ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(5): 26-32
www.agriculturaljournals.com
Received: 20-01-2026
Accepted: 25-02-2026

A Sangeetha
Faculty, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

P Gokul Raj
UG Student, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

S Balakrishnan
Faculty, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

S Leonal Rabins
Faculty, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

R Durairajan
Faculty, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

C Nandhinidevi
PG Student, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

A Akash
PG Student, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

Corresponding Author:
A Sangeetha
Faculty, Department of Veterinary Public Health and Epidemiology, Veterinary College and Research Institute, Orathanadu, Thanjavur, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India

Dairy farmer's awareness level on antibiotic residues in bovine milk in Thanjavur region

A Sangeetha, P Gokul Raj, S Balakrishnan, S Leonal Rabins, R Durairajan, C Nandhinidevi and A Akash

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i5a.1479

Abstract
In dairy sector, antimicrobials used for therapeutic and prophylactic purposes directly leaves residues in milk. Consuming these residues disrupt the gut microflora that triggers the emergence of antimicrobial resistant bacteria (AMR). AMR bacteria create serious threat by causing treatment failures, biofilm, and potential toxicity in human. Hence, understanding dairy farmer's awareness on antibiotic residues is necessary to implement intervention strategies in Thanjavur, Tamil Nadu. A cross-sectional study was structured to collect from 100 dairy farmers on socio-demographic details, awareness on antibiotic residues, AMR, health hazards associated with antibiotic usage and attitude of dairy farmers towards antibiotic residue control measures and training in Thanjavur region. In this study, awareness of antibiotic residues showed no significant association with socio-demographic factors ($P > 0.05$), whereas AMR awareness was significantly associated with age, education level and herd size ($P < 0.05$), with younger, educated farmers with larger herds were more aware. Majority of farmers (82%) who use antibiotics for their animals had poor knowledge on withdrawal periods and health hazards associated with antibiotic residues. Most of dairy farmers showed positive attitude toward residue control measures such as milk testing (72%), record maintenance (60%) and training programs (92%). The results of the survey indicate inadequate awareness and practices related to antibiotic use, withdrawal periods and antimicrobial resistance among dairy farmers in the Thanjavur region posing a potential risk to public health. Therefore, to close the gap, awareness among dairy farmers regarding use of antimicrobials through veterinary guidance, implementing routine milk residue monitoring interventions could be framed to break the antibiotic residues cycle in milk and further development of milk borne AMR in humans.

Keywords: Milk, antibiotic residues, antimicrobial resistance, cross sectional study and dairy farmer awareness

Introduction
In India, dairy sector play a vital role by contributing to agricultural economy, milk serving as a key source of income and nutrition for rural communities vastly (Somasekaran *et al.*, 2025) [15]. When dairy animals are regularly treated with improper dose antimicrobials to cure diseases and save lives can result in residues in raw milk and dairy products and consuming of residues present in products can pose serious health risks such as allergies, hypersensitivity reactions, ultimately disruptions in gastrointestinal microflora, lead to development of resistant intestinal commensal bacteria (Navratilova *et al.*, 2024**)** **[21].** Additionally, these residues can cause economic losses for the dairy industry as they may inhibit the growth of microbial cultures essential for producing certain dairy products (Estany-Gestal *et al.*, 2024; WHO, 2023) [7]. In other hand, development of antimicrobial resistance (AMR) is a complex phenomenon and has emerged as one of the most significant global public health issues in recent days (Ferdinand *et al.*, 2024) [8]. In general, antimicrobial resistance arises when microorganisms develop the ability to withstand antimicrobial drugs, which allow the conventional treatments ineffective (Aslam *et al*, 2018) [3]. When microorganisms that develop AMR can make diseases in both humans and animals significantly harder to treat thereby prolonging illness, increasing the risk of transmission and resulting in higher mortality rates (Ahmed *et al.*, 2024) [1].
These issues can be overcome by ensuring residue free milk which requires not only regulatory supervision but also responsible practices at the field level by the farmers. In the

