EISSN: 2707-0425

East African Journal of Science, Technology and Innovation, Vol. 7 (2): March 2026

Parents' and livestock keepers' knowledge, attitudes, and practices regarding antimicrobial residues in cow milk in Morogoro Municipality and Monduli District, Tanzania

[1]NYAISA, M.G., [*1]NONGA, H.E., [1,2]MDEMU, S., [3]SULEIMAN, R., [1]MDEGELA, R.H.

[1]Department of Veterinary Medicine and Public Health, College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, P. O. Box 3021, Chuo Kikuu, Morogoro, Tanzania.
[2]Tanzania Veterinary Laboratory Agency, Tanzania Vaccine Institute, P.O. Box 3017, Kibaha, Pwani, Tanzania
[3]Department of Food Science and Agro-processing, Sokoine University of Agriculture, P. O. Box 3006, Chuo Kikuu, Morogoro, Tanzania.
***Corresponding author:** hezron@sua.ac.tz

Abstract
Milk is an important human dietary source of essential nutrients, particularly children and other nutritionally vulnerable groups. However, uncontrolled antimicrobial use in lactating cows may contribute to presence of antimicrobial residues in milk. This cross-sectional study evaluated the knowledge, attitudes and practices (KAP) of livestock keepers and parents or guardians of children under five on antimicrobial residues in cow's milk and related health implications in Morogoro Municipality and Monduli District. A questionnaire was administered to 100 livestock keepers and 340 parents or guardians, and descriptive statistics summarized the data. Multivariable logistic regression was employed to assess the relationship between potential explanatory variables and the KAP scores of respondents. It was found that cattle diseases and poor knowledge were primary factors contributing to indiscriminate use of antimicrobials. Up to 64.4% of parents or guardians were unaware of antimicrobial residues, 42.6% of livestock keepers did not comply with drug withdrawal time, and 59.7% of parents or guardians had inadequate knowledge on health impacts of antimicrobial residues on children. Most livestock keepers and parents or guardians demonstrated favourable opinions of 50% and 51.5% respectively, about milk safety and expressed concern about potential health impacts of antimicrobial residues in milk. Up to 79% of livestock keepers concurred with compliance on antimicrobial withdrawal period. The KAP of livestock keepers about antimicrobial residues were strongly affected by age, gender, farming experience, and cattle breed ($p < 0.05$). Among parents or guardians, age significantly influenced knowledge ($p=0.047$). The findings underscore the necessity for tailored stakeholder-specific interventions, despite positive KAP scores, to enhance milk safety and mitigate public health risks.

Key words: *Antimicrobial residues; Antimicrobial resistance; Cattle; Food safety; Public health*

Cite as: Nyaisa *et al.* (2026): Parents' and livestock keepers' knowledge, attitudes, and practices regarding antimicrobial residues in cow milk in Morogoro Municipality and Monduli District, Tanzania. *East African Journal of Science, Technology and Innovation, 7 (2).*

Received: 27/08/25
Accepted: 06/03/26
Published: 30/03/26

Introduction

In many developing countries, milk is a fundamental human dietary component and important source of nutrients (Gwandu *et al.,* 2018; Pogurschi *et al.,* 2022). In Tanzania, milk industry is essential for the economic growth, food security and livelihood of the majority especially the rural communities (Kivaria *et al.,* 2006; Hounmanou and Mdegela, 2022). The average annual milk production in 2024 was estimated at 4.1 billion litres (MLF, 2024). However, the per capita milk consumption in Tanzania is only 68.1 litres which is below the FAO-recommended 200 litres (MLF, 2024). Most of the milk produced and used in the country comes from cattle, whose population is estimated at 38 million. Almost 96% of cattle in Tanzania are indigenous breed raised under traditional production system (TLMP, 2017; MLF, 2024). The indigenous cattle produce more than 80% milk which is always contaminated by biological, chemical and physical hazards (Ngasala *et al.,* 2015; Gwandu et al., 2018; Mengele *et al.,* 2023; Lugamara *et al.,* 2023). Additionally, more than 90% of the milk produced in Tanzania is consumed in unprocessed form because it is supplied in informal market operated by smallholder producers (Lugamara *et al.,* 2023).

Livestock industry in Tanzania faces many challenges including poor husbandry practices and inadequate extension services which fuels increased incidences of diseases that warrants uses of veterinary drugs in particular antimicrobials (Hounmanou and Mdegela, 2018; Sangeda *et al.,* 2021; Kimera *et al.,* 2020). Most of the pastoral and agropastoral communities have low knowledge on antimicrobial residues and withdrawal period as a result the milk supplied is always contaminated (Katakweba *et al.,* 2012; Olasoju *et al.,* 2021; Mashauri *et al.,* 2025). Indeed, most pastoral and agropastoral communities in Tanzania rely on cow milk as a primary source of nutrition for their children (Lotto *et al.,* 2024). The World Health Organization (WHO) acknowledges that imprudent uses of antimicrobial in livestock is among the main causes of ever increasing antimicrobial resistance (AMR) worldwide (Gwandu *et al.,* 2018; Sangeda *et al.,* 2021; Mashauri *et al.,* 2025). Consequently, United Nations (UN) and other international bodies have called for coordinated actions to regulate antimicrobial use in livestock farming, strengthen food safety systems, and promote public awareness about AMR (Kimera *et al.,* 2020; Lotto *et al.,* 2024). However, in many developing countries, safety practices are poorly implemented due to limited knowledge, weak regulatory frameworks, and economic pressures on smallholder farmers (Mdegela *et al.,* 2009; Sangeda *et al.,* 2021; Mashauri *et al.,* 2025). Studies show that most raw cow milk enters the value chain without routine testing for antimicrobial residues, suggestive of constant exposure of the public to antimicrobial residues (Blackmore *et al.,* 2022; Rwehumbiza *et al.*, 2013; Simbine-Ribisse *et al.,* 2024). Therefore, the current study assessed the knowledge, attitudes, and practices on antimicrobial residues in cow milk among livestock keepers and parents or guardians in Morogoro Municipality and Monduli District, Tanzania.

