

Supplementary result

Table S1: List of full-text articles included in the systematic review.

Type of Study	Authors	Year published	Region
Human	Dekker et al.[1]	2016	Ashanti
	Afum et al. [2]	2022	Greater Accra
	Inusah et al. [3]	2021	Upper East
	Attram et al. [4]	2019	Multicenter
	Sampane-Donkor et al. [5]	2017	Greater Accra
	Bekoe et al. [6]	2022	Greater Accra
	Gnimatin et al. [7]	2022	Northern
	Sah, & Feglo. [8]	2022	Western
	Quansah et al. [9]	2019	Multicenter
	Krumkamp et al. [10]	2020	Ashanti
	Abana et al. [11]	2019	Greater Accra
	Deku et al. [12]	2022	Volta
	Agyepong et al. [13]	2018	Ashanti
	Deininger et al. [14]	2022	Volta
	Osei et al. [15]	2022	Greater Accra
	Janssen et al. [16]	2018	Western
	Andoh et al. [17]	2017	Ashanti
	Mohammed et al. [18]	2018	Greater Accra
	Asafo-Adjei et al. [19]	2018	Greater Accra
	Donkor et al. [20]	2023	Multicenter
	Karikari et al. [21]	2022	Northern
	Asare et al. [22]	2022	Central
	Omenako et al. [23]	2022	Ashanti
	Labi et al. [24]	2014	Greater Accra

	Codjoe et al. [25]	2019	Multicenter
	Dwomoh et al. [26]	2022	Greater Accra
	Vicar et al. [27]	2023	Northern
	Asamoah et al. [28]	2022	Multicenter
Animal	Agbeko et al. [29]	2022	Multicenter
	Adinortey et al. [30]	2020	Central
	Mensah et al. [31]	2022	Greater Accra
	Boamah et al. [32]	2017	Multicenter
	Ohene Larbi et al. [33]	2022	Greater Accra
	Andoh et al. [34]	2016	Multicenter
	Adzitey et al. [35]	2020	Northern
	Paintsil et al. [36]	2022	Ashanti
	Dsani et al. [37]	2020	Greater Accra
	Karikari et al. [38]	2017	Ashanti
	Asuming-Bediako et al. [39]	2022	Greater Accra
	Baah et al. [40]	2022	Greater Accra
	Eibach et al. [41]	2018	Ashanti
	Dekker et al. [42]	2019	Ashanti
Environmental	Saba et al. [43]	2022	Northern
	Odonkor et al. [44]	2022	Multicenter
	Adomako et al. [45]	2021	Greater Accra
	Saba et al. [46]	2017	Northern
	Ahmed et al. [47]	2022	Greater Accra
	Addae-Nuku et al. [48]	2022	Greater Accra

Table S2: Demographic features of studies included in the systematic review.

Demographic Features	Human Studies (28) n (%)	Animal Studies (14) n (%)	Environmental Studies (6) n (%)	References
Common Infection				
Blood stream infection	3 (10.71)			[1,20,24]
Cholera	2 (7.14)			[2,11]
HIV	1 (3.57)			[5]
Infected wound	2 (7.14)			[10,16]
Septic/Sepsis	1 (3.57)			[23]
UTI	4 (14.29)			[19,21,22,28]
Diarrheal	1 (3.57)			[2]
Animal Study				
Fish		2 (14.29)		[29,30]
Chicken/Poultry		7 (50)		[31,32,34–36,39,41]
Pigs		1 (7.14)		[33]
Cattle		5 (35.71)		[35–38,40]
Human Study				
Patients	15 (53.57)			[1,2,4,7,10,12–14,16,17,19–21,24,26]
Children	2 (7.14)			[5,15]
Neonates	1 (3.57)			[23]
Healthy Volunteer	1 (3.57)			[6]
Food Handlers	1 (3.57)			[27]