dairy sector, lack of awareness among dairy farmers regarding judicious antibiotic use, withdrawal periods and residue related hazards can hasten the spread of AMR microorganisms. In Tamil Nadu, and particularly in the Thanjavur region, dairy farming is an important livelihood activity. The cow population in different districts are characterized by a significant presence of indigenous breeds and a well-established dairy infrastructure. Tamil Nadu has a total of 9.52 million cattle. Thanjavur alone contributes approximately 10.67% of the total cow population, making it a key livestock hub in the state (20th Livestock Census, 2019) [20]. However, information on dairy farmer's awareness levels on antibiotic residues and antimicrobial resistance remains limited. Hence, understanding farmer's knowledge, attitudes, and practices related to antibiotic use is essential for designing effective control interventions and promoting safe milk production. Therefore, the present study was undertaken to assess the awareness level of dairy farmers in the Thanjavur region regarding antibiotic residues in bovine milk.

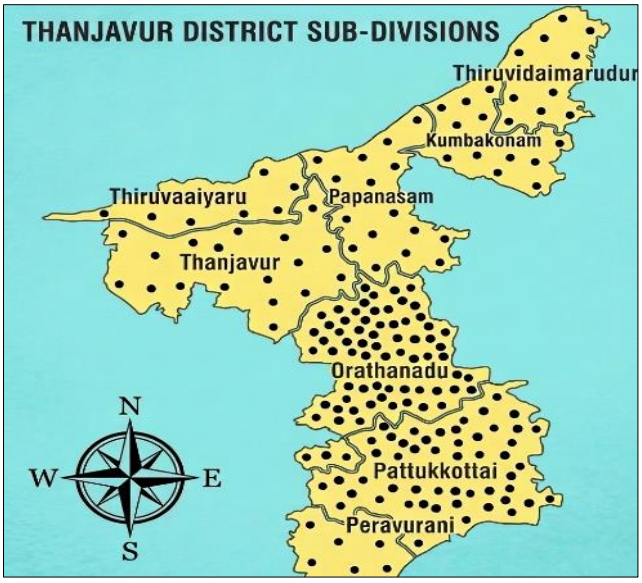
Materials and Methods

Study design and population

A cross-sectional study was conducted to assess the current state of antibiotic usage and resistance in the dairy industry. A structured questionnaire served as the main instrument for collecting data from a representative sample of 100 dairy farmers. The survey was specifically crafted to gather socio-demographic information and evaluate the baseline awareness levels concerning antibiotic residues. Participants shared their understanding of Antimicrobial Resistance (AMR) and the potential health risks associated with contaminated milk. Additionally, the study investigated the perspectives of these farmers regarding the enforcement of stringent residue control measures on their farms. A specific section of the questionnaire was dedicated to examining the availability and effects of technical training offered to the farming community. By employing a cross-sectional methodology, the study provided a snapshot of existing practices and identified knowledge gaps at a specific point in time.

Implementation of survey

The questionnaire encompassed socio-demographic variables, knowledge and practices concerning antibiotic usage, residues, antimicrobial resistance (AMR), the management of milk following antibiotic use, the health implications of antibiotic residues, and the farmers' willingness to adopt residue control measures and training programs. A pilot study was conducted to pre-test the questionnaire for clarity, reliability, accuracy, and consistency prior to documentation (Jacob *et al.*, 2015) [10]. Data collection was carried out through face-to-face interviews with 100 dairy farmers to ensure the precision and dependability of the responses. The collected data was subsequently analyzed statistically, with percentages computed to elucidate the existing trends and identify knowledge gaps.



Map 1: Shows the distribution of selected farmers in district (Taluk wise)

Systematic data collections and statistical analysis

Upon the conclusion of the field-level data collection, the essential information obtained from 100 dairy farmers was carefully compiled and systematically coded within a Microsoft Excel spreadsheet to guarantee data integrity. This structured dataset formed the basis for a comprehensive quantitative analysis aimed at assessing the prevalence of knowledge gaps and behavioral patterns. Initially, descriptive statistics, particularly focusing on frequency distributions and percentage calculations, were utilized to summarize the socio-demographic profiles of the participants and to classify their baseline awareness levels concerning antibiotic residues and the broader implications of Antimicrobial Resistance (AMR).

The study explored the potential relationships between various independent socio-demographic variables such as age, educational background, and farming experience and the farmers' actual knowledge of health hazards. These relationships were statistically assessed using the Chi-square test, adhering to the established methodologies for Veterinary and Epidemiological research as outlined by Thrusfield and Christley (2018) [17]. This non-parametric test was crucial for determining whether the observed differences in awareness were statistically significant or simply attributable to chance.