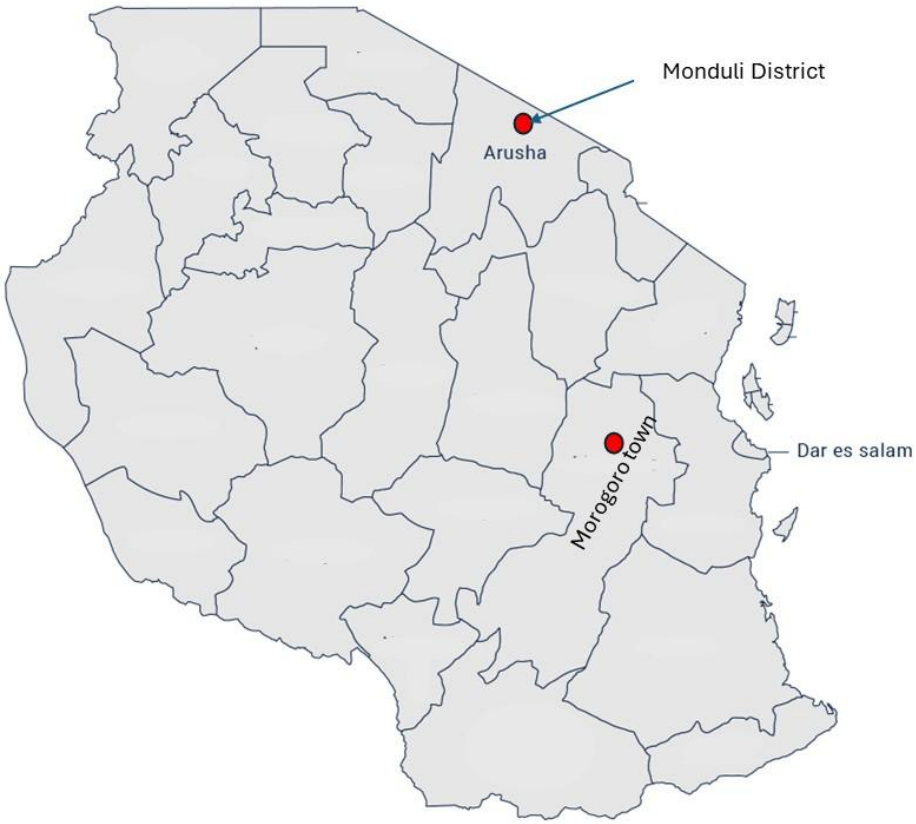
Materials and Methods

Study area and animals

The study was conducted in Morogoro Municipality and Monduli District (Figure 1). According to the National Census of 2022, Morogoro Municipality had a human population 471,409 (DHS, 2022). Administratively, the Morogoro Municipality has 29 wards, of which Kichangani, Magadu, Mazimbu and Kilakala were purposively selected for study based on high number of livestock keepers keeping. The cattle population in Morogoro was estimated at 20,000 dominated by crossbred dairy cattle raised under intensive or semi-intensive system (Gillah *et al.,* 2014). Further, Monduli District of Arusha region was also involved in the study and has a human population of 227,585 distributed across 20 wards (DHS, 2022). Mswakini ward villages, namely Ormang'wai and Engusero, were purposively selected for study since have many livestock keepers with indigenous cattle. Cattle population in Monduli district was estimated at 286,000 which more than 95% were indigenous cattle, particularly the Tanzanian short-horn zebu (TSHZ) raised by agro-pastoralists and pastoralists (NSCA, 2012).

Figure 1

Map of Tanzania showing location of relative Morogoro Municipality and Monduli District in Arusha region, (red dots).



Study design, sample size and selection of study participants

A cross-sectional study design approach was used to evaluate the KAP of parents or guardians and livestock keepers regarding antimicrobial residues in milk. A total of 21 streets from 4 wards of Morogoro Municipality and 2 villages from Mswakini ward of Monduli district were purposively selected for study. The inclusion criteria of the study participants included having a child under five years, actively keeping livestock, accessible during the study, and consented to participate. The sample was estimated using the formula for finite population (Uakarn, 2021). Based on registers from the District Livestock Offices a sample size of 100 livestock keepers including 35 from Morogoro Municipality and 65 from Monduli District were interviewed (Kivaria *et al.,* 2006; Charan and Biswas, 2013). Additionally, 340 parents or guardians, that included 214 from Morogoro Municipality and 126 from Monduli District were interviewed. Eligible livestock keepers and parents or guardians were chosen through simple random selection.

Data collection

The questionnaire used was categorized into four parts; (i) sociodemographic information, cattle management and disease control, and antimicrobial usage; (ii) knowledge of antibiotic residues, associated health risks, and withdrawal periods; (iii) attitudes towards antibiotic residues; and (iv) practices that may lead to contamination of antibiotic residues in raw cow milk. Pretesting of the questionnaires was done in Arusha District, and all the necessary amendments were done. The questionnaire was administered in Kiswahili, the national language in Tanzania. Additionally, participants were interviewed individually in private settings to encourage openness and participation.

Data Analysis

Data were cleaned, coded and analyzed using Microsoft Office Excel 2016 and IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Descriptive statistics including percentages, frequencies, medians and means were used to describe the proportions of farms/sociodemographic characteristics, KAP and antimicrobial uses. The scores for knowledge, attitude, and practices were then divided into two categories using the median as the cutoff and recoded as "correct" or "incorrect." Associations between categorical variables and KAP scores were determined using Chi-square tests and Fisher's exact tests. Variables with p-value less than 0.25 were included in multivariable logistic regression analysis performed using backward elimination, with an exit alpha of 0.15 to finalize the models. Statistical significance was then set at $p < 0.05$ in the final models.

A score of "0" was assigned to each incorrect response and "2" for each correct response for knowledge and practice questions, while a score of "1" was assigned to each correct response and "0" for each incorrect response for attitude questions. Cronbach's alpha test values of 0.73 for livestock keepers and 0.71 for parents or guardians indicated acceptable internal consistency in the 'attitude' domain. The scores were transformed into a scale where zero represents the minimum score and 43 signifies the maximum score, utilizing the scoring algorithm established after calculating the mean for each respondent. On interpretation of the analysis output from the scoring scheme, a score beyond 50% was regarded satisfactory, while a score below 50% was regarded as unsatisfactory. The KAP scores for livestock keepers varied from 4 to 22 for knowledge, 18 to 43 for attitudes, and 2 to 8 for practices, whereas for parents or guardians, the scores ranged from 8 to 30 for knowledge, 0 to 12 for attitudes, and 4 to 10 for practices.

Ethical considerations

A research permit was obtained from Sokoine University of Agriculture (SUA) with Ref. No. SUA/ADM/R.1/8/1116. Permits to conduct research in Local Government Office were obtained from Presidents Office Regional Administration and Local Government (PO-RALG) with Permission number Ref. No.AB.307/323/01/254 and Ref. No.AB.275/376"C"/01/254 in Morogoro Municipality and Monduli District respectively. Verbal consent was obtained from each study participant on voluntary basis and confidentiality was taken into great

consideration.

