Global Journal of Health Ethics,Volume1,Issue2,June,2025,DOI: https://doi.org/10.63101/gjhe.v1i2.009

Original Article

Accessibility of Veterinary Health Information and Its Association with the Uptake of Veterinary drug residue contaminated products Among Farmers in Bugesera District, Rwanda.

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ABSTRACT

Background: Veterinary drug residue contaminated products result from extensive use of veterinary drugs in farm animals and non-strict adherence to the drug withdrawal period. The uptake of veterinary drug residue contaminated products poses human health risks, including antimicrobial resistance, cancer, and birth defects, among others.

Objective: This study aims to determine the accessibility of veterinary Health Information and its association with the uptake of veterinary drug residue contaminated products among farmers in Bugesera District, Rwanda.

Methods: A mixed-method, cross-sectional study was conducted among 236 farmers supplying meat and milk in Bugesera District. Data was collected through surveys, interviews, and focus group discussions. Descriptive statistics, including frequencies and percentages, were used to summarize the quantitative data. Fisher's exact test and cross-tabulations were employed for inferential analysis. Qualitative Data were analyzed using content analysis.

Results: The results showed that 65.77% of respondents accessed veterinary health information on the uptake of veterinary drug residue contaminated products through training on meat and milk safety and 89%, 11% through veterinary service delivery from private public partnerships. Inferential analysis showed that access to Veterinary health information was strongly associated with the non-uptake of veterinary drug residue contaminated milk where trained participants were 65% less likely to deliver veterinary drug residue contaminated milk to Milk Collection centers (Mcc), OR (0.35 at 95% CI (0.18, 0.68).

Conclusion: The study found a need for increased comprehensive private public partnerships on veterinary health education and put in place other protective measures like improved ways of destroying condemned carcasses to prevent and control drug residues in one health ecosystem.

Key words*:* Veterinary drug residue contaminated products, Veterinary health information, Private public Partnership, drug residues, withdrawal period.

1. Introduction

Veterinary health information encompasses a wide range of activities aimed at improving animal health, which in turn supports the wellbeing of both animals and humans. This includes the prevention and control of diseases, ensuring the safety of animal-derived products, and the responsible use of veterinary medications to enhance the health and productivity of farm animals. Additionally, veterinarians play a key role as educators by raising public awareness about infectious diseases and collaborating with professionals from other disciplines to promote a holistic approach to health education (Shrivastava, Sahoo, & Venkatesh, 2025). Veterinary medications are commonly used to improve health and production of farm animals to meet animal source food demand (Mume,2023). The lack of veterinary health information on non-use of animals products from currently treated animals (before the time withdrawal period) in food value chain results in production of veterinary drug residue contaminated products (Mouiche et al., 2024 & Donkor et al., 2011).The uptake of veterinary drug residue contaminated products is a major public health problem irrespective of geographical areas, economic, legal differences between countries and are beyond permissible level in developing countries (Singh et al., 2024&Oloso et al., 2018). Farmers supply veterinary drug residue contaminated products, and their consumption leads to adverse health effects including cancer, birth defects among others (Hosain et al., 2021& Soares et al., 2022).

Studies proved that inaccessibility to veterinary health information regarding withdrawal period leads to increased uptake of veterinary drug residue contaminated products (Murugesan et al., 2023), while accessibility of veterinary health information through veterinary service delivery protects the public from consuming veterinary drug residue contaminated products and other veterinary related hazards (Kabirigi,2022 &Ture et al., 2019 and Young et al., 2010). In Namibia rural farmers did not access veterinary health information through veterinary service delivery due to long distance from town to their residence and this poses a great risk to them since they didn't know how to handle and protect them while performing their farming activities, they were at risk of getting zoonotic diseases and supplying veterinary drug residue contaminated products (Haakuria et al., 2020). A survey conducted in Cameroon revealed that 98% of surveyed farmers did not access veterinary health information on drug residues in slaughtered animals (Vougat Ngom et al., 2020). Another research conducted in Kenya on Knowledge of antimicrobial resistance and drug withdrawal revealed that 75.7% of farmers reported that they did

