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A Dual Focus Approach: Unveiling Drug Consumption Patterns and AMR Reduction Strategies in India's Small Dairy Sector

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Abstract

The production of livestock, especially dairy products, is crucial to the food and nutritional security of Indian communities. It boosts the nation's economy and provides wages for an enormous number of farmers. In India, antimicrobial resistance (AMR) microorganisms pose a major threat to public health, a country that consumes a great deal of antibiotics. The objectives of this study were to assess prior AMR-mitigation methods, highlight medication usage and animal health practices that can be contributing to the establishment and spread of AMR in the nation that discuss the Theory of Change (TOC) as a method for influencing the selection of alternatives. We identified activities in India that have the possibility of facilitating the development and dissemination of resistant antibiotics. We conducted a review of the literature using PubMed, Google Scholar and Google then summarized as well as reviewed the findings by categories. One thousand studies from three distinct sources were found after a thorough review of the literature. After rigorous screening and meeting qualifying standards, thirty papers were included in the final analysis. Inadequate infrastructure supports the delivery of services and animal disease surveillance is not as advanced. Services for animal health are provided by a number of entities. Farmers therefore, take care of their animals and seek consultation when an animal's condition becomes unresponsive to therapy. Antibiotics are employed when treating mastitis instances. There is little evidence of drug withdrawal periods and there have been reports of antibiotic-contaminated milk. This study addresses different medication usage and animal health behaviors that result in AMR and recommends that stakeholders engage in a TOC exercise to support treatments that prioritize animal health and investigate adoption incentives.

Keywords: Livestock Production, Drug Consumption, Antibiotics and Antimicrobial Resistant (AMR) Bacteria, Theory of Change (TOC)

INTRODUCTION

The industry confronts a variety of difficulties, two of which are the increasing threat of antimicrobial resistance (AMR) and the usage of antibiotics. This research delves deeply into the complex interactions that exist between medication use and AMR mitigation tactics in India's small dairy industry. Despite being a worldwide issue, Antibiotic resistance is believed to have the greatest impact on low and middle-income countries (LMICs). Laws controlling the use of antibiotics in humans and animal medicine are loosely implemented; India ranks fourth in the world for the use of antibiotics in cattle (1). The factors that influence and determine the use of antibiotics on farms are not well understood. Antimicrobial Higher-income countries (HICs) have become more aware of stewardship in veterinary care as a result of the collection of extensive baseline data on antibiotic use on farms (2). The use of antibiotics and related practices, the recognized risk of antibiotic residues and AMR bacteria migrating from dairy cows to people are the reasons for the stringent regulations on dairy farms in the High-Imperiancy Corridor (HIC). Given the size and diversity of India, there is much data about the use of antibiotics there, especially on dairy farms. It is difficult to impose rules on dairy farms in a nation of vast and

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diverse (3). Nonetheless, since India produces more milk than any other country in the world, the public's safety needs to find evidence of antimicrobial use in dairy farms. Beyond merely rating farmers' degrees of expertise, the research sought to do more. It was anticipated that a more comprehensive and cross-validated understanding of antibiotic usage would be obtained by examining the farmer, the agricultural setting and the milk that is produced (4). No other research has used a three-pronged method, looking at the farm, the product and the farmer gains a comprehensive picture of the function of small-scale dairy farmers. Antimicrobials are necessary for fighting microbial diseases, protecting animal and human health. Nevertheless, careless AMR develops more quickly when medicines are used, decreasing their efficacy of therapy and threatening the continued use of medicinal treatments in humans and animals (5). Milk provides essential nutrition for people worldwide. Drinking unpasteurized milk raises health risks since it has a significant number of microorganisms and provides a favorable environment for the growth of germs. When it comes to animal welfare and dairy farm income, mastitis is the most prevalent illness among cows used for dairy production. Antimicrobials are employed in veterinary medicine and health maintenance. They serve to stop the spread of illnesses among poultry and animals. There is debate about the use of antibiotics on food-raised animals (6). Frequent antibiotic usage in animals raised for food is considered to worsen antibiotic-resistant bacteria AMR for prophylaxis, feed proficiency enhancement and growth acceleration. Antibacterial residues in food items, including beef, poultry, eggs along with their by products from food-producing animals, potentially lead to health issues. Mutability, tumor formation and allergic or hypersensitive reactivity are examples of serious health problems. Transformation of microbiota and potential development of AMR occur in less severe situations. Certain beneficial bacteria that is present in animals that produce food spread to fresh meat and dairy products. These bacteria can function as repositories for resistant genes that could be incorporated into human pathogenic microbes. Figure (1) represents AMR in dairy animals (7). The increasing issues of bacteria becoming resistant to antibiotics poses a hazard to both people and animals worldwide.