All statistical significance thresholds were rigorously maintained at a p-value of less than 0.05 ($p<0.05$), ensuring a 95% confidence level in the results. The extensive computational analysis was conducted using IBM SPSS Statistics. This specialized software facilitated a precise interpretation of the data, ultimately providing a solid scientific foundation for identifying which specific groups of farmers necessitate the most urgent educational training and intervention.

Results and Discussions

The socio-demographic characteristics of dairy farmers are presented in Table 1. Many respondents were between 41 and 60 years of age (54%), followed by 26-40 years (30%). Most respondents had completed secondary education (44%), while a considerable proportion had no formal education. Most farmers (70%) maintained small herds

consisting of 1-5 animals. Awareness of antibiotic residues showed no significant association with age, education, or herd size ($p>0.05$). However, awareness of AMR was significantly associated with age, education level, and herd size ($p<0.05$). Younger farmers (<25 years) had highest AMR awareness (71.4%), while awareness reduced progressively with increasing age, and none of the respondents above 61 years reported awareness ($p<0.001$). A significant association was also observed between Education level and AMR awareness ($p<0.001$). Respondents with no formal or primary education were not aware of AMR, whereas awareness increased among those with secondary education (31.3%) and college/university education (44.4%). Similarly, herd size significantly influenced AMR awareness ($p<0.05$), with farmers managing larger herds (>10 animals) had highest awareness (66.6%).

Table 1: Distribution of study participants based on socio-demographic characteristics

Variables	Category	No of respondent (N=100)	% aware of antibiotic residues	P value	% aware of AMR	P value
Age in years	< 25 years	14	57.1	$p>0.05$	71.4	$p<0.001$
	26 - 40 years	30	33.3		20.0	
	41 - 60 years	54	29.6		11.1	
	Above 61 years	2	0		0	
Education Level	No formal education	26	30.7	$p>0.05$	0	$p<0.001$
	Primary	12	33.3		0	
	Secondary	44	36.3		31.3	
	College/University	18	33.3		44.4	
Herd Size (animals)	1-5	70	37.1	$p>0.05$	20.0	$p<0.05$
	6-10	24	33.3		33.3	
	>10	6	0		66.6	

These findings are consistent with Kumar *et al.* (2018) [11] who reported that large dairy farmers were had highest awareness about antibiotic resistance compared to small holders. The Antibiotic Resistance Awareness Index (ARAI) developed indicated that education and herd size positively influenced awareness levels. Similarly, Dhayal *et al.* (2023) [6] reported that level of antibiotic awareness increased with education level, even though no significant correlation between education, experience, age, and the level of awareness concerning withdrawal period was observed.

Awareness regarding antibiotic usage patterns is presented in Table 2. A high proportion of respondents (82%) reported using antibiotics in their dairy animals. In the past 12 months, 42% used antibiotics 1-2 times and 34% reported use for 3-5 times. The primary sources of antibiotics were veterinary prescriptions (76%), followed by pharmacy/medical shops (22%) and fellow farmers (2%). For completion of full course of antibiotics for dairy animals, only 46% of farmers reported completing the full antibiotic course whereas 40% farmers reported completing the course of antibiotics sometimes and 14% never complete full course treatment. These results highlight significant knowledge gaps regarding proper treatment protocols and the use of antibiotics among dairy farmers. Ultimately, fostering rational drug practices will lead to more sustainable and high-quality dairy production.

Table 2: Awareness on antibiotic usage patterns and antimicrobial resistance among dairy farmers

Questions	Response Category	Response (%)
Do you use antibiotics?	Yes	82.0
	No	18.0
Frequency of antibiotic use in past 12 months	None	12.0
	1-2 times	42.0
	3-5 times	34.0
	>5 times	12.0
Professionals responsible for deciding antibiotic use in animals	Veterinarian	76.0
	Paravet/AI worker	22.0
	Self-decision	2.0
Completing full course of antibiotics	Always	46.0
	Sometimes	40.0
	Never	14.0
Do you know what withdrawal period means?	Yes	28.0
	No	72.0
Have you ever heard of the term antimicrobial resistance?	Yes	22.0
	No	78.0
Do you think antibiotics can lose their effectiveness if misused?	Yes	54.0
	No	46.0
Do you think boiling of milk removes residues?	Yes	12.0
	No	56.0
	Not sure	32.0