Results

Sociodemographic factors of livestock keepers and parents or guardians

Table 1 has the sociodemographic factors of livestock keepers and parents or guardians and cattle management. Most livestock keepers were from Arusha (65%); over half were men (54%) and 69% reared indigenous cattle breeds. Cattle production was largely practiced under extensive grazing systems (78%). Most cattle diseases occurred during rainy season, whereby acaricides and vaccinations were the commonly practiced control methods. The use of antimicrobial for cattle treatment was reported as a common practice (68%) especially in Monduli districts. The types of antimicrobials used in treatment of cattle were mainly Tetracyclines and Penicillin (Figure 2). Most parents or guardians studied were from Morogoro (62.9%), predominantly female (95.6%), had secondary education (49.4%) and the main source of income was crop and livestock production (31.8%).

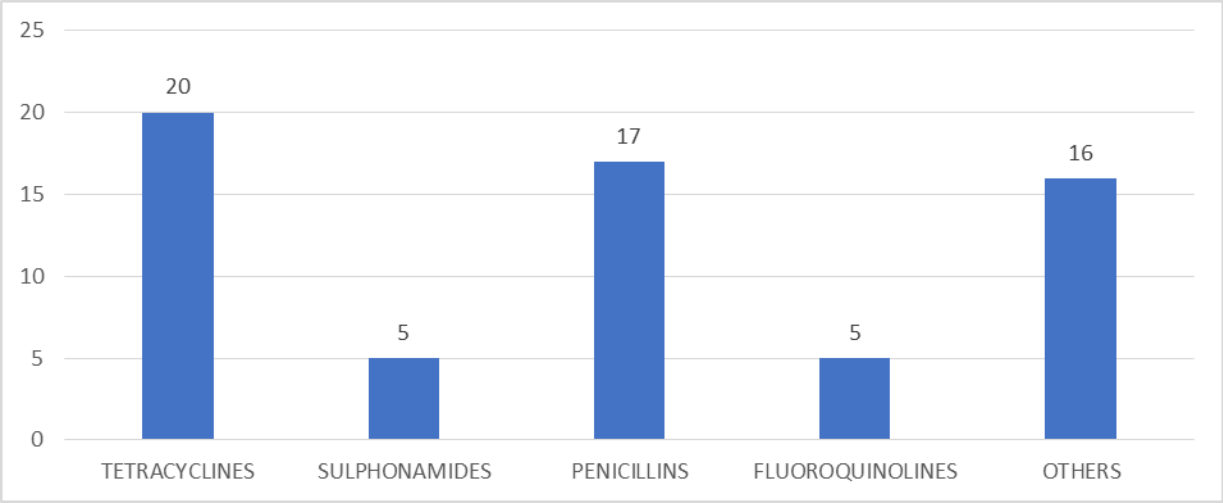
Table 1

Sociodemographic characteristics of livestock keepers, parents or guardians and cattle management in Morogoro Municipality and Monduli District, Tanzania

Parameter	Category	Livestock keepers	Parents or guardians
		Number (%)	Number (%)
Monduli District	Ormang'wai	25 (25.0)	64 (18.8)
	Engusero	40 (40.0)	62 (18.2)
Morogoro Municipality wards	Kichangani	9 (9.0)	53 (15.6)
	Magadu	9 (9.0)	63 (18.6)
	Mazimbu	7 (7.0)	50 (14.7)
	Kilakala	10 (10.0)	48 (14.1)
Sex of respondents	Female	54 (54.0)	325 (95.6)
	Male	46 (46.0)	15 (4.4)
Age	18-25	19 (19.0)	24 (24.0)
	26-33	13 (13.0)	16 (16.0)
	34-41	11 (11.0)	16 (16.0)
	More than 41	57 (57.0)	44 (44.0)
Level of education	No formal education	15 (15.0)	21 (6.2)
	Primary education	32 (32.0)	130 (38.2)
	Secondary education	39 (39.0)	168 (49.4)
	College education	14 (14.0)	21 (6.2)
Main source of income of respondents	Crop and livestock production	82 (82.0)	108 (31.8)
	Employment	3 (3.0)	24 (7.1)
	Livestock production	3 (3.0)	0 (0.0)
	Others (e.g. business)	12 (12.0)	40 (11.8)
Type of cattle	Dairy crosses	31 (31.0)	-
	Indigenous	69 (69.0)	-
Duration of keeping cattle	0-5	22 (22.0)	-
	6 – 10	16 (16.0)	-
	11 -15	16 (16.0)	-
	16-20	16 (16.0)	-
	Above 20 years	30 (30.0)	-
Cattle grazing system	Extensive	78 (78.0)	-
	Intensive or semi-intensive	22 (22.0)	-
Season with high disease incidences in cattle	Dry season	44 (44.0)	-
	Rainy season	56 (56.0)	-
Prevention of cattle diseases	Use of acaricides	60 (60.0)	-
	Vaccination	42 (42.0)	-
	Routine treatment whenever cattle are sick	60 (60.0)	-
Medicines used in treatment of cattle	Antimicrobials	78 (78.0)	-
	Anti-helminthics	56 (56.0)	-
	Anti-trypanosomes	42 (42.0)	-
	Herbs and other traditional medicines	68 (68.0)	-

Figure 2

Livestock keepers' antimicrobial usage in Morogoro Municipality and Monduli District, Tanzania



Knowledge of livestock keepers and parents or guardians on antimicrobial residues

Table 2 shows the knowledge levels of livestock keepers and parents or guardians on antimicrobial residues. More than 50% of the livestock keepers had low knowledge on veterinary drugs handling, antimicrobial residues, and antimicrobial residues health effects to humans. Administration of antimicrobial was mainly done by livestock owners (59%). Up to 64.4% of parents or guardians were unaware of antimicrobial residues, 42.6% of livestock keepers did not comply with drug withdrawal time, and 59.7% of parents or guardians had inadequate knowledge on health impacts of antimicrobial residues on children. Few parents or guardians (42.6%) knew about withdrawal periods.