Specimen type				
Intestinal		1 (7.14)		[29]
Fecal sample		5 (35.71)		[31,32,34,36,38]
Rectal swab		1 (7.14)		[33]
Poultry drinking water		1 (7.14)		[34]
Poultry feed		1 (7.14)		[34]
Meat		5 (35.71)		[35,37,39,40,42]
Blood	12 (42.86)			[3,7–9,12,13,17,18,20,22–24]
Stool	4 (14.29)			[2,17,22,26]
Aspirate	3 (10.71)			[3,9,26]
Cerebrospinal fluid	2 (7.14)			[3,22]
Ear swab	5 (17.86)			[3,9,12,18,22]
High Vaginal swab	6 (21.43)			[3,7,9,12,18,22]
Semen	2 (7.14)			[3,18]
Sputum	3 (10.71)			[3,7,9]
Urethral swab	4 (14.29)			[3,4,18,22]
Wound swab	10 (35.71)			[3,7–10,13,16,18,22,26]
Urine	13 (46.43)			[3,6–9,12–14,18,19,21,22,26]
Nasopharyngeal swab	3 (10.71)			[3,5,15]
Fecal sludge	1 (3.57)			[17]

Palm swab	1 (3.57)			[27]
Mobile phone			1 (16.67)	[43]
Water source			4 (66.67)	[44,45,47,48]
Door handles			1 (16.67)	[46]

Table S3: Characteristics of studies included in the systematic review.

Author	Region	Year	Study Design	Study Period	Definition of MDR Adopted	Microorganisms studied	Main MDR Microorganism	No. of Isolate	No. of MDR (%)	Identification of microbes	AST Testing Method	Break point Used for MIC	Sample Features	Av. age	Subjects (N)	Settings	Sector
Afum et al. [2]	Greater Accra	2022	Cross-sectional	Aug 2017-May 2021	Resistant to ≥ 3 classes of antibiotics	<i>Escherichia coli</i> ; <i>Salmonella</i> spp; <i>Vibrio</i> spp; and <i>Shigella</i> spp.	<i>Shigella</i> spp.	772	17.6%	Culture-based; standard biochemical tests; MALDI-TOF assay; and serological analysis	Kirby-Bauer disk diffusion and Microscan autoScan4 MIC panels	CLSI	Diarrhea Patients	29.3	792	Five health facilities	Human
Sampson-Donkor et al. [5]	Greater Accra	2017	Cross-sectional	Feb-Apr 2015	Resistant to ≥ 3 classes of antibiotics	<i>Staphylococcus aureus</i> ; <i>Moraxella catarrhalis</i> ; <i>Streptococcus pneumoniae</i> ; <i>Coagulase-Negative Staphylococci</i> ; <i>Diphtheroid</i> ; <i>Streptococcus viridans</i> ; <i>Neisseria meningitidis</i> ; and <i>Citrobacter</i> spp.	<i>Staphylococcus aureus</i>	221	84.6%	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion	CLSI	HIV infected children	5.8	118	Korle-Bu Teaching Hospital	Human
Deku et al. [12]	Volta	2021	Cross-sectional	Apr 2018-Apr 2020	n.a	Extended-spectrum b-lactamase	<i>Escherichia coli</i>	135	41.5%	Culture-based; standard biochemical tests; and PCR	Kirby-Bauer disk diffusion	CLSI	General population	33	135	Ho teaching hospital laboratory	Human
Osei et al. [15]	Greater Accra	2022	Cross-sectional	Sep-Dec 2016	n.a	Aerobic GNB	<i>Acinetobacter baumannii</i>	57	100%	Bruker BD MALDI-TOF MS	Kirby-Bauer disk diffusion	CLSI	Under-Five children in nurseries and kindergartens	39 months	410	Nurseries and kindergartens	Human
Asafo-Adjei et al. [19]	Greater Accra	2018	Cross-sectional	Jan-Jun 2017	n.a	<i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Citrobacter</i> spp.; <i>Enterobacter</i> spp.;	<i>Escherichia coli</i>	144	98.1%	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion	CLSI	Bladder outlet obstruction	69.1	188	Korle-Bu Teaching Hospital	Human