Similarly, Farhan *et al.* (2024) [9] reported 32.9% farmers did not follow correct dosage instructions and 39% discontinued treatment once clinical signs subsided**.** Additionally, 43% get advice from non-veterinarian sources, and over 20% shared antibiotics with other farmers. Likewise, Das *et al.* 2025 [25] identified storage of antimicrobials at home, sharing drugs with peers, and lack of veterinary consultation as significant predictors of misuse. Compared to these findings, the higher proportion Of veterinary-guided antibiotic use (76%) in the present study is encouraging, though pharmacy access without prescription remains a concern.

In contrast, Kumar *et al.* **(**2021) [12] documented only 10% antibiotic usage among small-scale dairy farmers in Assam and Haryana, suggesting regional variation in antibiotic usage patterns. However, like the present findings, awareness of withdrawal period in that study was extremely low (2%), highlighting a widespread knowledge gap across Indian dairy sectors.

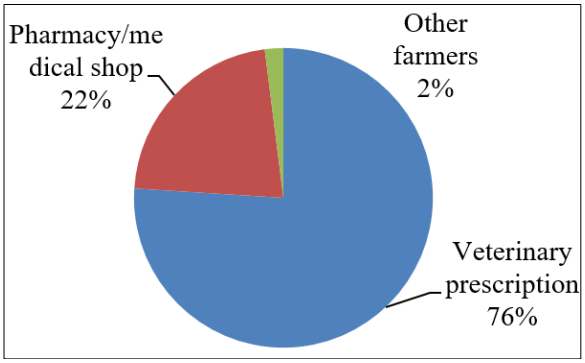


Fig 1: Sources of Antibiotics for Dairy Farmers

Only 28% of farmers in the present study were aware of the withdrawal period, and merely 26% discarded milk after antibiotic administration. Alarmingly, 58% never discarded milk during the withdrawal period, posing a substantial risk of antibiotic residues entering the milk supply chain. These findings closely align with Dhayal *et al.*, (2023) [6] where 63.9% of farmers were unaware of withdrawal time, and 64% did not know about antibiotic residues during this period. Similarly, Das *et al.* (2025) [5] reported that only 8.9% adhered to drug withdrawal periods. A study by Prabhu *et al.* (2025) [14] in southern part of India found that none (0%) of the surveyed small-scale dairy farmers in southern India were aware of antibiotic withdrawal periods, leading to zero adherence and potential contamination of milk entering the food chain. The research highlights a critical need for education, as formal education levels correlated significantly with proper treatment completion, and most farmers failed to maintain necessary animal health records.