Table 2

Knowledge levels of livestock keepers and parents or guardians on antimicrobial residues in Morogoro Municipality and Monduli District, Tanzania

Respondent category	Question	Response	Frequency (%)
Livestock keepers	Have you received training on how to handle and administer veterinary drugs to cattle?	Yes	39 (39.0)
		No	61 (61.0)
	Does the person who administers treatment read instructions before administration?	Yes	87 (87.0)
		No	13 (13.0)
	What are the main issues to consider before drug administration?	Type of drugs to be administered	54 (37.0)
		Proper dose for weight and age of animal	59 (40.0)
		Expiry date of the drugs	11 (7.0)
		Withdrawal period	23 (16.0)
	Who administer antimicrobials to cattle?	Livestock keepers	59 (59.0)
		Livestock workers	2 (2.2)
		Livestock officer	8 (8.8)
		Veterinarian	31 (31.0)
	Are you aware about antimicrobial residues?	Yes	55 (55.0)
		No	45 (45.0)
	Do you know about drug withdrawal period?	Yes	79 (79.0)
		No	21 (21.0)
	At what period /time do you provide your animals with antimicrobials?	When proven sick	43 (43.0)
		When thought to be sick	41 (41.0)
		Anytime even when not sick	16 (16.0)
	Are you aware of any health effects to children who consumes milk with antibiotic residues?	Yes	47 (47.0)
		No	53 (53.0)
Parents or guardians	**Question**	**Response**	**Frequency (%)**
	Do you know what antimicrobial residues are?	Yes	121 (35.6)
		No	219 (64.4)
	Are you aware of antimicrobials used for cattle treatment?	Yes	121 (35.6)
		No	219 (64.4)
	Have you heard about issues on antimicrobial residues?	Yes	129 37.9)
		No	211 (62.1)
	Have you ever heard on health risks of giving your children milk from cows treated with antimicrobials?	Yes	137 (40.3)
		No	203 (59.7)
	Do you know that consuming milk with antimicrobials residues may pose negative health effects on children?	Yes	74 (21.8)
		No	266 (78.2)
	Do you know about drug withdrawal period in cattle production?	Yes	145 (42.6)
		No	195 (57.4)
	Do you know how long after antimicrobials treatment is safe to consume cow milk?	Two days	39 (11.4)
		According to doctors' instructions	79 (23.3)
		I don't know	222 (65.3)

Attitudes of parents or guardians and livestock keepers towards milk safety

Parents or guardians expressed highly positive attitudes toward milk safety whereby, (47.6%) were concerned about the possible health effects of residues in milk on their children (Table 3). Over 50% of livestock keepers acknowledged the importance of adhering to withdrawal periods after antimicrobial use in cattle (Table 3).

Table 3

Livestock keepers' and parents or guardians' attitudes towards milk safety in Morogoro Municipality and Monduli District, Tanzania

Respondent category	Opinions	Number (%) of choices				
		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Livestock keepers	Overuse of antimicrobials can lead to antimicrobial resistance	6 (6.0)	40 (40.0)	44 (44.0)	7 (7.0)	3 (3.0)
	I am concerned about the potential impacts of antimicrobial resistance on human health	3 (3.0)	44 (44.0)	24 (24.0)	25 (25.0)	4 (4.0)
	It is important to follow proper dosage and administration guidelines for antimicrobial drugs to livestock	8 (8.0)	58 (58.0)	24 (24.0)	9 (9.0)	1 (1.0)
	Using antimicrobials in cows affects the quality of the milk they produce	7 (7.0)	46 (46.0)	21 (21.0)	23 (23.0)	3 (3.0)
	Proper training on antimicrobial use can significantly reduce the misuse of antimicrobials among livestock keepers	11 (11.0)	36 (36.0)	27 (27.0)	23 (23.0)	3 (3.0)
	Antimicrobials are essential for keeping livestock healthy and should be used whenever necessary	0 (0.0)	12 (12.0)	26 (26.0)	45 (45.0)	17 (17.0)
	It is important to follow withdrawal periods after administering antimicrobials to cows	12 (12.0)	55 (55.0)	16 (16.0)	16 (16.0)	1 (1.0)
	Customers care whether the milk they purchase contains antimicrobial residues	14 (14.0)	35 (35.0)	28 (28.0)	22 (22.0)	1 (1.0)
	livestock keepers should discuss antimicrobial use and milk safety with their customers	5 (5.0)	38 (38.0)	32 (32.0)	17 (17.0)	8 (8.0)
	Public health campaigns about antimicrobial residues in milk would help improve practices among livestock keepers	15 (15.0)	55 (55.0)	20 (20.0)	9 (9.0)	1 (1.0)
Parents or guardians	**Opinions**	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
	I trust the milk I purchase from livestock keepers or vendors to be safe and free of harmful residues	44 (12.9)	147 (43.2)	68 (20)	63 (18.5)	18 (5.3)
	I trust the information provided by my milk supplier about the use of antimicrobials in their cows	51 (15)	155 (45.6)	65 (19.1)	64 (18.8)	5 (1.5)
	It is important to ensure that milk consumed by children is antimicrobials residues-free	48 (14.1)	156 (45.9)	69 (20.3)	60 (17.6)	7 (2.1)
	I am concerned on the possible health effects of drug residues in milk to children	44 (12.9)	162 (47.6)	94 (27.6)	29 (8.5)	11 (3.3)
	I am likely to switch to a different milk supplier if I knew the current one used antimicrobials on their cows	61 (17.9)	150 (44.1)	78 (22.9)	38 (11.2)	13 (3.8)
	There should be more public awareness campaigns about the risks of antimicrobial residues in milk	56 (16.5)	177 (52.0)	53 (15.6)	47 (13.8)	7 (2.1)

Practices on milk consumption among parents or guardians and milk production and handling among livestock keepers

Table 4 contains details on livestock keepers' practices on antimicrobial uses in cattle and parents or guardians' practices on milk consumption in children. About 84% of livestock keepers reported that they do not sell milk from treated cattle, and 54% reported to isolate sick cattle from the herd. Parents or guardians reported that every child consumed cow milk, with 70.0% receiving about half a litre (500 mL) daily. Up to 9.4% of children were reported to drink raw unboiled milk.