not sell or consume veterinary drug residue contaminated products (Kemp et al., 2021). A study conducted in Ethiopia intended to identify drug residues in carcasses and KAP level of community about drug residues in beef showed that only 25.8% knew about withdrawal period and limited knowledge on effect of drug residues on human health,47.5% have never heard antibiotic residues in meat (Kimera et al., 2020). Earlier researchers reported that boiling raw milk at 100.7°C for 2 and 5 minutes reduced oxytetracycline residues by 30.5% and 54.1%, respectively, and sulfamethazine residues were more stable, showing only 1.7% and 9.5% reductions whereas freezing at -10°C showed no effect, leaving the risk significant to consumers (Fathy et al., 2019). Previous studies demonstrated that the drug withdrawal period was not consistently understood and followed by farmers due to lack of awareness (Abdeta et al., 2024). Expensive veterinary services pushed farmers to look veterinary information from non-professionals like antimicrobial vendors, use of antimicrobial informally through purchase without prescription (Vivienne et al., 2018). In Tanzania farmers reported to supply veterinary drug residue contaminated products to avoid economic loss (Tufa et al., 2023). A review on veterinary drug residue contaminated products revealed that the lack of governmental oversight, supervision on antimicrobial use and low enforcement of laws regulating the use of antimicrobials contribute to increased veterinary drug residue contaminated products (Mbanza & Sibomana, 2019).

In Rwanda, milk should be delivered to Milk Collection Centers where it undergoes quality testing before consumption. Research indicated that consumers were willing to pay more for higher-quality milk (Mbanza & Sibomana, 2019), while farm animals should be slaughtered at abattoirs to provide safe meat for human consumption. Additionally, a study on veterinary drug usage reported an annual average consumption of $11{,}763.80 \pm 1{,}486.91$ kg used in farm animals and could lead to production of veterinary drug residue contaminated products (Manishimwe et al., 2024). In Bugesera District, a recent study found that farmers received Veterinary health information primarily from other farmers (37%), veterinarians (24%), and the radio (12%), with smaller proportions obtaining information from local government officials, schools, and hospitals (each 1.3%) (Munyeza et al., 2025). There is currently no information on farmers' knowledge regarding the effects of veterinary drug residue-contaminated products in Bugesera District and could lead to increased uptake of Veterinary drug residue contaminated products. This study aims to assess the accessibility of veterinary health information and its association with the consumption of such contaminated animal source food among farmers in the district.

2. Materials and Methods

2.1. Study Area

A mixed-method, questionnaire-based cross-sectional study combining a quantitative survey and qualitative focus group discussions (FGDs) was conducted between February and March 2025. The study involved farmers supplying meat and milk in Bugesera District, located in the Eastern Province of Rwanda. A total of four sectors of Bugesera District in which the abattoirs and milk collection centers are found were purposively selected. The selected abattoirs and milk collection centers are in Nyamata, Mayange, Ruhuha and Rweru sectors where all farmers from Bugesera District are supposed to supply meat and milk depending on their proximity. The district covers an area of approximately 1,228 square kilometers, with fifteen sectors, located in the climatic zone of tropical savannah with an average rainfall of 850 to 1,200 mm. As of the 2023 census, its population was approximately 551,103 (Male:49.3% &50.7%) with the population density of 450. Christianity is the predominant religion in the district, and traditional beliefs and practices are almost absent (0.01%). According to National Institute of Statistics of Rwanda (NISR) 2023, 19,010 households' rear cows, 33,057 rear goats, 1,594 rear sheep, 11,446 rear pigs, 3,364 rear rabbits, and 20,013 rear chickens, the total households engaged in livestock farming is 58,917out137,777 (42.8%). Bugesera District is home to an international airport, attracting a diverse population of international visitors and stakeholders. Additionally, the Gako Meat Project is focused on producing high-quality meat for export. In this context, it is essential to prepare local farmers to consistently supply high-quality meat and milk directly from the farm. Ensuring that farmers meet international standards is crucial for tapping into export opportunities and effectively contributing to the growing international market (htpps://www.afbdb.org, https://www.mininfra.gov.rw&https://www.minagri.gov.rw).

2.2. Questionnaire Design

The questionnaire was designed to assess the accessibility of veterinary health information and its association with knowledge, attitudes, and practices (KAP) related to the consumption of veterinary drug residue-contaminated meat and milk. It included both open-ended (n = 5) and closed-ended (n = 17) questions. The questionnaire covered household demographics and farm characteristics (n = 7), accessibility of veterinary health information (n = 22), and KAP regarding the uptake of veterinary drug residue-contaminated products (n = 11). KAP was assessed using "Yes" or "No" questions.The questionnaire was prepared in English and adapted from the previous study conducted in central Ethiopia [18], and then, the questionnaire was translated into local language (Kinyarwanda) for collecting response information. The questionnaire was subjected to a piloting test of 23 farmers supplying meat and milk in Rukumberi Sector of Ngoma District abattoir and milk collection center neighboring Bugesera District and revised for validation.