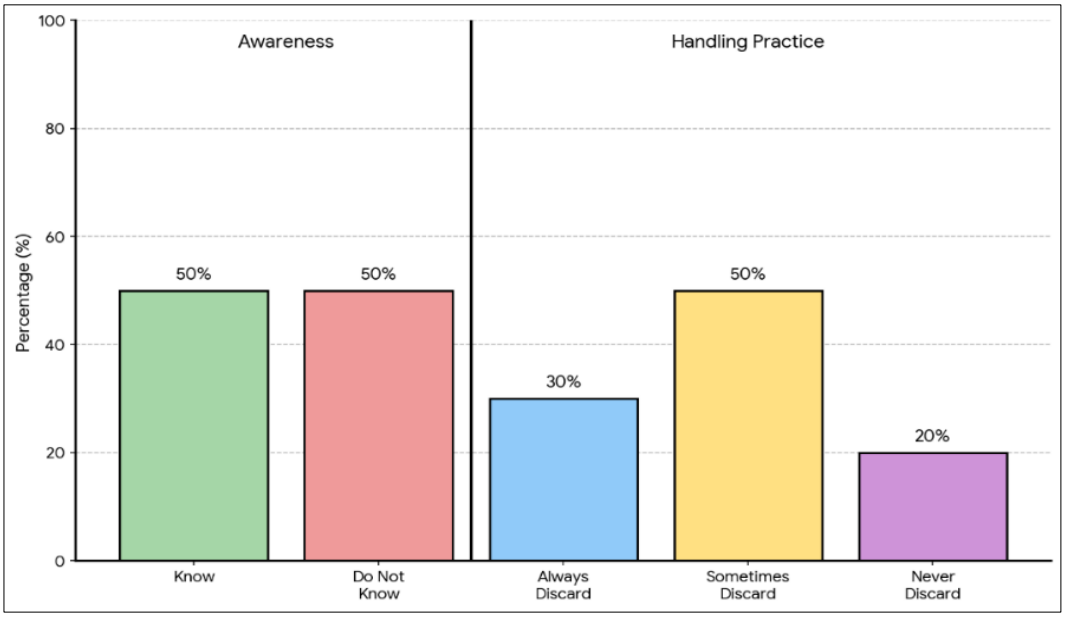


Fig 2: Awareness of milk withdrawal period and handling

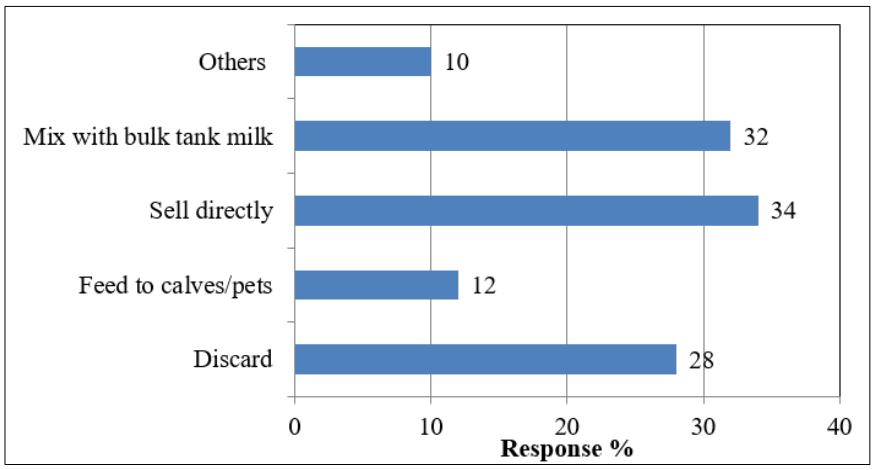


Fig 3: Fate of milk during withdrawal period

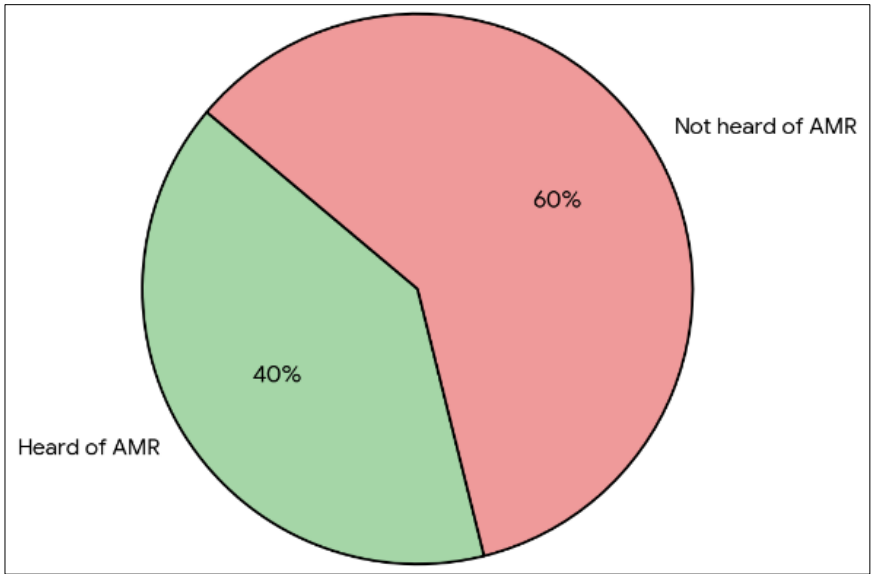


Fig 4: Awareness on AMR

Table 3: Awareness on milk handling practices during withdrawal Period

Question	Response Category	Response (%)
After giving antibiotics, do you discard milk for the withdrawal period?	Always	26.0
	Sometimes	16.0
	Never	58.0
What is done with milk during withdrawal period?	Discard	28.0
	Feed to calves/pets	12.0
	Sell directly	34.0
	Mix with bulk tank milk	32.0
	Others	10.0

Internationally, Widiastuti, (2025) [18] reported that only 32.65% of farmers were concerned about withdrawal periods, and laboratory analysis detected doxycycline residues exceeding permissible levels in several milk samples. This supports the public health concern raised in the present study that poor compliance with withdrawal periods directly contributes to residue contamination.