						<i>Pseudomonas</i> spp.; <i>Proteus</i> spp.; <i>Providencia</i> spp.; <i>Serratia</i> spp.; <i>Salmonella</i> spp.; <i>Staphylococcus aureus</i> ; Coagulase-Negative <i>Staphylococcus aureus</i> ; and <i>Shigella</i> spp.							patients				
Donkor et al. [20]	Multicenter (Accra, Eastern, Ashanti, and Volta)	2023	Cross-sectional	Apr-Dec 2021	In vitro non-susceptibility to ≥1 agent in ≥3 antimicrobial classes	<i>Acinetobacter baumannii</i> ; <i>Escherichia coli</i> ; <i>Klebsiella pneumoniae</i> ; <i>Pseudomonas aeruginosa</i> ; and <i>Salmonella</i> spp.	<i>Klebsiella pneumoniae</i>	334	88%	BD Bruker IVD MALDI-TOF version 4.2.100	BD Phoenix M50 analyzer and Kirby-Bauer disk diffusion	CLSI	Patients with bloodstream infections	6	334	Hospitals	Human
Omenako et al. [23]	Ashanti	2022	Cross-sectional	Jan-Dec 2021	n.a	<i>Coagulase-negative Staphylococcus aureus</i> ; <i>Enterococcus</i> spp.; <i>Streptococcus</i> spp.; <i>Pseudomonas</i> spp.; <i>Klebsiella</i> spp.; and <i>Escherichia coli</i>		70		Culture-based	Kirby–Bauer disc diffusion	CLSI	Neonates Admitted with Suspected Sepsis	1 day	549	Komfo Anokye Teaching Hospital (KATH)	Human
Dwomoh et al. [26]	Greater Accra	2022	Cross-sectional	Dec 2020-Mar 2021	Resistant to at least one agent belonging to three or more antibiotic classes	<i>Escherichia coli</i> ; and <i>Klebsiella pneumoniae</i>	<i>Escherichia coli</i>	144	69.4%	Culture-based; and standard biochemical tests	Kirby–Bauer disc diffusion	CLSI	Clinical isolate		144	Korle Bu Teaching Hospital (KBTH).	Human
Vicar et al. [27]	Northern	2023	Cross-sectional	Nov 2020-Mar 2021	n.a	<i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Citrobacter</i> spp.; <i>Proteus</i> spp.; <i>Enterobacter</i> spp.; <i>Pseudomonas aeruginosa</i> ; Coagulase negative <i>Staphylococci</i> ; <i>Staphylococcus aureus</i> ; and <i>Enterococcus</i> spp.		406		Culture-based	Kirby–Bauer disc diffusion	CLSI	Food handlers	26.5	406	Food vending stations	Human
Asamoah et al. [28]	Multicenter (Accra and	2022	Cross-sectional	Jan 2017-Dec 2021.	Resistance to three or more antibiotic drug classes.	<i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Proteus</i> spp.; <i>Pseudomonas</i> spp.;	<i>Klebsiella</i> spp.	20,010	68.6%	Culture-based	Kirby–Bauer disc diffusion	CLSI	Patients with Urinary Tract	38.8	328,073	MDS Lancet Laboratories	Human