2.3. Data Collection

Based on the selected study sectors with abattoirs and milk collection centers and considering the number of farmers supplying meat and milk to these facilities, a total of 236 farmers were selected to participate in the study:

89 from Ruhuha, 67 from Rweru, 44 from Nyamata, and 36 from Mayange sectors. Simple random sampling was used by distributing small pieces of paper marked "Yes" or "No" to farmers gathered at each site. Those who picked a paper marked "Yes" were chosen to participate in the study. A face-to-face interview was conducted using a structured questionnaire by a trained assistant, the researcher, and a local veterinary technician. The responses were translated into English for further analysis. Additionally, Data from focus group discussions were recorded using an audio recorder and later validated by asking respondents for further clarification to ensure accuracy. Each interview lasted approximately 50 minutes. The sample size needed for the study (236) was determined using Fisher's formula ($n = z^2pq/d^2$) and adjusted using a finite population correction procedure. Figure 1 presents the administrative map of Bugesera District in Rwanda, highlighting the selected sectors included in the study.

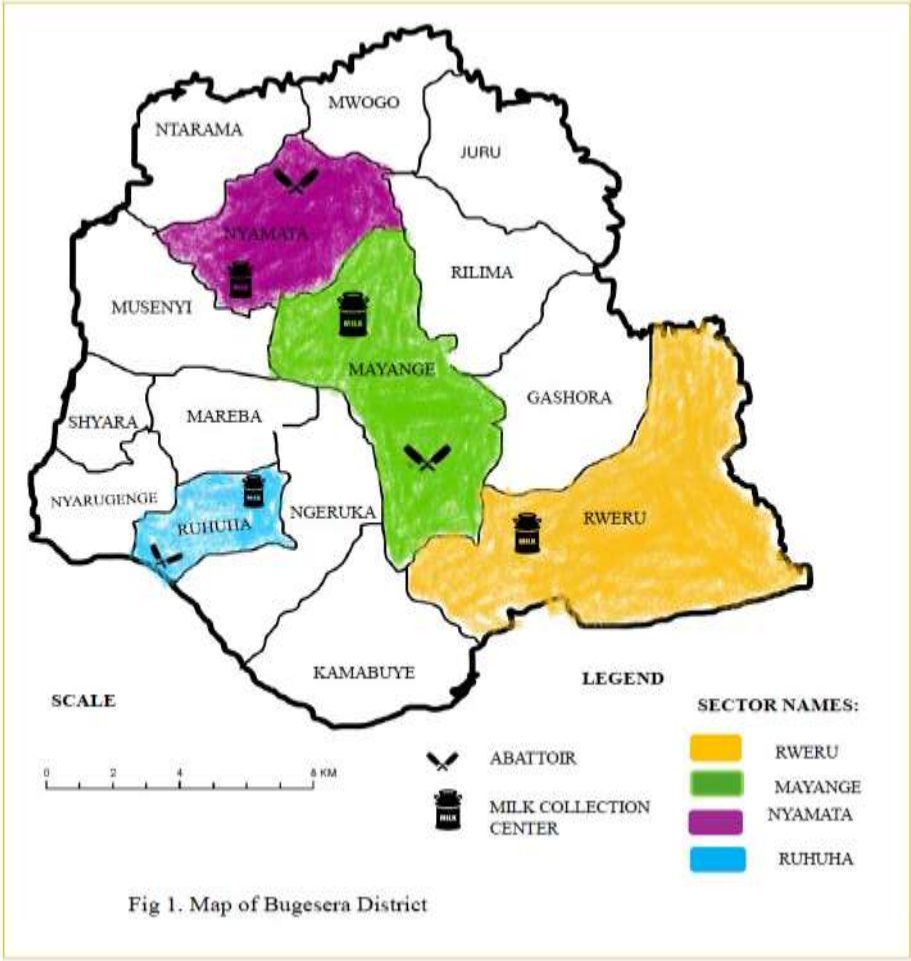

Fig 1. Map of Bugesera District

2.4. Ethical approval

Ethical approval for the study was granted by the Mount Kenya University Ethical Review Board (REF: MKU/ETHICS/04/16/2025), and permission for data collection was obtained from the Bugesera District leadership (Ref:03859/05.07/ANR). Participants were informed about the purpose of the study, how their responses would be used, and their right to withdraw at any time. Informed consent was obtained through signed consent forms from those who agreed to participate.