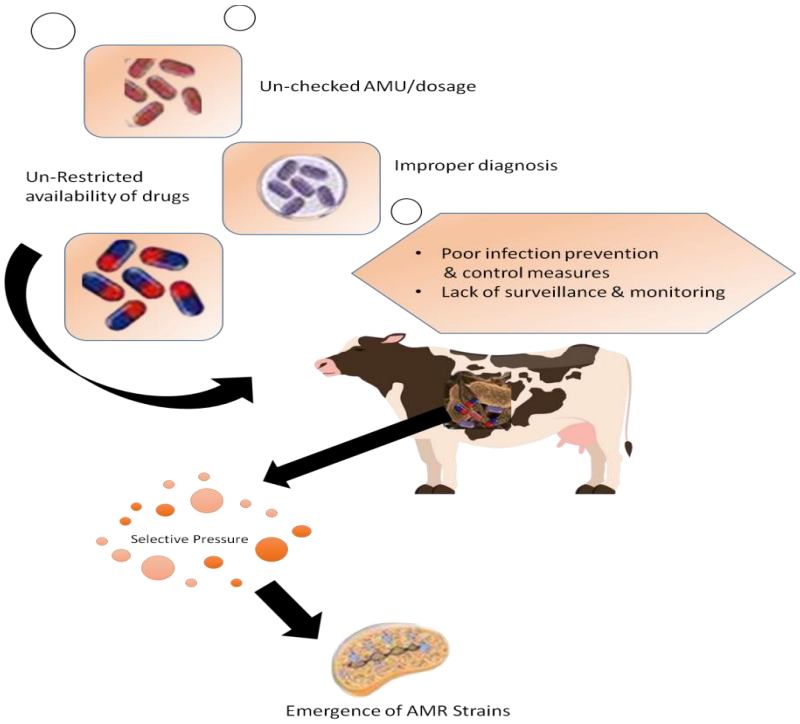

Figure (1). Antimicrobial resistance in dairy animal

(**Source:** https://www.researchgate.net/figure/Possible-factors-leading-to-antimicrobial-resistance-AMR-in-dairy-animals_fig3_321831984)

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The initiative is a small-scale effort to reduce the overuse of antibiotics in dairy cattle via research-based therapies. By educating the action-learning population about the use of herbs and lowering the incidence of illness, good management, cleanliness as well as infection control measures, the five-layer strategy from natural livestock farming was applied (8). The goal of the study is to shed light on common practices by analyzing the kinds, amounts and modes of administration of antimicrobial medications in small dairy businesses. It aims to determine, assess and provide practical methods for reducing AMR risks in the industry. Modern processing and retailing organizations usually invest in modernizing their procurement procedures to get raw materials of the highest caliber. Farmers need to invest in new technologies increase efficiency for minimal production, enhance product quality, or meet other private demands. Numerous studies have shown how difficult it will be for small and impoverished farmers to comply with these new regulations and whether this will further marginalize this group. These farmers face new obstacles, but the same mechanisms and pressures are a driving factor toward innovation, technology transfer and agricultural involvement (9). The Indian dairy chain is a very pertinent example. First, since the poor are heavily dependent on agriculture, labor-intensive industries like dairy, which do not unduly depend on economies of scale or access to land, are assumed to provide the poorest rural households with limited land with better opportunities for income development.