	Ashanti)					and <i>Acinetobacter</i> spp.							Infections				
Sah et al. [8]	Western	2022	Cross-sectional	Oct 2020-Feb 2021	n.a	<i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Enterobacter</i> spp.; <i>Citrobacter</i> spp.; <i>Salmonella</i> spp.; <i>Proteus</i> spp.; and <i>Pseudomonas aeruginosa</i>	<i>Escherichia coli</i>	258	48.6%	Culture-based; and standard biochemical tests	Kirby–Bauer disc diffusion	CLSI	Clinical isolate	28	807	Hospitals	Human
Gnimatin et al. [7]	Northern	2022	Retrospective Cross-sectional	Jun 2018-May 2022	Resistant to at least one antibiotic agent in any three or more antibacterial categories	<i>Acinetobacter</i> spp.; <i>Enterobacter</i> spp.; <i>Klebsiella</i> spp.; <i>Moraxella</i> spp.; <i>Escherichia coli</i> ; <i>Pseudomonas</i> spp.; <i>Staphylococcus</i> spp.; <i>Sphingomonas</i> spp.; <i>Shewanella</i> spp.; <i>Providencia</i> spp.; <i>Photobacterium</i> spp.; <i>Gardnerella</i> spp.; <i>Raoultella</i> spp.; <i>Salmonella</i> spp.; and <i>Streptococcus</i> spp.	<i>Staphylococcus</i> spp.	1,222	41.6%	Culture-based; standard biochemical tests; and API 20E system (bioMérieux SA, Marcy l'Etoile, France)	Kirby–Bauer disc diffusion	CLSI	Clinical isolate	41	1,222	Tamale Zonal Public Health Reference Laboratory	Human
Dekker et al. [1]	Ashanti	2016	n.a	May 2007-August 2012	Resistance to at least three groups of antibiotics or being an MRSA	<i>Staphylococcus aureus</i>	<i>Staphylococcus aureus</i>	9,834	35.7%	Culture-based; standard biochemical tests; and Multiplex polymerase chain reaction (PCR)	VITEK 2 system (AST 603 cards, bioMérieux, France)	EUC AST	Patients of all age groups	3	9,834	St. Michael's Hospital (SMH)	Human
Labi et al. [24]	Greater Accra	2014	Retrospective	Jan 2010-Dec 2013	In vitro non-susceptibility to ≥ 1 agent in ≥ 3 antimicrobial categories	<i>Salmonella</i> spp.	<i>Salmonella</i> spp.	181	44.8%	BACTEC 9240 blood culture system; Crystal Enteric/Nonfermenter identification system®	Kirby–Bauer disc diffusion	CLSI	Clinical isolate	9.5	2,768	Korle Bu Teaching Hospital (KBTH).	Human
Abana et al. [11]	Greater Accra	2019	n.a	Oct 2015-Jan 2016	n.a	<i>Vibrio cholerae</i>	<i>Vibrio cholerae</i>	n.a	97%	Culture-based; standard biochemical tests; <i>V. cholerae</i> O1 polyvalent antiserum (Remel Europe Ltd., UK); and PCR analysis	Kirby–Bauer disc diffusion	CLSI	Clinical isolates	n.a	51	Korle Bu Teaching Hospital (KBTH)	Human

Krumkamp et al. [10]	Ashanti	2020	n.a	n.a		<i>Escherichia coli</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Staphylococcus aureus</i> ; <i>Klebsiella pneumoniae</i> ; <i>Streptococcus</i> spp.; and <i>Candida</i> spp.				Culture-based; standard biochemical tests; MALDI Biotyper standard method (Bruker Daltonics, Bremen, Germany); and qPCR assay	VITEK 2 system	EUC AST	Patients with chronically infected wounds	54	105	Kumasi Centre for Collaborative Research in Tropical Medicine, Ghana	Human
Janssen et al. [16]	Western	2018	Prospective	Mar–Jul 2014	n.a	<i>Staphylococcus aureus</i> ; <i>Enterococcus faecalis</i> ; <i>Proteus mirabilis</i> ; <i>Escherichia coli</i> ; <i>Klebsiella pneumoniae</i> ; <i>Enterobacter cloacae</i> ; <i>Pseudomonas aeruginosa</i> ; and <i>Acinetobacter baumannii</i>	n.a	32	n.a	Culture-based; standard biochemical tests; and MALDI Biotyper 3.0 (Bruker Daltonics, Bremen, Germany).	VITEK 2 (bioMérieux, Marcy-l'Étoile, France)	EUC AST version 4.0	Hospital-acquired wound infection patients	40.1	67	St. Martin de Porres Hospital	Human
Karika et al. [21]	Northern	2022	Prospective cross-sectional	Apr 2018–Sep 2018	Resistance of isolates to 3 or more classes of antibiotics.	<i>Escherichia coli</i> ; <i>Staphylococcus aureus</i> ; <i>Staphylococcus</i> spp.; <i>Klebsiella</i> spp.; <i>Serratia</i> spp.; <i>Proteus</i> spp. and <i>Streptococcus</i> spp.	<i>Escherichia coli</i>	74	87.9% – 92.7%	Culture-based; and standard biochemical tests	Kirby–Bauer disk diffusion method.	CLSI	Cases of Urinary Tract Infections	39.18	219	Tamale Teaching Hospital (TTH) and the Tamale Central Hospital (TCH)	Human
Asare et al. [22]	Central	2022	Retrospective cross-sectional	Jan 2013–Dec 2015	n.a	<i>Staphylococcus</i> spp.; <i>Neisseria gonorrhoeae</i> ; <i>Escherichia coli</i> ; <i>Citrobacter</i> spp.; and <i>Klebsiella</i> spp.	n.a	1,515	n.a	Culture-based; and standard biochemical tests	Kirby–Bauer disk diffusion method	n.a	Patients attending the outpatient department	25–26	1,515	University of Cape Coast hospital	Human
Inusah et al. [3]	Upper East	2021	Retrospective	Jan 2018–July 2020	Resistant to at least one agent in three or more antimicrobial categories	<i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Proteus</i> spp.; <i>Pseudomonas</i> spp.; <i>Citrobacter</i> spp.; <i>Enterobacter</i> spp.; <i>Moraxella</i> spp.; <i>Morganella</i> spp.; <i>Providencia</i> spp.; <i>Salmonella</i> spp.;	<i>Escherichia coli</i>	800	99.6%	Culture-based; and standard biochemical tests	Kirby–Bauer disc diffusion method	n.a	General population	n.a	800	Bolgatanga Regional hospital, Ghana	Human