2.5. Data Management and Statistical Analysis

The Data collected through the questionnaires were initially recorded using Microsoft Excel 2021 and exported to SPSS version 25 for descriptive analysis on the accessibility of veterinary health information (Table 2). Socio-demographic Data were summarized and presented in terms of frequencies and percentages (Table 1). To examine the relationship between the accessibility of veterinary health information and the uptake of veterinary drug residue contaminated products, as well as the knowledge, attitudes, and practices (KAP) related to this uptake, Fisher's exact test and cross-tabulation were used. A 95% confidence interval was applied, and statistical significance was considered at a p-value ≤ 0.05. The strength of association was measured using the odds ratio (OR) (Table 4).

Qualitative data from four focus group discussions (FGDs) were audio-recorded, transcribed into text, and translated using Google Translate. The translated transcripts were later edited and reviewed by human review for contextual accuracy. Each transcript was read multiple times to gain a deeper understanding of emerging themes that were validated by independent reviewers. Thematic analysis was conducted using a hybrid approach inductive themes emerged from the data, while deductive codes were based on known effects of veterinary drug residue contaminated products. Coding was conducted manually by two independent researchers. Inter-coder reliability was ensured through an iterative process of comparison and resolution of discrepancies. NVivo 12 software was used to organize and manage the qualitative data. To validate the findings, member checking was carried out with seven participants to confirm the accuracy of preliminary interpretations. Data were segmented and grouped into similar categories to support a narrative synthesis of the results. Non-verbal cues such as body language were also considered and provided valuable insights into participants' agreement or disagreement during discussions. Gestures such as nodding and applauding were interpreted as signs of agreement, while headshaking indicated disagreement. Audio recordings were cross-referenced with participants' body language to enhance the depth and accuracy of data interpretation. The meaning of body language and gesture were provided by participants after group discussions. (Denham & Onwuegbuzie, 2013).

3. Results

3.1. Respondents' Demographic Characteristics

The socio-demographic characteristics of respondents are summarized in (Table 1). Most respondents were male (93.20%), with only 6.80% female. The majority were aged between 36–47 years (42.37%), followed by 24–35 years (27.12%), 48–59 years (25.43%), and over 59 (5.08%). In terms of education, 77.54% attended primary school, 16.00% attended secondary school, 0.42% held a master's degree, and 6.00% had no formal education. Most respondents were farmers (90.70%), while others included milk transporters (6.00%), MCC workers (1.27%), abattoir workers (1.27%), and farm managers (0.84%). The majority (67.80%) kept cows only, while 32.20% kept cows along with other animals.

Table 1 Sociodemographic Characteristics of Respondents

Characteristics	**Frequency (n)**	**Percentage**
Sector		
Nyamata	44	18.6
Mayange	36	15.25
Rweru	67	28.39
Ruhuha	89	37.71
Gender		
Male	220	93.22
Female	16	6.78
Age groups (years)		
[24-35]	64	27.12
[36-47]	100	42.37
[48-59]	60	25.43
>59	12	5.08
Education		
No Education	14	5.93
Primary	183	77.54
Secondary	38	16.10
Masters	1	0.42
Marital status		
Married	167	98.73
Divorced	3	1.27
Religion		
Catholic	117	49.57

Protestant	95	40.25
Seventh Day Adventists	24	10.16
Occupation		
Farmer	214	90.67
Farm manager	2	0.84
Milk transporter	14	5.93
Vet at abattoirs	3	1.27
Vet at Mcc	3	1.27
No Cow	7	2.96
[1-10]	161	68.22
[11-20]	14	5.93
[21-30]	18	7.62
>30	36	15.25
Others owned animals		
Chickens	24	10.16
Goats	28	11.871
Goats and Chickens	13	5.50
Goats, Chickens & pigs	3	1.27
Pigs	8	3.38
No other animals	160	67.79

3.2. Accessibility of Veterinary Health Information Among Farmers in Bugesera District

The study found that farmers accessed veterinary health information on the effects of veterinary drug residue contaminated products primarily through two main channels: training on meat and milk safety (65.77%) and veterinary service delivery, with 89% receiving information from private veterinary services and 11% from public veterinary services (Table 2).