METHODOLOGY

A systematic examination of existing literature was conducted to ascertain practices that can have a role in the development and dissemination of antibiotic resistance in India. Google, Google Scholar and PubMed were searched. A suitable mix of keywords was employed, such as “drug resistance”, “antibiotic resistance”, “AMR” and “animal health concerns”, or “animal husbandry” and “agriculture”. Figure (2) depicts the PRISMA flow diagram: they looked and examined articles that were referenced in the papers under evaluation. Our attention was drawn to the practices of the dairy subsector. The extracted content was determined to be pertinent to the study. Table (1) shows the benefit of animals AMR interventions, antimicrobial stewardship, the dairy industry, the mastitis issue, the provision usage of antibiotics, veterinary medical care, patterns, antibiotics traces in dairy as well as the "theory of change" were the topics that were used to summarize and explain the findings.

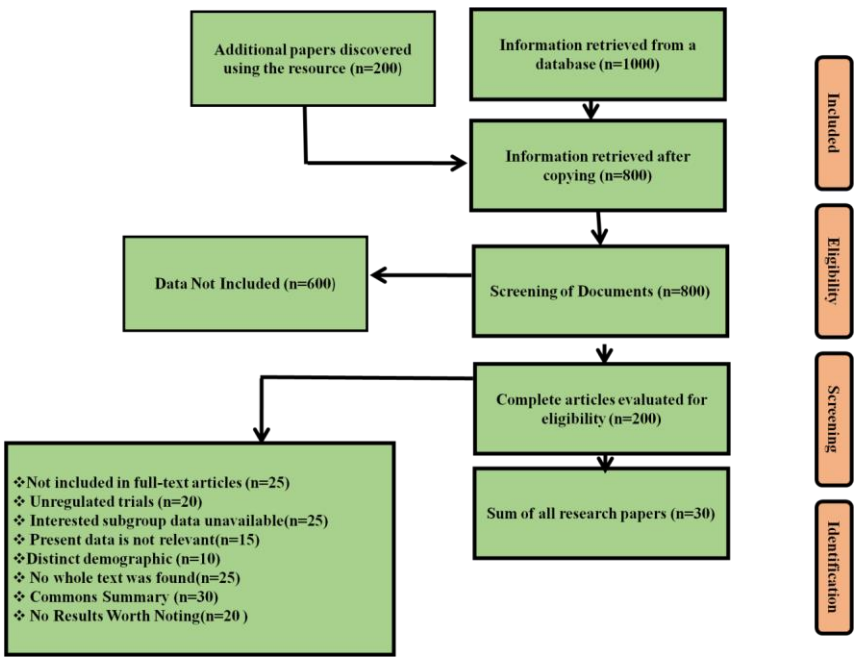

Figure (2). PRISMA flow diagram

(Source: Author)

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Table (1). Antibiotic use for the benefit of animals

(Source: Author)

Resistant to antibiotics	**Methods used on farms (that might lead to AMR)**	**Endless access to medicines**	**Advice given when a pet is unwell**
Protocols for animal health	Profiting from the sale of antibiotic-treated milk inadequate methods of disease control, such as immunization For individuals who are knowledgeable, the loss implications make it impracticable to contemplate antibiotic withdrawal periods.	Sale of pharmaceuticals directly to farmers' over-the-counter usage (reusing previous orders and informal prescribers, with or without permission).	Veterinarian consultations are typically delayed until the situation has worsened and frequently follow the treatment of sick animals by untrained personnel. Consulting with unprofessional groups (such as para-veterinarians and milk merchants)
Inference	Unsupervised withdrawal durations and residual levels beyond the permissible limits expose consumers to low doses of antibiotics, which can lead to the development of microorganisms resistant to these drugs.	The plan could persuade farmers to take antibiotics even when they aren't necessary combat AMR, it is crucial to take medications with caution.	Because they lack the necessary training, they are ill-equipped to know which medications to provide. Furthermore, they lack an understanding of AMR.