						<i>Serratia</i> spp.; <i>Shigella</i> spp.; <i>Neisseria</i> spp.; <i>Staphylococcus</i> spp.; and <i>Streptococcus</i> spp.											
Attram et al. [4]	Multicenter (Accra and Western)	2019	n.a	Sep 2012-Dec 2015	n.a	<i>Neisseria gonorrhoeae</i>	n.a	44	n.a	Culture-based; standard biochemical tests; and API-NH (Biomérieux, Marcy l'Etoile, France) test	Kirby–Bauer disc diffusion method	CLSI	General population	n.a	990	Five health facilities	Human
Bekoe et al. [6]	Greater Accra	2022	n.a	n.a	n.a	Coagulase-negative staphylococci; and <i>Staphylococcus</i> spp.	n.a	63	n.a	Culture-based; standard biochemical tests; and MALDI-TOF/MS (Bruker Biotyper system, Microflex LT/SH MS, Roskilde, Denmark)	n.a	EUC AST	Healthy volunteers	n.a	401	Korle-Gonno and Dodowa	Human
Quansah et al. [9]	Multicenter (Upper East, Ashanti and Central)	2019	n.a	Oct 2017-Mar 2018	n.a	<i>Klebsiella</i> spp.	n.a	139	n.a	Culture-based; standard biochemical tests; and DNA	n.a	CLSI	General population	n.a	139	Health facilities	Human
Agyepong et al. [13]	Ashanti	2018	n.a	Feb-Aug 2015	Resistant to at least one agent in three or more antibiotic classes.	<i>Klebsiella pneumoniae</i> ; <i>Acinetobacter baumannii</i> ; <i>Pseudomonas aeruginosa</i> ; <i>Enterobacter</i> spp.; <i>Escherichia coli</i> ; <i>Yersinia</i> spp.; <i>Proteus mirabilis</i> ; <i>Pasteurella</i> spp.; <i>Chromobacterium violaceum</i> ; <i>Salmonella enterica</i> ; <i>Vibrio</i> spp.; <i>Citrobacter koseri</i> ; <i>Pantoea</i> spp.; <i>Serratia</i> spp.; <i>Providencia</i> spp.; <i>Burkholderia</i>	<i>Pseudomonas aeruginosa</i>	200	89.5%	Culture-based; and standard biochemical tests	Vitek-2 (Biomérieux, France) Automated Systems	n.a	In-patients and out-patients.	35.95	200	Komfo Anokye Teaching Hospital (KATH)	Human