Table 2. Accessibility of Veterinary Health Information among Farmers in Bugesera District

Variable	Frequency	Percentage
Trained in meat and milk safety		
Yes	155	65.77
No	81	34.32
Total	236	100.00
Veterinary Service Delivery		
Private Practitioner	209	89.00
Sector Animal Resources Officer	27	11.00
Total	236	100.00

The results were further supported by findings from the Focus Group Discussions (FGDs), which revealed a single overarching theme that was the accessibility of veterinary health information. This theme was presented in a thematic flow and illustrated with participants' narratives. The discussions highlighted the importance of veterinary health information to farmers, detailing how and where they access this information, as well as the challenges and limitations in veterinary health information accessibility. A total of four (4) group discussions composed of thirty-two (32) participants among 24 (75.00%%) were females, 26 (81.25%) attended primary school, 6 attended the secondary school, 25 (78.12%) were between 30-45 of age, 7 (21.75%) were aged between 46-55. Participants were selected depending on their will to participate, 24 (75%) only owned cows while other 8(25%) owned cows and goats. It was one FGD per site and they were asked the same questions.

Question 1: How do you get Veterinary Health Information?

Respondents occasionally had the opportunity to attend training on milk and meat safety held at milk collection centers and abattoirs. However, many respondents reported being unable to attend these sessions regularly due to geographical constraints. Additionally, farmers mentioned that they often received brief veterinary health advice from veterinarians after veterinary service delivery. As one male participant reported *"Send a Cow, Rwanda Dairy Development Project (RDDP), Milk Collection Center (Mcc) and abattoirs leadership sometimes give us short training on meat and milk quality starting from the farm with animal healthcare including feeding, watering, early detection and report of diseases to veterinary professionals and avoid consumption of animal products from diseased and dead animals".* A female participant supplemented *"We get Veterinary Health Information after veterinary service delivery, but the veterinarian is rushing to serve other farmers, he/she does not have sufficient time to provide sufficient information about animal health and drug use".*

Question 2: How do you think veterinary health information accessibility can be improved?

Farmers reported limitations in accessibility Veterinary Health Information among them selective criteria for governmental partners that provide training, short time discussion with the veterinarian after service delivery, one of them expressed "*Village public meeting and community public work are good opportunity to equally obtain veterinary health education since most citizens including farmers attend these weekly and monthly events".* Another farmer suggested "*Veterinary officers would regularly use media like Radio and Television in evening hours after news to disseminate animal-human health interconnectedness information since it is after work, many peoples are watching, listening to the Radio and Television."*

3.3. Knowledge, Attitude and Practices (KAP) on the Uptake of veterinary drug residue contaminated Products

The study found that most participants (83.50%) knew that drug residues in meat and milk can pose health risks to humans, while only 37.30% knew about the drug withdrawal period while 27.50% of farmers reported being familiar with the term "drug residues" in meat and milk. Only 3.00% rarely consumed Veterinary drug residue contaminated meat and milk, while 97.00% reported consuming them occasionally for distinct reasons, including avoiding loss of food and money (39.83%), following a long-standing routine (57.20%), and 2.54% remained unconvinced about the harmful effects of consuming veterinary drug residue contaminated meat and milk. Besides diagnosis and treatment of sick animals, respondents reported accessing other veterinary services such as vaccination (33.10%), artificial insemination (25.00%), deworming (4.66%), and pasture management (17.37%). These services were typically delivered at home within one hour (68.20%) or two hours (31.80%) after a telephone call.

Farmers also mentioned occasionally receiving veterinary health education through village public meetings (10.60%) and media sources like radio and television (5.00%). Regarding milk from treated cows, 33.00% reported discarding it after one day, 19.49% delivered it to milk collection centers (Mcc), 28.38% consumed it at home, 3.38% sold it to neighbors or kiosks, and 15.70% gave it to other animals. In terms of managing veterinary drug residue contaminated meat, 25.40% reported burying them and deploying security guards to prevent them from being unearthed, while 74.60% believed that washing and boiling such carcasses was a sufficient safety measure for consumption (Table 2). The study also revealed similar findings during the focus group discussions (FGDs) conducted in the study area, as one participant stated *"Cows should not be buried like humans, washing and boiling two to three times kill bacteria and drug residues in both veterinary drug residue contaminated products meat and milk, we ate them many years ago and nothing happened to us"*

Table 3. Knowledge, Attitudes and Practices on the Uptake of Veterinary drug residue contaminated Meat and milk among Farmers in Bugesera District.