Awareness of health hazards associated with antibiotic residues was low (32%), and only 18% recognized the role of residues in causing AMR. Furthermore, 90% of respondents had not received any government or cooperative guidelines regarding antibiotic use. These findings are consistent with Dhangar *et al.* (2023) [4] who reported low to medium knowledge about antibiotics and very limited awareness of AMR. Similarly, Das *et al.* (2025) [5] observed that only 18.2% of farmers had heard of AMR, closely matching the 22% AMR awareness observed in the present study. The findings also align with Sharma *et al.* (2022) [16], who reported low knowledge of antibiotics and high prevalence (64.52%) of antibiotic-resistant bacteria in milk samples traded by informal vendors. Numerous studies on awareness reveal a significant deficiency in knowledge at the grassroots level, indicating a serious shortcoming in existing educational outreach and extension strategies. As a result, there is an immediate necessity to revamp communication frameworks to emphasize the "withdrawal

period" and the dangers of drug residues. This highlights the broader public health implications of poor antibiotic awareness not only at farm level but also within the milk distribution chain.

Table 4: Awareness on health hazards associated with antibiotic usage

Question	Response Category	Response (%)
Antibiotic residues affect human health	Yes	32.0
	No	48.0
	Not sure	20.0
Residues cause antimicrobial resistance in humans	Yes	18.0
	No	82.0
Have you received any government or cooperative guidelines about antibiotic usage in dairy animals?	Yes	10.0
	No	90.0

Table 5: Attitudes and willingness of dairy farmers towards antibiotic residue control measures and training

Question	Response Category	Response (%)
Would you support the milk testing system at collection center to check the residues?	Yes	72.0
	No	28.0
Would you be willing to maintain record book of antibiotic treatments in dairy animals?	Yes	60.0
	No	40.0
Interested in training on judicious use of antibiotics and residues prevention?	Yes	92.0
	No	8.0

Despite knowledge gaps, most farmers supported implementation of milk testing systems at collection centers (72%), maintenance of antibiotic treatment records (60%), and participation in training programs. This indicates a positive attitude toward corrective measures. Such willingness to engage in interventions supports the recommendation of Dhangar *et al.* (2023) [4] strongly recommended the implementation of regular training programs, awareness initiatives, and hands-on demonstrations to address the knowledge deficit at the grassroots level. Research indicates that these focused interventions are crucial for encouraging responsible antibiotic usage and rectifying prevalent misunderstandings about medication. By shifting from sporadic posters to ongoing educational efforts on farms, the aim is to substantially lower the risk of antimicrobial resistance within the dairy sector. In the end, these organized programs are intended to guarantee that safety protocols are effectively integrated into the daily practices of small-scale farmers. Similarly, Research conducted by Ahmed *et al.* (2011) [2] underscored that the trends in milk production in Pakistan are significantly affected by technological advancements and the awareness of farmers, forecasting a consistent increase in production until 2015. Their research supports the necessity for strong extension services to ensure that these production improvements result in safe, residue-free dairy products. More recent studies related to this topic highlight that without regular training at the grassroots level, such increases in production frequently compromise the rational use of antibiotics. By connecting production forecasting with safety education, establish a framework for sustainable development in the dairy sector.

Conclusions

The present research highlights a significant deficiency in awareness concerning antibiotic residues and the dangers associated with Antimicrobial Resistance (AMR). Although there is a moderate dependence on veterinary counsel, there remains a persistent issue with noncompliance regarding withdrawal periods, coupled with the ease of obtaining drugs over the counter. These findings reflect wider national patterns of insufficient training and the misuse of antimicrobials among small-scale producers. Nevertheless, the farmers' favorable disposition towards milk testing and professional advice presents a valuable opportunity for effective intervention. Therefore, the establishment of organized awareness initiatives and integrated surveillance is crucial to protect public health in the Thanjavur region.

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