						<i>cepacia</i> ; <i>Aeromonas</i> spp.; <i>Cadecea lapagei</i> ; and <i>Sphingomonas paucimobilis</i>											
Deininger et al. [14]	Volta	2022	Retrospective	Oct 2019–Dec 2021	n.a	<i>Escherichia coli</i> ; <i>Candida</i> spp.; <i>Klebsiella</i> spp.; <i>Citrobacter</i> spp.; <i>Proteus</i> spp.; <i>Salmonella</i> spp.; <i>Staphylococcus</i> spp.; and <i>Pseudomonas</i> spp.	n.a	131	n.a	Culture-based; and standard biochemical tests	Kirby–Bauer disc diffusion method	CLSI	Inpatient or outpatient	40	348	Margret Marquardt Catholic Hospital (MMCH)	Human
Andoh et al. [17]	Ashanti	2017	n.a	n.a	Resistant to three or more classes of antimicrobials	<i>Salmonella</i> spp.	<i>Salmonella</i> spp.	137	42.3%	Culture-based; and standard biochemical tests	n.a	EUC AST	Patients with suspected septicemia or diarrhea	n.a	137	Two hospitals	Human
Mohammed et al. [18]	Greater Accra	2018	Retrospective	Jan-Dec 2016	n.a	<i>Staphylococcus</i> spp.; <i>Staphylococcus aureus</i> ; and <i>Escherichia coli</i>	n.a	10,237	n.a	Culture-based; and standard biochemical tests	Kirby–Bauer disk diffusion method	CLSI	General population	n.a	10,237	Three hospitals and three private diagnostic service laboratories.	Human
Codjoe et al. [25]	Multicenter (Accra, Western, Ashanti and Volta)	2019	Prospective	Sept 2012–Sep 2014	n.a	<i>Pseudomonas aeruginosa</i> ; <i>Acinetobacter</i> spp.; <i>Escherichia coli</i> ; <i>Pseudomonas</i> spp.; <i>Klebsiella pneumoniae</i> ; <i>Enterobacter</i> spp.; <i>Cronobacter</i> spp.; <i>Providencia</i> spp.; <i>Shigella</i> spp.; and <i>Sphingomonas</i> spp.	n.a	3,840	n.a	Culture-based; and standard biochemical tests	Kirby–Bauer disk diffusion method	CLSI	General population	n.a	3,840	Hospitals	Human
Agbekoko et al. [29]	Multicenter (Western and Central)	2022	n.a	Oct 2019–Feb 2020	n.a	<i>Serratia</i> spp.; <i>Escherichia coli</i> ; <i>Edwardsiella</i> spp.; <i>Citrobacter</i> spp.; <i>Shigella</i> spp.; <i>Staphylococcus aureus</i> ; and <i>Staphylococcus</i> spp.	n.a	145	n.a	Culture-based; standard biochemical tests; and DNA	Kirby–Bauer disk diffusion method	CLSI	Fish	n.a	145	Nine fish farms	Animal