Variable	Category/Response	*n*	%
Knowledge of drug-withdrawal period	Yes	88	37.30
Knowledge of health effects of residue-contaminated meat & milk	Yes	197	83.50
Familiarity with the term "veterinary drug residues"	Yes	65	27.50
Frequency of consuming residue-contaminated meat & milk	Rare	7	3.00
	Sometimes	229	97.00
Reasons for consuming residue-contaminated meat & milk †	Avoid loss of food & money	94	39.83
	Routine for many years	135	57.20
	Resistance to change	6	2.54
Other veterinary services received †	Vaccination	78	33.10
	Artificial insemination	59	25.00
	Deworming	11	4.66
	Pasture management	41	17.37
Typical consultation/intervention time	One hour	161	68.20
	Two hours	75	31.80
Alternative sources of veterinary health information †	Village public meetings	25	10.60
	Radio / television	12	5.00
Management of milk from treated cows	Rejected after one day	78	33.00
	Delivered to milk-collection center (MCC)	46	19.50
	Consumed at home	67	28.40
	Sold to neighbours	8	3.40
	Given to other animals	37	15.70
Management of carcasses from treated animals	Burial & security measures	59	25.40
	Washing & boiling prior to consumption	176	74.60

3.4. Association between Veterinary Health Information accessibility and Practices on the Uptake of Veterinary drug residue contaminated Products.

The study found a strong association between training on meat and milk safety and the reduced consumption of milk contaminated with veterinary drug residues. Participants who had received such training were 5.5 times more

likely to discard contaminated milk after one day compared to those who had not received training (OR = 5.5; 95% CI: 2.66–11.56; p = 0.001). The p-value well below the 0.05 threshold, indicates a statistically significant relationship between training and the likelihood of discarding contaminated milk. Additionally, trained respondents were significantly less likely to deliver milk contaminated with veterinary drug residues to milk collection centers (Mccs). The odds ratio was 0.35 (95% CI: 0.18–0.68; p = 0.001), indicating that trained participants were 65% less likely to deliver contaminated milk compared to their untrained counterparts. The p-value of 0.001 was below the 0.05 threshold, confirms a strong statistical significance between training and the non-delivery of contaminated milk to Mccs. The training was also significantly associated with the likelihood of reduced veterinary drug residue contaminated milk home consumption (OR = 0.53; p = 0.03) and selling it to neighbors (OR = 0.07; p = 0.01). However, providing veterinary drug residue contaminated milk products to other animals was not statistically associated with training, as shown by an odds ratio of 1.76 and a p-value of 0.168, suggesting that the observed difference could be due to chance.

Furthermore, the study found farmers were not yet convinced with non-consumption of veterinary drug residue contaminated carcasses that access to veterinary health information with odds ratio of 1.06 (95% CI: 0.94), with a p-value of 0.850 that is above the 5% significance threshold. This finding underscores the need for a more comprehensive approach to disseminating veterinary health information, along with stronger enforcement of animal-source food safety regulations, to effectively protect the public from consuming veterinary drug residue contaminated carcasses. The cross tabulation showed that the odds ratio was 1.06 (0.57-1.97) among trained farmers who bury veterinary drug residue contaminated meat, signifying the benefits of rejecting contaminated meat were not yet perceived believing that washing and boiling them were safety protocols for consumption with odds ratio 0.94 (95% CI 0.51-1.75), some reasons for such unsafe practice like routing for many years ago, avoid of food and money and resistance to change were mentioned in the Table(3). Indeed, the knowledge gap in meat safety could contribute to the consumption of veterinary drug residue contaminated meat.

Table 4. Relationship between accessibility of Veterinary health information and uptake of veterinary drug residue contaminated meat and milk

Variables	Trained in meat and milk		OR	95% CI	P-Value
	Yes	**No**			
Rejected milk after one day	68	10	5.50	2.66-11.56	0.00
Delivered to Mcc	21	25	0.35	0.18-0.68	0.00
Consumed at home	38	30	0.53	0.30-0.95	0.03
Sold to neighbors	1	7	0.07	0.01-0.57	0.01
Given to other animals	28	9	1.76	0.79-3.94	0.16

Bury the carcass and deploy security	40	20	1.06	0.57-1.97	0.85
Washing and boiling prior consumption	115	61	0.94	0.51-1.75	0.85

