antibiotics tested is a public health concern. The possible reason for the high resistance of the isolated bacteria to the antimicrobials may due to indiscriminate use of antibiotics by livestock keepers (40). This is shown clearly from the results where milk samples positive for antibiotic residues harbored more resistant pathogens compared to the samples with no detectable antimicrobial residues (Table 3). This is as a result of limited veterinary extension services, farmers' inadequate knowledge on animal health and easy access to antibiotics in livestock markets (41). Bacteria may have developed resistance through the inappropriate use of the antibiotics in cattle and the acquisition of resistance genes (14, 40, 42).

Table 1: Antibiotic-resistance profiles of bacteria pathogens from raw milk

Bacteria species	N	Number (%) of resistant bacteria																	
		NA		GEN		CIP		TET		CHL		AMP		COT		CTR		FOX	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%
E. coli	30	30	(100.0)	30	(100.0)	8	(26.7)	28	(93.3)	30	(100.0)	19	(63.3)	30	(100.0)	28	(93.3)		NT
E. coli 0157:H7	5	5	(100.0)	5	(100.0)	2	(40.0)	2	(40.0)	5	(100.0)	1	(20.0)	5	(100.0)	4	(80.0)		NT
Salmonella sp.	10	7	(70.0)	2	(20.0)	1	(10.0)	2	(20.0)	10	(100.0)	9	(90.0	0	(0.0)	10	(100.0)		NT
Shigella sp.	7	1	(14.3)	2	(28.6)	1	(14.3)	2	(28.6)	7	(100.0)	7	(100.0)	1	(14.3)	7	(100.0)		NT
Proteus sp.	6	5	(83.3)	6	(100.0)	5	(83.3)	4	(66.7)	5	(83.3)	6	(100.0)	6	(100.0)	5	(83.3)		NT
P. aeruginosa	9	5	(55.6)	5	(55.6)	1	(11.1)	4	(44.4)	9	(100.0)	5	(55.6)	8	(88.9)	5	(55.6)		NT
K. pneumoniae	34	30	(88.2)	33	(97.1)	34	(100.0)	34	(100.0)	24	(70.6)	24	(70.6)	34	(100.0)	19	(55.9)		NT
S. aureus	21	19	(90.5)	14	(66.7)	17	(81.0)	12	(57.1)	12	(57.1)	10.0	(47.6)	12	(57.1	10	(47.6)	10	(47
Total	122	102	(83.6)	97	(79.5)	69	(56.6)	88	(72.1)	102	(83.6)	81	(66.4)	96	(78.7)	88	(72.1)	10	(8.

AMP: Ampicillin; COT: Trimethoprim-sulfamethoxazole e; FOX: Cefoxitin; CTR: Ceftriaxone: Chloramphenicol; NA: Nalidixic acid; CIP: Ciprofloxacin: GEN: Gentamicin; TET: Tetracycline: NT: Not Tested

Table 2: Antibiotic-resistance profiles of bacteria pathogens from milk products

Bacteria species	N	Number (%) of resistant bacteria																	
		NA		GEN		CIP		TET		CHL		AMP		COT		CTR		FOX	
		n	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
E. coli	12	12	(100.0)	8	(66.7)	4	(33.3)	6	(50.0)	7	(58.3)	5	(41.7)	12	(100.0	11	(91.7	NT	
Salmonella sp.	2	2	(100.0)	0	(0.0)	0	(0.0)	0	(0.0)	2	(100.0)	2	(100.0)	0	(0.0)	1	(50.0	NT	
P. aeruginosa	2	1	(50.0)	0	(0.0)	0	(0.0)	2	(100.)	2	(100.0)	0	(0.0)	2	(100.0)	0	(0.0)	NT	
K. pneumoniae	4	3	(75.0)	4	(100)	1	(25.0)	3	(75.0)	2	(50.0)	1	(25.0)	1	(25.0)	2	(50.0	NT	
S. aureus	8	4	(50.0)	4	(50.0)	3	(37.5)	2	(25.0)	4	(50.0)	0.0	(0.0)	4	(50.0)	2	(25.0)	2	(25.0)
Total	28	22	(78.6)	16	(57.1)	8	(28.6)	13	(46.4)	17	(60.7)	8	(28.6)	19	(67.9)	16	(57.1)	2	(7.1)

AMP: Ampicillin; COT: Trimethoprim-sulfamethoxazole e; FOX: Cefoxitin; CTR: Ceftriaxone: Chloramphenicol; NA: Nalidixic acid; CIP: Ciprofloxacin: GEN: Gentamicin; TET: Tetracycline: NT: Not Tested

Table 3: Multidrug resistance detected among bacteria isolated

	Raw Milk			Milk Products		
Isolates	No. of isolates	MDR	(%)	No. of isolates	MDR	(%)
E. coli	30	21	(70.0)	12	4	(33.3)
E. coli 0157:H7	5	2	(40.0)	0	0	0
Salmonella sp.	10	4	(40.0)	2	1	(50.0)
Shigella sp.	7	3	(42.9)	0	0	0
Proteus sp.	6	2	(33.3)	0	0	0
P. aeruginosa	9	7	(77.8)	2	2	(100.0)
K. pneumoniae	34	24	(70.6)	4	2	(50.0)
S. aureus	21	18	(85.7)	8	6	(75.0)
Total	122	81	(66.4)	28	15	(53.6)

5. Conclusion

The study found high levels of resistance to commonly prescribed antibiotics in the bacteria isolates from raw milk. This calls for strengthening of regulations that cover the sale, distribution, dispensing, and prescription, of veterinary antibiotics. This is because antibiotic resistant bacteria may cause complicated, untreatable, and prolonged infections in humans, leading to higher healthcare cost and sometimes death. Fortunately, Ghana, which hosted the Global AMR call to action agenda in November 2018, like many developing countries has developed an AMR action plan (launched in April 2018) that seeks to address the challenges posed by this menace through public engagement and training of farmers of antimicrobial resistance (AMR) and antimicrobial usage (AMU).

Conflict of interest

The authors declared that they have no conflict of interest.

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Authors' contributions

This work was carried out in collaboration with all authors. Authors GIM and EKV designed the study, wrote the protocol and prepared the first draft manuscript. Author EKV did the sample collection. Authors EKV SEKA and WW performed the bacteria culture and isolation and antimicrobial susceptibility testing. Authors EKV, GIM, PKF and CSKS performed the data analysis. Authors EKV, GIM and PKF revised the manuscript. All authors read and approved the final manuscript.

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