Adinortey et al. [30]	Central	2020	n.a	n.a	n.a	<i>Citrobacter</i> spp.; <i>Klebsiella pneumoniae</i> ; <i>Escherichia coli</i> ; <i>Serratia</i> spp. and <i>Proteus mirabilis</i>	<i>Escherichia coli</i>	n.a	100%	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion method	CLSI	Fish	n.a	n.a	Six small-to-medium scale fish farms	Animal
Mensah et al. [31]	Greater Accra	2022	Cross-sectional	Jan-Mar 2020	Resistance to at least 2 classes of antibiotics	<i>Escherichia coli</i>	<i>Escherichia coli</i>	75	57.1-62.5%	Culture-based; standard biochemical tests; and MALDITOF-MS	Kirby-Bauer disk diffusion method	CLSI	Fecal and chicken samples	n.a	75	Selected Farms and Retail Outlets	Animal
Boamah et al. [32]	Multicenter (Brong Ahafo, Ashanti, and Greater Accra)	2017	n.a	n.a	Simultaneous resistance to three or more antibiotics	Coagulase-negative <i>Staphylococci</i>	Coagulase-negative <i>Staphylococci</i>	368	19.14 %	Culture-based; standard biochemical tests; and MALDITOF-MS	Kirby-Bauer disk diffusion method	EUC AST	Fecal and chicken samples	n.a	368	400 poultry farms	Animal
Labi et al. [33]	Greater Accra	2022	Cross-sectional	Jan-Mar 2022	Resistance to three antimicrobial classes	<i>Escherichia coli</i> ; <i>Enterobacter</i> spp.; and <i>Klebsiella pneumoniae</i>	<i>Escherichia coli</i>	197	23%	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion method	CLSI	Rectal swabs from pigs	4 months	200	20 pig farms	Animal
Andoh et al. [34]	Multicenter (Accra and Kumasi)	2016	Cross-sectional	n.a	Resistance to ≥ 3 classes of antimicrobials	<i>Salmonella</i> spp.	<i>Salmonella</i> spp.	94	40.4 %	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion method	EUC AST	Fecal and chicken samples	n.a	200	20 poultry farms from Accra and 55 farms from Kumasi	Animal
Adzitey et al. [35]	Northern	2020	n.a	n.a	Resistance to ≥ 1 agent in >3 antibiotic classes	<i>Escherichia coli</i> ; <i>Citrobacter</i> spp.; <i>Enterobacter</i> spp.; <i>Klebsiella</i> spp.	<i>Escherichia coli</i>	189	68.33 %	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion method	CLSI	Meat samples from beef, chevon, mutton, chicken, and guinea fowl	n.a	225	Tamale Metropolis	Animal
Paintsil et al. [36]	Ashanti	2022	Cross-sectional	Mar 2019-Jul 2020	Resistance to three or more antimicrobials of any substance group	<i>Campylobacter</i> spp.	<i>Campylobacter</i> spp.	322	23.3%	Culture-based; standard biochemical tests; and MALDI-TOF MS	Kirby-Bauer disk diffusion method	EUC AST	Poultry and livestock faecal samples	n.a	1,585	Commercial and smallholder farms	Animal
Dsaniet al. [37]	Greater Accra	2020	Cross-sectional	Jan 2019-Jun 2019	Resistance to three or more classes of	<i>Escherichia coli</i>	<i>Escherichia coli</i>	98	22%	Culture-based; and MALDI-TOF MS	Kirby-Bauer disk diffusion	n.a.	Beef, chevon and	n.a	205	Slaughterhouses	Animal

					antimicrobial agents						method		mutton samples				
Karikari et al. [38]	Ashanti	2017	n.a	Mar 2013-Feb 2014	Resistance to three or more antibiotics	<i>Campylobacter</i> spp.	<i>Campylobacter jejuni</i>	241	66.6%	Culture-based; standard biochemical tests; and API CAMPY system (bioMérieux, Marcy l'Etoile, France)	Kirby-Bauer disk diffusion method	EUC AST and CLSI	Faeces and Carcasses of Healthy Livestock	n.a	938	Kumasi Abattoir	Animal
Asuming-Bediako et al. [39]	Greater Accra	2022	n.a	Febr 2019-Jan 2020	n.a	<i>Campylobacter</i> spp.	<i>Campylobacter jejuni</i>	153	26.9%	Culture-based; standard biochemical tests; and MALDI-TOF MS	n.a	n.a	Raw retail chicken meat	n.a	400	Metropolitan Accra	Animal
Baah et al. [40]	Accra	2022	Cross-sectional	n.a	Resistance to three or more antibiotic classes	<i>Escherichia coli</i> ; <i>Aeromonas hydrophila</i> ; <i>Vibrio cholerae</i> ; and <i>Klebsiella pneumoniae</i>	<i>Escherichia coli</i>	558	14.9%	Culture-based; standard biochemical tests; API 20E (Biomérieux SA, Marcy-l'Étoile, France), and MALDI-TOF (Bruker Daltonics GmbH & Co., Bremen, Germany, MBT Compass IVD Ver. 4.2.100)	Kirby-Bauer disk diffusion method	CLSI	Meats (beef, goat meat, and chicken)	n.a	270	Meat vending shops	Animal
Eibach et al. [41]	Ashanti	2018	n.a	May-Dec 2015	n.a	<i>Escherichia coli</i> ; and <i>Klebsiella pneumoniae</i>	n.a	71	n.a	Culture-based; standard biochemical tests; API 20E (bioMérieux, Marcy L'Etoile, France); and MALDI-TOF mass spectrometry (Bruker, Billerica, USA)	n.a	EUC AST	Local and imported poultry meat	n.a	200	94 stores and markets	Animal
Dekker et al. [42]	Ashanti	2019	Cross-sectional	May-Dec 2015	Resistance to three classes of antibiotics	<i>Salmonella</i> spp.; <i>Campylobacter</i> spp.; and <i>Arcobacter</i> spp.	<i>Campylobacter</i> spp.	92	20%	Culture-based; standard biochemical tests; and MALDI-TOF MS	n.a	EUC AST	Frozen and fresh meat	n.a	200	Poultry industry and imports	Animal
Saba et al. [43]	Northern	2022	n.a	Mar-Apr 2016	Resistance to three or more antibiotics	<i>Staphylococcus aureus</i> ; and <i>Escherichia coli</i>	n.a	78	n.a	Culture-based; and standard biochemical tests	n.a	EUC AST	Mobile phones of health personnel	n.a	220	Three major government hospitals in the	Environmental