Table 4

Livestock keepers' practices on antimicrobial uses in cattle and parents or guardians' practices on milk consumption in children in Morogoro Municipality and Monduli District, Tanzania

Category of respondent	Practice	Response	Number (%)
Livestock keepers	Do the person who administer drugs read instruction before administration to cattle	No	13 (13.0)
		Yes	87 (87.0)
	How frequent are drugs administered per day	According to veterinarian instructions	65 (65.0)
		Once per day	24 (24.0)
		Twice per day	11 (11.0)
	Are sick cattle isolated from the herd	No	46 (46.0)
		Yes	54 (54.0)
	Do you milk and sell milk during cattle treatment	No	84 (84.0)
		Yes	16 (16.0)
	How do your customers get milk	Collect from a selling/collection point	7 (7.0)
		Collect from the farm	29 (29.0)
		Deliver to their places	10 (10.0)
		Others	54 (54.0)
Parents or guardians	**Practice**	**Response**	**Number (%)**
	How do you prepare raw milk to be consumed by the child?	Boil and sieve, prepare and mix with other foods	308 (90.6)
		Give raw milk	32 (9.4)
	How do you store milk for children?	Thermos flask	198 (58.2)
		Cooking pot	93 (27.3)
		Refrigerator	23 (6.8)
		Gourd	26 (7.6)
	Estimated amount of milk given to children per day	One litre (1000 mls)	67 (19.7)
		Half and a quarter litre (750 mls)	5 (1.5)
		Half litre (500 mls)	238 (70.0)
		Quarter litre (250 ml)	30 (8.8)

Scores of knowledge, attitude, and practices for livestock keepers and parents or guardian

Generally, the results show that more than half of the livestock keepers and parents or guardians had good knowledge (>50%), attitudes (almost 50%) and practices (>50%) on antimicrobial residues in milk (Table 5).

Table 5

Knowledge, attitude, and practice scores for livestock keepers and parents or guardians in Morogoro Municipality and Monduli District, Tanzania

KAP	Overall KAP scores			
	Livestock keepers		Parents or guardians	
	Correct (%)	Incorrect (%)	Correct (%)	Incorrect (%)
Knowledge	62 (62.0)	38 (38.0)	182 (53.5)	158 (46.5)
Attitudes	50 (50.0)	50 (50.0)	175 (51.5)	165 (48.5)
Practices	61 (61.0)	39 (39.0)	312 (91.8)	28 (8.2)

Note: Number of livestock keepers= 100, Number

Factors affecting KAP among livestock keepers and parents or guardians

Multivariable logistic regression analysis revealed significant association between knowledge and several factors related to livestock keepers and livestock keeping characteristics (Table 6). It was established that knowledge was associated with age and experience of the livestock keeper, and breed of cattle, whereas attitudes and practices were associated with sex of the respondent. Among parents or guardians, age was statistically associated with KAP, as shown in Table 7. These results imply that age, sex and experience of the livestock keepers, and cattle breed kept are significant predictors of KAP.

Table 6

Multivariable logistic analysis between demographic and livestock keeping characteristics and KAP scores of livestock keepers in Morogoro Municipality and Monduli District, Tanzania

Parameter	Category	Knowledge			Attitude			Practices		
		OR	95% CI (LL-UL)	P value	OR	95% CI (LL-UL)	P value	OR	95% CI (LL-UL)	P value
Study site	Arusha (Ref.)									
	Morogoro	0.56	0.044 – 7.17	0.656	2.68	0.26 – 27.37	0.405	19.94	0.96 – 41.43	0.053
Sex	Female (Ref.)									
	Male	2.148	0.72 – 6.38	0.168	3.14	1.09 – 9.08	0.035*	4.04	1.05 – 15.50	0.042*
Age	18-25 (Ref)									
	26-33	6.83	1.34 – 34.90	0.021*	0.91	0.22 – 3.68	0.890	0.60	0.12 – 3.02	0.538
	34-41	3.97	0.88 – 17.85	0.072	3.11	0.70 – 13.90	0.137	1.19	0.27 – 5.32	0.817
	Above 41	2.0	0.56 – 6.80	0.292	0.32	0.09 – 1.11	0.073	2.32	0.53 – 10.22	0.267
Experience	< 10 years (Ref.)									
	≥ 10 years	3.80	1.29 – 11.19	0.015*	0.57	0.21 – 1.57	0.278	1.46	0.56 – 4.68	0.521
Cattle breed	Indigenous (Ref.)									
	Exotic	14.03	1.47 – 13.41	0.022*	0.39	0.05 – 2.97	0.36	4.0	0.19 – 81.33	0.371
Grazing system	Semi-intensive (Ref.)									
	Intensive	2.30	0.32 – 16.41	0.407	2.34	0.51 – 10.69	0.272	0.36	0.03 – 4.81	0.438
	Free range	0.80	0.05 – 11.93	0.870	0.54		0.980	0.43	0.01 – 0.67	0.980

Note: Number of livestock keepers (n) =100, OR= Odds ratio, Ref.= Reference group, CI= Confidence Interval, UL= Upper Limit, LL= Lower Limit, *=P-value <0.05

Table 7

Multivariable logistic analysis between demographic characteristics and KAP scores for parents or guardians in Morogoro Municipality and Monduli District, Tanzania

Parameter	Category	Knowledge			Attitude			Practices		
		OR	95% CI (LL-UL)	P value	OR	95% CI (LL-UL)	P value	OR	95% CI (LL-UL)	P value
Study site	Arusha	1.356	0.853 –2.156	0.197	0.958	0.604–1.520	0.855			.994
	Morogoro	Ref								
Sex	Female	Ref								
	Male	1.197	0.370 –3.876	0.764	1.823	0.574 –5.791	0.309	0.547	0.204 –1.468	.821
Age	18-25	Ref								
	26-33	0.486	0.145 -1.626	0.241	0.382	0.129–1.132	0.083	0.547	0.204–1.468	.231
	34-41	0.299	0.091– 0.984	0.047*	0.782	0.268–2.285	0.654	0.567	0.173–1.855	.348
	Above 41	0.277	0.081 –0.949	0.041*	0.579	0.190 –1.765	0.337	2.108	0.205 –21.659	.530

Note: Number of parents or guardians (n) =340, OR= Odds ratio, Ref.= Reference group, CI= Confidence Interval, UL= Upper Limit, LL= Lower Limit, *=P-value <0.05

Discussion

This study evaluated KAP of livestock keepers and parents or guardians of children under-five regarding antimicrobial residues in raw cow milk and associated health risks in Morogoro Municipality and Monduli District. The findings indicate that although both groups exhibited satisfactory practices, their knowledge and attitudes were only moderately sufficient. Key socio-demographic factors and significant predictors influenced the KAP outcomes, demonstrating shortcomings in milk safety awareness and emphasizing the necessity for targeted interventions to address antimicrobial resistance and improve public health outcomes.

