 using a combination of keywords related to "antimicrobial resistance," "antibiotic resistance," "cattle," "farm environment," and "Indonesia," combining keywords according to scientific literature search standards.

The articles included are original research publications, surveillance reports, and review articles that examine antibiotic resistance in cattle or cattle farm environments in Indonesia, including samples of feces, milk, meat, wastewater, soil, and other environmental materials. Literature that is not based in Indonesia, does not contain antibiotic resistance data, or consists only of opinions, editorials, and conference abstracts is excluded from the selection.

The selection process was conducted through a review of titles, abstracts, and full texts to ensure relevance to the topic of AMR. From each selected study, extracted data included the type of bacteria, resistance testing methods, the types of antibiotics tested, main findings on resistance patterns, and the study locations. Synthesis was performed descriptively according to the narrative review approach.

Result and Discussion

Field studies on cattle in various provinces of Indonesia through the examination of fecal samples, rectal swabs, meat, and milk show a relatively similar pattern of resistance to several groups of antibiotics. *E. coli* samples from dairy and beef cattle farms in East Java and West Java show the highest frequency of resistance to penicillin and its derivatives, including ampicillin and amoxicillin, as well as to tetracycline antibiotics, which reflects the high use of antibiotics in local farming systems (Pratiwi et al., 2020; Widiastuti et al., 2019). Moderate to high resistance to sulfonamide–trimethoprim and streptomycin has also been reported in several studies at dairy cattle production centers, while gentamicin and some fluoroquinolones such as ciprofloxacin generally show lower levels of resistance (Sudarwanto et al., 2017). This is in line with the findings of international studies on intensive livestock farming systems in developing countries, which show that the classes of antibiotics such as first-generation β-lactams, tetracyclines, and sulfonamides tend to have higher resistance rates compared to aminoglycosides and fluoroquinolones (Van Boeckel et al., 2019).

In addition to resistance to common antibiotics, several studies in Indonesia have shown the presence of Extended Spectrum β-lactamase (ESBL)-producing *E. coli* isolates, particularly the CTX-M type, as well as occurrences of multidrug resistance (MDR) in isolates obtained from milk, beef, and livestock feces. The ESBL-producing isolates found in cattle and their derivative products indicate the circulation of plasmid-based resistance genes in the farming environment, consistent with international findings that CTX-M is the most dominant ESBL in the livestock sector in Asia (Dahmen et al., 2013; Madec & Haenni, 2018).

The magnitude of resistance rates across studies in Indonesia varies greatly, depending on the region, type of sample, number of isolates, and the testing method used (either disk diffusion or minimal inhibitory concentration (MIC)). Therefore, comparisons between years or between provinces are difficult to make without a standardized national surveillance framework, which is a challenge also identified by the WHO in the implementation of AMR monitoring in middle-income countries (World Health Organization, 2021).

Table 1. Resistance data antibiotics *E. coli* from cattle in Indonesia

No	Referance (year)	Sample (location)	Amp/Amox / Penicillin (%)	Tetracycline (%)	Ciprofloxacin / Enrofloxacin (%)	Gentamicin (%)	Ceftazidime / 3GC (%)	MDR (%)
1.	Mustika et al., 2024 (data 2023–24)	Rectal swab of cattle (Surabaya abattoirs)	Amoxicillin 29.3%	Tetracycline 24.4%	Ciprofloxacin 7.3%	Gentamicin 2.4%	Ceftazidime 2.4%	7.3%
2.	Dewi et al., 2024 (Veterinary World study).	Cattle production systems (Sumatera Utara)	-	-	-	-	-	High MDR reports (number vary between locations)
3.	Sudarwanto et al., 2016 (CTX-M study).	CTX-M producing *E. coli* (cow)	High for β-laktams; MDR pattern reported	-	-	-	3GC resistance (reported in ESBL isolates)	Many MDR isolates (reports)
4.	Normaliska et al., 2019 (Acta Vet/Review data Indonesia).	Milk samples / dairy farm	Ampicillin/penicillin is often high (some studies >30%)	A series of studies showed moderate-high tetracycline resistance	Variable; some studies show a low-moderate range	Generally lower	Several studies have found ESBL in milk	Some studies: MDR reported
5.	Rotinsulu et al., 2022 (Bogor).	Cow feses (Bogor)	Reportes resistance to some β-laktam	Reprted (specific numbers depend on antibiotic)	Reported for enrofloxacin/ciprofloxacin in some isolates	-	-	-
6.	Berbagai studi local (2010–2023; market, meat,	Meat, markets, wastewater (some province	Reports of ampicillin/amoxicillin resistance 20-70% (varies)	Tetrasiklin 10–60% (range)	Ciprofloxacin 5–35% (range)	Gentamicin is generally <15%	ESBLs are found sporadically	MDR: 5–30%

The development of antimicrobial resistance in *E. coli* on Indonesian cattle farms is mainly influenced by uncontrolled and long-term patterns of antibiotic use. Several studies indicate that antibiotics are still often used without laboratory tests or veterinary prescriptions, both for prevention, mass treatment, and as growth promoters, thereby increasing the selective pressure on commensal and pathogenic bacteria in the cattle's digestive tract (Setiawan et al., 2012). This improper use is exacerbated by farmers' limited understanding of the correct dosage and duration of therapy; there are many cases where antibiotics are stopped before the recommended time or administered based on experience rather than diagnosis (Rahmawati & Suryanto, 2015). These conditions allow bacteria exposed to sub-lethal levels to survive and develop resistance mechanisms (Agustin et al., 2018).