Issue of mastitis and the dairy industry

In India, agriculture and animal husbandry employ around 70% of the workforce. India is home to more dairy animals than any other country in the world, with over 400 million cows (10). 60% of all milk is produced by cattle and depending on the area, dairy cows produce milk. The majority of the animals are owned by local farmers, who account for more than 70% of all milk animals in the nation, according to information included in research on the "impacts of mastitis in small-scale dairy production systems." Just 6% of agriculture has more than six animals (11). Although it varies by state, per capita milk consumption is thought to be highest in metropolitan areas, where 60% of milk is eaten on farms. The disease continues to be an issue in a large number of dairy herds, accounting for over 75% of all losses. Its incidence is caused by a number of things, including the incapacity to segregate sick animals, the lack of sanitary milking practices and the failure to disinfect cow barns. When these infections are detected in milk, they should be thrown out as they are not appropriate for humans using 6344 cattle from 25 investigations, a combined rate of 54% for mastitis subclinical in the Indian subcontinent (12).

Usage procedures for antibiotics

Antibiotics are seldom used prophylactically by smallholder dairy producers and animal immunization is not a regular practice. Farmers make the decision about when to use antibiotics because extension networks are not yet completely formed. Rather than being kept in isolation, sick animals are attended by the ranchers individually (without the assistance of qualified veterinary specialists). Antibiotics are easily obtained over the counter, even without a prescription or with an outdated one (13). Farmers seek treatments using fast-acting

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medications, depending on what is accessible, their past experience using the medication to treat comparable problems and recommendations from feed shops, colleagues and vets. They reported increasing the number of drugs when it was thought that the patients were not responding well to therapy to cover animals after parturition and boost milk supply; antibiotics are employed. The other issue is that drug supplier's salespeople, who are allegedly well-established in the villages, are directly selling narcotics to farmers. There have been reports of drug access via associations, feed stores and milk vendors. Table (2) shows the current situation of antibiotic residues (14). Essential antibiotics are utilized in aquaculture and animals. Farmers are aware of the effects of incorrectly discarding milk from infected and cured cows, which can contaminate ecosystems.

Table (2). Current situation of antibiotic residues in Indian milk as determined by a desk analysis

(Source: Author)

Study area	**Bihar**	**Assam**	**Punjab**	**Andhra Pradesh**	**Thrissur**
Test analyses procedure	HPLC (n=260)	Entice Rosa	Immunoassay for Ridascreen Competitive Enzymes (n=122)	Raw milk Delvo test (n = 350)	Antimicrobial Activity Test (n = 170)
% positive	1.4(Metronidazole)	90(Streptomycin with Neomycin)	13.7 (antibiotic)	9 (medication), 8 (antibiotics), 6 (chemical)	8 (remaining antibiotics)

Ownership of crossbred cattle, proximity to animal health facilities and the farmer's financial situation affect which animal health services the rancher chooses desire among vets for assistance because they felt that they were more accessible to them when needed; in others, they went to government representatives or cooperatives that they belonged for assistance (15). It was discovered that farmers relied on reading up on para-vets 68% more than on experts. In the Districts, 82% of farmers sought counsel from quacks prior to seeing veterinarians. Informal medication prescribers are referred to as confidential physicians (16). Veterinarians are the primary suppliers of services at the farm level, charging less. Small-scale farmers contact physicians after an animal has gotten very sick and after the animal has received many antibiotic treatments. It is challenging to choose a course of therapy to reduce the risk of AMR since farmers rarely provide their veterinarians with information about prior treatment histories (17). Dairy farms with many areas of land tend to use antibiotics sparingly and seek the advice of licensed veterinarians rather than small-scale farmers, who contact assistants. Select "quacks only" (24%) and "veterinarians only" (30%) as the sole suppliers of animal medical care. Additionally, select "veterinarians and quacks" (52%). In a similar vein, smallholder farmers (n = 58), doctors (52%), paramedics (32%), salespeople at over-the-counter (14%) and milk dealers (9%). Farmers decide to sell animals if they don't react well to therapy.