This study confirmed that parents or guardians had limited knowledge of antimicrobial residues, as evidenced by livestock keepers selling milk from cows undergoing antimicrobial treatment. Knowledge of drug withdrawal periods and awareness of the health impacts of antimicrobial residues on children were both limited, as previously reported (Olasoju *et al.,* 2021). Consumer's limited awareness on antimicrobial residues and the variable procedures of manufacturers increases the danger of exposure, thus contributing to AMR and other negative health risks (Patel *et al.,* 2020). The knowledge disparity was particularly evident in older age groups (>34 years), potentially attributable to restricted exposure to food safety and public health education. Parents or guardians in Monduli District demonstrated poor knowledge of drug residues compared to those in Morogoro Municipality. This reflects the limited access to education and information in Monduli, which lowers awareness, aligning with global evidence that shows poor consumer knowledge of antimicrobial residues in dairy foods. Further, it highlights the importance to investigate consumer awareness on food safety and understanding on antimicrobial residues in livestock products (Ramesh and Tripathi, 2022).

The study also established that the knowledge among the livestock keepers was generally proficient, notably among males aged 26-33, those with over 10 years of experience, and individuals raising exotic breeds. Owners of exotic breeds typically undergo training in livestock husbandry procedures, which enhances their understanding of antimicrobial usage and residues in cattle. Similar research done by Omolo *et al.* (2024) in Kenya, indicated a favorable correlation between knowledge and years of farming experience, as well as a strong association between higher education levels and enhanced knowledge. Despite adequate knowledge levels, 50% of livestock keepers exhibited favorable attitudes, with male livestock keepers demonstrating considerably more positive views than their female counterparts regarding the relevance of antimicrobial residue-free milk for public health. This gender gap may indicate wider social and educational dynamics in rural Tanzania, where men frequently assume greater roles in decision-making about animal care and access to training programs (Gwandu *et al.,* 2018; Kelly *et al.,* 2018; Zhang *et al.,* 2016). The findings underscore the necessity for gender-sensitive initiatives to improve understanding and perception of antimicrobial resistance risk among female livestock keepers.

It was further found that children in the study locations consumed an average of half a litre of cow milk per day, with some consuming raw milk, a common practice that expose the public to milk-borne hazards (Ngasala et al., 2015; Nyokabi, 2023; Mhozya, 2017). A separate study on antimicrobial residue levels in the same districts established that oxytetracycline concentrations in milk ranged from 84 to 116 µg/L. This implies that when children consume half a litre of milk daily, the amount of oxytetracycline residues ingested is 42 to 58 µg, a situation that places them at health risks (Kosgey *et al.,* 2018). It is important to mitigate the indiscriminate antimicrobial usage in food-producing animals to protect public health. Parents or guardians depicted a strong positive attitude towards milk safety, expressing concern over the health effects of residues to their children. However, livestock keepers acknowledged the significance of adhering to antimicrobial withdrawal periods but admitted to selling milk from cows undergoing treatment. Nonetheless, there are several legislations regulating milk as food, which include The Animal Diseases Act Cap 156 (2003), The Dairy Industry Act Cap 262 (2006), The Tanzania Food Drugs and Cosmetics Act CAP 219 (2003), The Standards Act Cap 130 (2009), The Public Health Act, Cap 263 (2009), The Tanzania Food and Nutrition Act CAP 109 (2009). The problem has been enforcing laws to ensure

safety of the milk along the value chain.

Regarding practices, majority of livestock keepers showed commendable behavior, with those in Morogoro Municipality demonstrating superior knowledge compared to their counterparts in Arusha. This highlights the necessity for educational initiatives, veterinary outreach, livestock extension services, and improved market access in rural regions to enhance awareness of antimicrobial resistance. A study done by Caudell *et al.* (2017) in Northern Tanzania indicated a significant prevalence of self-administration of antimicrobial in cattle, with inadequate compliance to the drug withdrawal period. Nonetheless, discrepancies persist as some livestock keepers acknowledged selling milk during the treatment period. Although the attitude was positive, the disparity between attitude and actual practices among livestock keepers is of great concern. The ambiguous antimicrobial practices in cattle are supported by research published by Kurwijila *et al.* (2006) and Katakweba *et al.* (2012), that indicated that despite awareness of the withdrawal period, economic pressures frequently drive livestock keepers to this malpractices. This diverges from similar findings in other rural environments, where cultural norms, economic constraints, and insufficient regulatory monitoring undermine compliance with recommended practices (Hounmanou and Mdegela, 2018).

Conclusion

Participants from Monduli demonstrated reduced probabilities of favorable knowledge, attitudes, and practices (KAP) relative to those from Morogoro Municipal, highlighting regional disparities potentially influenced by variations in access to veterinary services and public health initiatives (Azabo *et al.,* 2022; Subedi *et al.,* 2023). Education has become a crucial factor, with individuals with higher education exhibiting better KAP outcomes. Parents or guardians with secondary education showed a greater tendency to implement safe milk handling procedures, whereas livestock keepers with secondary education demonstrated far better understanding and compliance regarding withdrawal periods (Subedi *et al.,* 2023). Gender additionally affected outcomes, with male livestock keepers demonstrating greater compliance with farming methods (Olasoju *et al.,* 2021). The findings underscore the complex influence of socio-demographic determinants on milk safety practices and stress the necessity for specific approaches that address regional, educational, and market inequities to improve public health outcomes (Merlino *et al.,* 2023).

Study limitations

This cross-sectional study focused on Monduli districts and Morogoro Municipality, interviewed livestock keepers and selected parents or guardians such as generalization of results countrywide may be limited. More districts from different zones of Tanzania may depict more on KAP of livestock keepers and parents or guardians with children under five years regarding antimicrobial residues in raw cow milk and associated health risks. Involvement of regulatory authorities in the study could disclose the reality of raw cow milk inspection and monitoring for antimicrobial residues in Tanzania.

Acknowledgements

The authors acknowledge the financial support provided by Tanzania Partnership Program (TPP). The livestock keepers and parents or guardians of children under five years of age in Morogoro Municipality and Monduli district are acknowledged for their cooperations. Local government authorities in the two study districts are thanked for giving the permits to conduct this study.

Data availability statement

Data supporting the findings of this study are available if requested from the corresponding author and not made public due to privacy and ethical reasons.

Conflict of Interest

Authors declare no conflict of interest.

References

Azabo, R. R., George, J. I., Mshana, S. E., Matee, M. I., & Kimera, S. I. (2022). Farm costs and benefits of antimicrobial use reduction on

broiler farms in Dar es Salaam, Tanzania. Frontiers in Antibiotics, 1:1011929. doi: 10.3389/frabi.2022.1011929.