In Indonesia, antibiotics for animals can be easily purchased by farmers at the market. Antibiotics can be bought without a prescription, making their use tend to be excessive and poorly documented (Lestari et al., 2019). On the other hand, inconsistent barn management and biosecurity systems also increase the chances of the spread of resistant *E. coli* strains. Poor barn hygiene, feces management, and drinking water sanitation allow resistant bacteria to survive longer in the environment and infect other animals through indirect contact (Yulianto et al., 2020; Agustin et al., 2025c).

Livestock environments also act as reservoirs for resistance genes. Several studies have found that liquid waste, soil around pens, and water flow contaminated with cattle feces carry the same resistance genes as those found in *E. coli* isolates from animals, indicating horizontal gene transfer within the livestock ecosystem (Harahap et al., 2021). In many cases, cattle are raised alongside other livestock species such as chickens and goats, which may also be exposed to different antibiotics. This practice broadens the sources of selective pressure and increases the chances of gene transfer between bacterial species (Putri et al., 2023).

Although the Indonesian government has tightened supervision of antibiotic use since 2018, including the ban on the use of antibiotic growth promoters (AGPs), implementation on the ground has not been fully consistent. The AMR surveillance system in the livestock sector is also not yet nationally integrated, making resistance trends difficult to monitor regularly (Darmawan & Kusuma, 2024). The combination of inappropriate antibiotic use, still-loose access, suboptimal biosecurity, and high environmental contamination makes cattle farming one of the key sectors in the development and spread of AMR in Indonesia (Agustin et al., 2025b).

The pattern of drug administration, including antibiotics, on Indonesian cattle farms is generally still influenced by self-medication practices and generational experience. Many farmers administer antibiotics based on estimates or personal judgment without professional examination, so decisions regarding drug use often do not follow standard therapy guidelines (Rahmawati & Suryanto, 2015; Agustin et al., 2022). Antibiotics are used when cattle appear sick, such as having a decreased appetite or looking weak, without confirming whether the cause is actually a bacterial infection. Such conditions lead to antibiotics being administered in cases where antibiotic therapy is not necessary, greatly increasing the risk of improper exposure (Setiawan et al., 2012; Agustin et al., 2025a).

Several studies report that farmers still use dosages based on visual estimates, such as "one pill" or "until the cow appears to improve," causing therapy to often be stopped too early or given excessively (Lestari et al., 2019). Administering antibiotics without following the complete regimen creates sub-lethal conditions for bacteria, which accelerates the emergence of resistant *E. coli* strains in the cow's digestive tract (Yulianto et al., 2020). On small farms, the use of leftover antibiotics from previous treatments is also

still common because it is considered more economical (Putri et al., 2023). Meanwhile, the involvement of veterinarians is more dominant on large and commercial farms, whereas on smallholder farms, cost and access limitations make self-medication the primary choice (Darmawan & Kusuma, 2024).

The use of antibiotics in Indonesia has shown an increasing trend over the past two decades, both in the human health sector and in animal-derived food production. Global analysis by Klein and colleagues shows that Indonesia's national antibiotic consumption increased significantly between 2000 and 2015, with a growth rate among the fastest in the Southeast Asian region (Klein et al., 2018). The increase in antibiotic use in Indonesia is mainly related to rising demand for healthcare services, population growth, and the relatively easy access to antibiotics at the community level. A systematic review by Lestari et al. (2022) confirms that the pattern of antibiotic use in Indonesia is still dominated by the 'Access' and 'Watch' categories, with high usage rates among outpatient patients, indicating that self-medication remains a major factor in the high national consumption.

The One Health Indonesia report indicates that the use of antibiotics in livestock is expected to increase alongside the growth of the national meat and dairy industry (Pradipta et al., 2021). Government regulations since 2018 have indeed restricted the use of antibiotics as AGPs, but uneven field supervision has meant that the trend of increasing antibiotic use in the livestock sector continues to be reported in recent studies (World Organisation for Animal Health, 2020).

Conclusion

Overall, the scientific literature indicates that antibiotic resistance in Indonesia tends to increase, supported by the rising use of antibiotics in the country, despite important policy measures in recent years. However, challenges related to unrestricted access, self-medication, and the monitoring of antibiotics in the livestock sector still require special attention.

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