Farmers claimed they selected quacks, which cost them less since the cost of hiring a veterinarian to inspect their farms was too high for them to shoulder. They occasionally ask vets to prescribe inexpensive antibiotics and these requests are simply granted unless the situation is complex. AMR is a concern associated with increased antibiotic usage. There have been reports of traditional herbal remedies that is used to cure a variety of illnesses in animals, primarily by smallholders. Acute mastitis and the effectiveness of homeopathy are managing it. They found that it was 87.7 % effective overall, that recovery took four to six days and that the cost was estimated (18). Dairy producers are likewise becoming more and more aware of new formulas. Table (3) represents the important measures for AMR regulations. A heavy dependence on traditional medicine might make it more difficult for farmers to participate in agricultural extension programs, particularly those aim to encourage the use of contemporary medicine.

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Table (3). Important measures for AMR regulations in India

(Source: Author)

The year that action was taken	2019	2020	2022	2019	2020
Implementing specifics	Its formulations are used in dairy, poultry, aqua farming and animal feed additives.	AMR National Action Plan	In February 2016, an international conference on AMR was held.	The media campaign named "Medicines with the Red Line" was initiated.	The use of antimicrobials is regulated by a set of regulations that were drafted.

Providing services related to animal health

Approximately 34,500 field veterinarians' work in India compared to a necessary 75,000. Over 75% of the team is dedicated to providing veterinary care, with the remaining 3.5 percent working on disease control and research projects. There are around 22 public veterinary vaccine manufacturing facilities, 60 veterinary colleges and 12 state veterinary institutions. Despite significant subsidies, the state's animal health and disease management programs are insufficient to meet the demands of impoverished farmers, advice from unskilled persons. Numerous distant locations are left out of ongoing programs, some communities lack access to veterinary clinics and monitoring systems do not cover the entire nation. Veterinarians hardly use the available testing facilities to treat illnesses since they are ill-equipped (19). Testing for antibiotic susceptibility is carried out in situations where there has been evidence of treatment failure or a poor response; it is not taken into account for regular case diagnosis. Samples are supplied by the farmers themselves, especially the larger ones received instructions. Due to their limited number and hectic schedules, veterinarians are able to participate in outreach programs. They feel compelled to issue prescriptions and advise over the phone (20). Veterinarians prefer to employ new-generation antibiotics for the treatment of refractory mastitis because they have a good track record of success. The medications are pricey and farmers might not be able to afford them. But more significantly, they might be the last choice for treating serious illnesses in people and using them might lead to resistance that is selected, which would restrict their potential use in the future. Field veterinarians follow the advice of powerful people when treating sick animals; they are not likely to be educated on AMR and its effects on general health.

AMR treatments

The effects of AMR are well recognized and several varying-level mitigation strategies have been started. Its strategic goals include lowering the prevalence of infectious illnesses, increasing knowledge via research and surveillance as well as raising public consciousness of AMR. Maximizing the application of antibiotics and guaranteeing long-term financial commitments to the fight against AMR. The goal of GAP was to assist member nations in creating their own National Action Plans, with yearly activity tracking serving as a gauge of success, ensuring the generation of trustworthy data, as well as promoting and strengthening national AMR surveillance. The World Health Organization (WHO) created a list of vital medications whose use in animals has to be limited to maintain their efficacy (21). The creation of new drugs has been pushed, but progress is hampered by developing resistance and pharmaceutical companies lack incentives to spearhead the effort in underdeveloped nations; infrastructure support for diagnosis, construction of an ongoing AMR surveillance system and monitoring of treatments are crucial. There are several suggested substitutes for antibiotics, such as probiotics, bacteria (which lyse microbes) and quorum-sensing inhibitors (which reduce microbial cytotoxicity).