Blackmore, E., Guarin, A., Kinyua, C., Vorley, W., Grace, D. & Alonso, S. (2022). The governance of quality and safety in Tanzania's informal milk markets. Frontiers in Sustainable Food Systems, 6. https://doi.org/10.3389/fnut.2023.1072208

Caudell, M. A., Quinlan, M. B., Subbiah, M., Call, D. R., Roulette, C. J., Roulette, J. W., Roth, A., Matthews, L. & Quinlan, R. J. (2017). Antimicrobial use and veterinary care among agro-pastoralists in Northern Tanzania. PLoS ONE, 12(1), 1–18. https://doi.org/10.1371/journal.pone.0170328

Charan, J. & Biswas, T. (2013). Review Article How to Calculate Sample Size for Different Study Designs in Medical Research ? Indian Journal of Psychological Medicine, 35(2):121–126. doi: 10.4103/0253-7176.116232

DHS. (2022). Administrative Units Population Distribution Report. National Population and House Census of Tanzania. National Bureau of Statistics, Dar Es Salaam, Tanzania. https://www.nbs.go.tz/nbs/takwimu/Census2022/Administrative_units_Population_Distribution_Report_Tanzania_volume1a.pdf

Gillah, K.A., Kifaro, G.C. & Madsen, J. (2014). Effects of management practices on yield and quality of milk from smallholder dairy units in urban and peri-urban Morogoro, Tanzania. Tropical Animal Health and Production, 46, 1177–1183. https://doi.org/10.1007/s11250-014-0624-3.

Gwandu, S. H., Nonga, H. E., Mdegela, R. H., Katakweba, A. S., Suleiman, T. S. & Ryoba, R. (2018). Assessment of raw cow milk quality in smallholder dairy farms in Pemba Island Zanzibar, Tanzania. Veterinary Medicine International, Volume 2018, Article ID 1031726, 9 pages https://doi.org/10.1155/2018/1031726

Hounmanou, Y. M. G. & Mdegela, R. H. (2018). Current situation for antimicrobial use, antimicrobial resistance and antimicrobial residues in the food and agriculture sectors in Tanzania: A review. Tanzania Veterinary Journal, 35(1), 58–62.

Katakweba, A.A.S., Mtambo, M.M.A., Olsen, J.E. & Muhairwa, A.P. (2012). Awareness of human health risks associated with the use of antibiotics among livestock keepers and factors that contribute to selection of antibiotic resistance bacteria within livestock in Tanzania. Livestock Research for Rural Development. Volume 24, Article #170. Retrieved March 6, 2026, from http://www.lrrd.org/lrrd24/10/kata24170.htm

Kelly, T. R., Bunn, D. A., Joshi, N. P., Grooms, D., Devkota, D., Devkota, N. R., Paudel, L. N., Roug, A., Wolking, D. J. & Mazet, J. A. K. (2018). Awareness and practices relating to zoonotic diseases among smallholder farmers in Nepal. EcoHealth, 15(3), 656–669. https://doi.org/10.1007/s10393-018-1343-4

Kimera, Z. I., Mshana, S. E., Rweyemamu, M. M., Mboera, L. E. G. & Matee, M. I. N. (2020). Antimicrobial use and resistance in food-producing animals and the environment: An African perspective. Antimicrobial Resistance and Infection Control, 9(1), 1–12. https://doi.org/10.1186/s13756-020-0697-x

Kivaria, F.M., Noordhuizen, J.P. & Kapaga, A.M. (2006). Evaluation of the hygienic quality and associated public health hazards of raw milk marketed by smallholder dairy producers in the Dar es Salaam region, Tanzania. Tropical Animal Health and Production, 38(3):185-94. doi: 10.1007/s11250-006-4339-y. PMID: 16986766.

Kosgey, A., Shitandi, A. & Marion, J. W. (2018). Antibiotic Residues in Milk from Three Popular Kenyan Milk Vending Machines. Journal of the American Veterinary Medical Association, 98, 1520–1522. https://doi.org/10.4269/ajtmh.17-0409

Kumar, N., Sharma, G., Leahy, E., Shome, B. R., Bandyopadhyay, S., Deka, R. P., Shome, R., Dey, T. K. & Lindahl, J. F. (2021). Understanding antibiotic usage on small-scale dairy farms in the Indian states of assam and Haryana using a

mixed-methods approach—outcomes and challenges. Antibiotics, 10(9). https://doi.org/10.3390/antibiotics10091124

Kurwijila, L. R., Omore, A., Staal, S. & Mdoe, N. S. Y. (2006). Investigation of the risk of exposure to antimicrobial residues present in marketed milk in Tanzania. Journal of Food Protection, 69(10), 2487–2492. https://doi.org/10.4315/0362-028X-69.10.2487

Lotto, T., Renggli, S., Kaale, E., Masanja, H., Ternon, B., Décosterd, L. A., D'Acremont, V., Genton, B. & Kulinkina, A. V. (2024). Prevalence and predictors of residual antibiotics in children's blood in community settings in Tanzania. Clinical Microbiology and Infection, 30(8), 1042–1048. https://doi.org/10.1016/j.cmi.2024.05.004

Lugamara, C.B., Urassa, J.K. & Massawe, G.D. (2023). A review of post-harvest milk losses in Tanzania's milk sector: lessons from production to consumption. Tanzania Journal of Agricultural Sciences, 22(02), 1-8.

Mashauri, H. L., Max, B. L., Makweba, S. M. & Nonga, H. E. (2025). Antimicrobial Residues and Food Safety: A Public Health Crisis of Concern in Tanzania. A Review. Health Science Reports, 8(8), e71155. https://doi.org/10.1002/hsr2.71155.

Mdegela, R. H., Ryoba, R., Karimuribo, E. D., Phiri, E. J., Løken, T., Reksen, O., Mtengeti, E. & Urio, N. A. (2009). Prevalence of clinical and subclinical mastitis and quality of milk on smallholder dairy farms in Tanzania. Journal of the South African Veterinary Association, 80(3):163-8. doi: 10.4102/jsava.v80i3.195

Mengele, I, J, Shirima, G.M., Bronsvoort, B.M., Hernandez-Castro, L.E. & Cook, E.A.J. (2023). Diagnostic challenges of brucellosis in humans and livestock in Tanzania: A thematic review. CABI One Health, (2023), 1-16.