5. Discussion

5.1. Comparative discussion

The demographic characteristics of respondents in the current study were consistent with those reported in study conducted in Nyabihu District, Rwanda, and in Ethiopia. In both studies, the majority of respondents were male, small-scale farmers keeping fewer than ten dairy cows, within the active age range of 30–60 years, and had attained primary education (Tufa et al., 2023 &Iraguha et al., 2024). These similarities should be considered when designing effective interventions to improve knowledge, attitudes, and practices (KAP) related to the uptake of veterinary drug residue contaminated products particularly among smallholder farmers who raise livestock for subsistence, cultural, and economic purposes. In this study, most respondents (77.54%) had completed primary education, suggesting that literacy and education levels are positively associated with access to veterinary health information. Educated individuals are generally more likely to attend extension training and to better understand the benefits of adopting safe and healthy practices. This finding aligns with studies in Rwanda and Kenya, which showed that individuals with primary education were more likely to pay a premium for quality milk in Rwanda and aflatoxin-free maize in Kenya (Habiyaremye et al., 2023, De Groote et al., 2016).The study also found that only a small proportion (6.78%) of respondents involved in the meat and milk supply chain were female, while a large majority (98.2%) were married. This highlights noTable gender disparities in access to veterinary health information and participation in decision-making related to livestock management. These findings are consistent with research from Ethiopia, which showed that female-headed households and plot managers were less likely to receive agricultural extension services and had limited access to quality veterinary care compared to their male counterparts (Ragasa et al., 2013). Although women often play a key role in livestock care such as caring of sick or newborn animals, feeding, cleaning, and managing production, their participation in critical activities like selling meat and milk remains limited. This is largely due to prevailing cultural norms and the dominant role of men in household decision-making (Bhanotra et al., 2015). The government could consistently encourage gender-based participation in livestock management and decision making, the increased veterinary extension to farmers cooperatives and formation of farmers field schools (FFs) could be efficient strategy for women veterinary health education accessibility.

The recent findings showed that 65.7% of farmers have received veterinary health information through training on meat and milk safety. Additionally, all farmers in the current study reported having access to veterinary service

delivery. This aligns with findings from Rwanda's Eastern Province, particularly in the districts of Kirehe, Ngoma, Nyagatare, and Kayonza (D`A et al., 2017). This level of accessibility in these areas is largely attributed to the region's favorable geography, which is relatively flat and lacks the hilly terrain that can hinder the delivery of veterinary services. In contrast, farmers in Nyabihu District and in Namibia reported limited access to veterinary services. In Nyabihu, the mountainous terrain poses significant logistical challenges, making it difficult for veterinarians to reach remote farming communities. Similarly, in Namibia, only 30% of farmers reportedly have access to veterinary services, reflecting similar geographical and infrastructural limitations (Haakuria et al., 2020 & Tufa et al., 2023).

This study found that 197 respondents (83.5%) were aware of the adverse health effects of consuming animal-source foods contaminated with drug residues. Additionally, 37.3% of respondents knew about the drug withdrawal period, while 27.5% were familiar with the term "veterinary drug residues" in animal-source foods. These findings are consistent with an earlier study conducted in Ethiopia on antibiotic residues in meat from abattoirs (Abdeta et al., 2024). The current study also found various practices related to the management of meat and milk from treated animals. This included discarding drug residue contaminated milk after one day post-treatment, delivering it to milk collection centers (Mccs), using it for home consumption, selling it to neighbors, or feeding it to calves. These practices are in line with findings from study conducted in Nyabihu District of Rwanda and in India (Tufa et al., 2023& Iraguha et al., 2024). Regarding attitudes and practices related to the consumption of contaminated animal source food, the present study found that trained farmers are more likely to discard milk from treated animals which aligns with the results from a study in Nyabihu District of Rwanda where training contributed to 38.5% decrease in rejection of milk contaminated with anti-microbial residues (Iraguha et al., 202420), and the minority of farmers in Canada findings from a research conducted in Canada on knowledge, attitudes, and practices (KAP) concerning food safety among dairy producers, with minority of farmers perceiving that milk should not be discarded, instead, it should be frigerated, curded, boiled and consumed (Young et al., 2010). The consumption of veterinary drug residue contaminated products could also be linked to multiple factors, including inadequate tools and equipment for testing animal-source foods at milk collection centers and abattoirs, non-enforced food safety laws, and the absence of compensation for high-quality milk. Economic pressures to avoid the loss of milk and meat are key income sources for dairy small-scale farmers. Additionally, improper antimicrobial use and misconceptions about food safety persist, with some respondents believing that washing or boiling drug residue contaminated meat and milk make them safe for consumption (Kemp et al., 2021 & Fathy et al., 2019). Other commonly cited reasons for consuming such products include longstanding practices, food loss

prevention, and economic hardship among underprivileged populations that are consistent with studies conducted in Kenya and Ethiopia (Abdeta et al., 2024 & Tufa et al., 202318,20).