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India has taken various measures to restrict AMR, including developing a national policy for AMR containment (22). Microorganisms' exhibit resilience is depicted in Figure (3). One of India's main concerns is the rise of AMR. The National Policy for Containment of AMR lays out techniques to mitigate AMR.

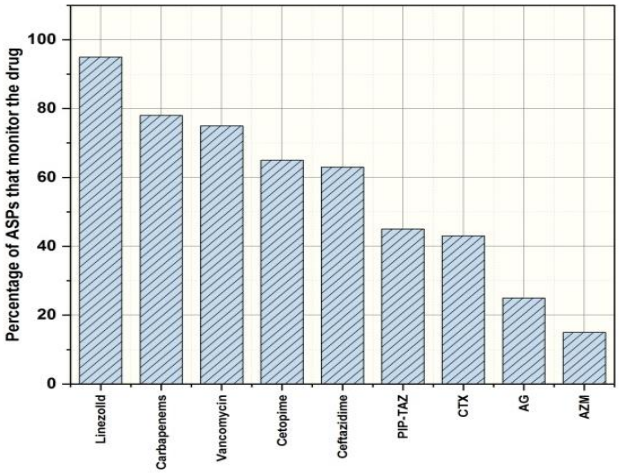

Figure (3). Microorganisms exhibit resilience

(Source: https://www.researchgate.net/figure/Bar-graph-showing-percentage-of-antimicrobial-stewardship-programs-ASPs-that-monitor_fig1_38032145)

These strategies include keeping tabs on antibiotic use and misuse, conducting hospital-wide surveillance on challenges related to resistant bacteria, tracking drug patterns, establishing a bacteria monitoring structure, enforcing regulations regarding the use of antibiotics for industrial, veterinary and human purposes, encouraging prudent antibiotic use and bolstering diagnostic capabilities the distribution of medications without a prescription, limitations in accordance with the Global Action Plan, India has created a National Action Plan for AMR (NAP-AMR) for the years 2018 through 2020 (23). Table (4) shows the theory of AMR interventions. The following major obstacles have been recognized as potential obstacles to its execution: funding to carry out and maintain the proposed activities, methods for effective government agencies working together, laws that are enforced effectively and technological oversight provided nationwide.

Table (4). Assumptions used in a theory of AMR interventions (Source: Author)

Factors presupposed	Inputs and results of outputs	Results
Farmers are familiar enough with the subject to comprehend the information	Farmers receive instruction and written materials about the significance of AMR and how to minimize the usage of antibiotics.	The usage of antibiotics and AMR are now more understood among farmers.
Farmers think it is possible and socially desirable for behavior to change	The farmer gets encouragement, messages and other communications that help them become ready for change	Farmers are inspired to adopt new behaviors
Farming can afford the necessary inputs. Alternatives are within the reach of farmers. Farmers perceive advantages in using less pesticide.	Options that can lower the usage of antibiotics are available to producers	AMR decreases when the use of medicines is decreased concerning living beings, their by products and the ecology of wildlife.

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Impact of the theory of change (ToC) on AMR mitigation

Over the past 20 years, AMR has risen and it is pervasive over the whole planet (24). Furthermore, it is established that the overuse and abuse of antibiotics might promote the growth of germs resistant to such drugs (25). Figure (4) shows the antimicrobial percentage displayed in a graph (26). There are several AMR mitigation strategies. Thus, it's important to show how each one helps to solve the issue. A project's long-term objective is specified and all prerequisites are found. Each pre-condition associated activity is listed and a program can use this information to determine where to take action given the facilities at its disposal (27).