Merlino, V. M., Mosca, O., Blanc, S., Sparacino, A., Massaglia, S., Borra, D., Mastromonaco, G. & Fornara, F. (2023). The role of socio-demographic variables and buying habits in determining milk purchasers' preferences and choices. Frontiers in Nutrition, 10, 1–10. https://doi.org/10.3389/fnut.2023.1072208

Mhozya, R. (2017). Assessment of antibiotic residues in raw cow milk in Mwanza, Tanzania. MSc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania, pp 105. Available at https://www.suaire.sua.ac.tz/items/a6c7de8f-2237-4288-bbdf-d411f855c043

MLF. (2024). Ministry of Livestock and Fisheries Budget Speech. https://www.mifugouvuvi.go.tz/

MLF. (2020). Ministry of Livestock and Fisheries Development Commodity Value Chain Briefs. Brief No 2, Dairy. 2. Available at: https://policyvault.africa/wp-content/uploads/policy/TZA139.pdf-NOT CITE, delete??

Ngasala, J. B., Nonga, H. E., Madundo, M., & Mtambo, A. (2015). Assessment of raw milk quality and stakeholders' awareness on milk-borne health risks in Arusha City and Meru District, Tanzania. Tropical Animal Health and Production, 47(5):927-32. doi: 10.1007/s11250-015-0810-y.

Nyokabi, S. N. (2023). Bridging the gap: improving milk quality on smallholder dairy systems in Kenya. [internal PhD, WU, Wageningen University]. Wageningen University. https://doi.org/10.18174/579689

NSCA, (2012). National Sample Census f Agriculture 2002/2003, Volume Ve: Regional Report: Morogoro Region. Available at https://www.nbs.go.tz/uploads/statistics/documents/en-1705482873-Morogoro%20Report.pdf

Olasoju, M.I., Olasoju, T.I., Adebowale, O.O. & Adetunji, V.O. (2021). Knowledge and practice of cattle handlers on antibiotic residues in meat and milk in Kwara State, Northcentral Nigeria. PLoS ONE 16(10): e0257249. https://doi.org/10.1371

Omolo, J. O., Omani, R., Caudell, M. A., Kimani, T., Kiambi, S., & Fasina, F. O. (2024). Knowledge, Attitudes, Practices on

Antimicrobial Use in Animals Among Livestock Sector Stakeholders in Kenya. Veterinary Medicine International, 2024(1). https://doi.org/10.1155/2024/8871774.

Patel, N. M., Kumar, R., Savalia, C. V, Desai, D. N. & Kalyani, I. H. (2020). Dietary exposure and risk assessment of antibiotics residues in marketed bovine raw milk. Journal of Entomology and Zoology Studies, 8(4): 1823-1827.

Pogurschi, E. N., Ghimpeteanu, O. M., Petcu, C., Dragotoiu, T. & Rusu, A. I. (2022). Antibiotic Residues in Milk and Assessment of Human Health Risk in Romania. Scientific Papers-Series D-Animal Science, 65(1), 542–547.

Ramesh, N. & Tripathi, H. (2022). Consumers' knowledge regarding antibiotic residues and their consciousness about food safety issues in livestock products. Indian Journal of Animal Sciences, 92(3), 306–310. https://doi.org/10.56093/ijans.v92i3.122259

Rwehumbiza, J.M., Ryoba, R. and Karimuribo, E.D. (2013). Assessment of microbiological status and presence of antibiotic residues in cow milk produced in Bagamoyo and Kisarawe districts, Tanzania. Tanzania Veterinary Journal, 28: 60-69.

Sangeda, R.Z., Baha, A., Erick, A., Mkumbwa, S., Bitegeko, A., Sillo, H.B. et al (2021) Consumption Trends of Antibiotics for Veterinary Use in Tanzania: A Longitudinal Retrospective Survey From 2010-2017. Frontitiers Tropical Diseases, 2, 1–11.

Simbine-Ribisse, E.O., Bila, M.N., Manhiça, A.J., Macuamule, C.J. and Bragotto, A.P.A. (2024). Antibiotic residues in dairy products in Africa: A systematic review. Food Chemistry Advances, 5 (2024): 100822. https://doi.org/10.1016/j.focha.2024.100822

Subedi, D., Jyoti, S., Thapa, B., Paudel, S., Shrestha, P., Sapkota, D., Bhatt, B. R., Adhikari, H., Poudel, U., Gautam, A., Nepal, R. & Al-Mustapha, A. I. (2023). Knowledge, Attitude, and Practice of Antibiotic Use and Resistance among Poultry Farmers in Nepal. Antibiotics, 12(9), 1–20. https://doi.org/10.3390/antibiotics12091369.

The Dairy Industry (Raw Milk Transportation) (Amendment) Regulations, (2020). Available at: https://www.mifugouvuvi.go.tz/

The Animal Diseases Act Cap 156. (2003). Available at: https://www.mifugouvuvi.go.tz/

The Veterinary Act Cap 319. (2003) Available at: https://www.mifugouvuvi.go.tz/ NOT CITED??

The Dairy Industry Act Cap 262. (2006). Available at: https://www.mifugouvuvi.go.tz/

The Public Health Act, Cap 263. (2009). Available at: https://www.parliament.go.tz/polis/uploads/bills/acts/1452146412-ActNo-1-2009.pdf

The Standards Act Cap 130. (2009). Available at: https://www.tbs.go.tz/publications/23

The Tanzania Food and Nutrition Act CAP 109. (2009). Available at: https://tanzanialaws.com/t/364-tanzania-food-and-nutrition-act

The Tanzania Food Drugs and Cosmetics Act CAP 219. (2003). Available at: https://www.tmda.go.tz/

TLMP (2017) Tanzania Livestock Master Plan of 2017/2018 – 2021/2022. https://www.mifugouvuvi.go.tz/

Zhang, H. L., Mnzava, K. W., Mitchell, S. T., Melubo, M. L., Kibona, T. J., Cleaveland, S., Kazwala, R. R., Crump, J. A., Sharp, J. P. & Halliday, J. E. B. (2016). Mixed Methods Survey of Zoonotic Disease Awareness and Practice among Animal and Human Healthcare Providers in Moshi, Tanzania. *PLoS Neglected Tropical Diseases*, *10*(3), 1–18. https://doi.org/10.1371/journal.pntd.0004476.

Uakarn, C. (2021). Sample size estimation using Yamane and Cochran and Krejcie and Morgan and Green formulas and Cohen statistical power analysis by G*power and comparisons. *Apheit International Journal*, *10*(2), 76–88.