5.2. Broader implications

The accessibility of veterinary health information through training and service delivery is generally consistent across Rwanda, as the veterinary profession is regulated by the Rwanda Council of Veterinary Doctors, and various livestock stakeholders operate nationwide. However, slight variations in accessibility may arise due to geographical differences, particularly in districts characterized by hilly terrain, which can hinder service delivery. Access to veterinary health information through village public meetings is a unique and context-specific approach in Rwanda. These meetings are held weekly and bring together all village residents aged 18 and above to address community issues and disseminate government policies. Each meeting is led by a local government delegate and the village chief, and this practice is uniformly applied throughout the country.

Additionally, access to veterinary health information via radio and television has proven to be an effective communication method. A study conducted in Tanzania reported a 98% effectiveness rate for this mode of information dissemination to farmers (Wamatu et al., 2023). This approach is particularly beneficial for farmers in remote areas where veterinary professionals are less likely to make regular visits, the finding that is consistent with research conducted in Nigeria (Obidike, 2011). The increased veterinary health information accessibility would be beneficial for human, animal and environment in African context since well-disposed dead carcasses would result in non-human exposure to drug residues,spread zoonotic and contagious microorganisms between humans and animals and environment sanitation, if we protect one, we protect all (Kaczmarek, Wiszniewska, Słomka, & Walusiak-Skorupa, 2024).

5.3. Policy Relevance

Livestock authorities in Bugesera District could mandate milk collection centers and abattoirs to use antimicrobial rapid test kits to detect drug residues in meat and milk. In addition, they could enforce sanctions such as discarding veterinary drug residue contaminated products and requiring farmers who supply veterinary drug residue contaminated meat and milk to pay administrative fines, these are fines found in the district council resolutions that could be implemented by Sector Animal Resources Officer and local revenues officer. These measures would contribute to raising farmers' awareness about the seriousness of drug residues in animal products. To further enhance veterinary health accessibility, channels of information dissemination such as Radio Izuba, a local

broadcaster working in Bugesera District, village meetings and community public work could improve health education among farmers in Bugesera District.

5.4. Limitations of the study

The study offers valuable insights but has limitations, including reliance on self-reported data that may be affected by recall bias or social desirability. Its focus on a single district in Rwanda also limits the generalizability of the findings. Indeed, a tendency to prioritize harmony and conformity over critical thinking (groupthink) could affect results from Focus group discussions. Future research should cover a wider geographic area and consider regional differences in veterinary health education and the uptake of veterinary drug residue contaminated meat and milk.

6. Conclusion and Recommendations

The study revealed that access to veterinary health information was linked to a reduction in the consumption of veterinary drug residue contaminated meat and milk among farmers supplying meat and milk in Bugesera District. Nevertheless, some farmers continue to consume meat and milk from recently treated animals. The National laws for meat and milk value chain state that all milk should be delivered to Milk collection Centers for quality tests and all animals should be slaughtered to approved and registered abattoirs to produce meat that are fit for human consumption (Ministerial order n° 001/11.30 of 10/02/2016 regulating the collection, transportation and selling milk/ Official Gazette nº 07 of 15/02/2016 and Nº 012//11.30 of 18/11/2010 Ministerial Order on animal slaughtering, meat inspection./ Official Gazette n° 50 of 13/12/2010).This underscores the urgent need for a comprehensive veterinary health education program aimed at increasing awareness and understanding of the potential health risks associated with consuming such products and collaboration with stakeholders for strict adherence to the government laws. Again, a combination of veterinary drug residue tests at Milk collection Centers and abattoirs together with consistency veterinary heath education among farmers should be implemented by Bugesera District leadership.

Authors' contributions

SM: Conceptualized the study, designed method, collected and analyzed the data, drafted reviewed and edited manuscript.

MSB: Conceptualized the study, designed method and analyzed the data, drafted reviewed and edited manuscript, and supervised the whole work.

CM: Conceptualized the study, designed method and analyzed the data, drafted reviewed and edited manuscript.

FB: drafted, reviewed, and edited manuscript

SE: Drafted, reviewed, and edited manuscript

Declaration of Competing Interest

The authors declare no competing interests.

Funding

Not applicable

Acknowledgement

We appreciate farmers supplying milk and meat at Bugesera Milk Collection Centers and abattoirs for freely participating in this study.

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