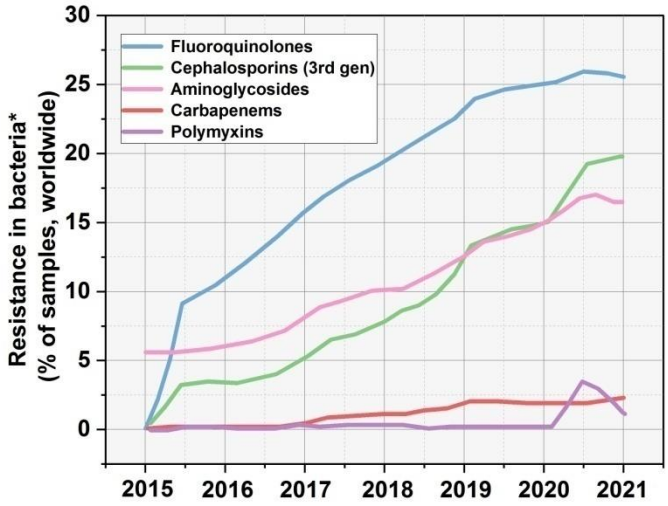

Figure (4). Antimicrobial percentage displayed in a bar graph

(**Source:** https://www.bioedonline.org/news/nature-news-archive/spread-of-antibiotic-resistance-gene-does-not-spell-bacterial-apocalypse-yet/)

Veterinarian Facilities

A total of 12% (CI 9–15%) of farmers responded in the negative when asked how they had veterinarian appointments. Of these, medium-scale farmers made up the remaining 78 % (CI 77 to 88%) and they were modest landowners (28). Small-scale farmers accounted for 87% (CI 83–90%) of the 61% (CI 44–57%) of farmers who reported having fewer trips to the veterinarian than annually, followed by medium-sized farms (9%; CI 6–13%) and large-scale farms (4%; CI 2-6%). In a similar vein, the low frequency of veterinary visits appeared to be more common in small-scale farms.

DISCUSSION

Antibiotics are produced and used in large quantities in India. AMR caused by food animals in a number of ways. Inappropriate usage of antibiotics can lead to bacterial mutations that make them resistant to antibiotic therapy (29). The resistance genes can be acquired by other bacteria, making them immune as well. Human and livestock usage of penicillin is comparable and antibiotic resistance (AMR) against medications used due to the health of animals affect human health. It is concerning when animals are given large doses of vitally needed antimicrobials for either prophylactic or therapeutic purposes (30). Once resistant, these bacteria can infect people (by tainted food, animal interaction, or natural environments). The result is an illness that is resistant to current medications, requiring the use of more advanced, potentially costly treatments when third-generation

cephalosporins are resistant, carbohydrates used as a last option, which might worsen the AMR issue. The release of medication residues in foods derived from animals is a significant mechanism for the establishment of AMR. Consuming milk polluted with residues can cause allergic responses in addition to the negative impacts on public health.

CONCLUSION

India has an issue with the usage of antibiotics. Filling up the gaps found in our study can help to reduce AMR, but first, stakeholders can participate in a theory of change exercise to learn more about the change process and how it occurs. It is important to support and plan actions that tackle AMR from the standpoint of animal health in a way that makes monitoring and assessment possible. The government's commitment to tackling the issue of AMR in the nation is demonstrated by initiatives like the National Health Policy of AMR. These initiatives should be supported. It is necessary to investigate strategies that improve the various stakeholders' compliance. Furthermore, it is necessary to investigate the way they were administered and whether their withdrawal periods have not been followed. When found in milk, it can obstruct the formation of lactic acid bacteria, which can disrupt several dairy processes and lower the standard of the item. There are medication residue limits for animals fed veterinary medicine.

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