																Tamale Metropo- lis of Ghana	
Odonkor et al. [44]	Multicenter (Accra and Eastern)	2022	n.a	n.a	n.a	<i>Acinetobacter</i> spp.; <i>Bacillus</i> spp.; <i>Citrobacter</i> spp.; <i>Enterobacter</i> spp.; <i>Enterococcus</i> spp.; <i>Escherichia coli</i> ; <i>Klebsiella</i> spp.; <i>Proteus</i> spp.; <i>Providencia</i> spp.; <i>Pseudomonas aeruginosa</i> ; <i>Salmonella</i> spp.; <i>Staphylococcus aureus</i> ; <i>Staphylococcus</i> spp.; <i>Streptococcus</i> spp.; and <i>Vibrio</i> spp.	<i>Staphylococcus aureus</i>	110	59.6%	Selective media methods and the analytical profile index (API)	Kirby-Bauer disk diffusion method	CLSI	Boreholes, dams, hand-dug wells	n.a	67	Seven communities	Environmental
Adomako et al. [45]	Greater Accra	2021	Cross-sectional	Jan–Jun 2018	n.a	<i>Escherichia coli</i> ; <i>Aeromonas hydrophila</i> and <i>Pseudomonas aeruginosa</i>	n.a	150	n.a	Culture-based; and standard biochemical tests	Kirby-Bauer disk diffusion method	CLSI	Wastewater and surface water samples	n.a	150	Legon Sewage Treatment plant	Environmental
Saba et al. [46]	Northern	2017	n.a	Feb-Mar 2015	Resistant to three or more antibiotics	<i>Staphylococcus aureus</i>	<i>Staphylococcus aureus</i>	47	19%	Culture-based; and standard biochemical tests	n.a	CLSI	Door handles and other points of contact	n.a	120	Tamale Teaching Hospital, Tamale Central Hospital and Tamale West Hospital	Environmental
Ahmed et al. [47]	Accra	2022	Cross-sectional	Dec 2021–Mar 2022.	Resistance to three or more classes of antibiotics.	<i>Escherichia coli</i> ; and <i>Pseudomonas aeruginosa</i>	<i>Escherichia coli</i>	317	58.3%	Culture-based; and MALDI-TOF MS (Bruker MALDI Biotyper, Billerica, MA, USA).	Kirby-Bauer disk diffusion method	CLSI	Potable water samples	n.a	542	CSIR–Water Research Institute,	Environmental
Addae-Nuku et al. [48]	Accra	2022	Longitudinal	Oct-Dec 2021	Resistance to 3 or more classes of antimicrobial drugs.	<i>Escherichia coli</i> ; <i>Klebsiella pneumoniae</i> ; <i>Citrobacter</i> spp.; <i>Alcaligenes faecalis</i> ; <i>Pseudomonas</i> spp.	<i>Escherichia coli</i>	294	28%	Culture-based; standard biochemical tests; and MALDI-TOF	Kirby–Bauer disc diffusion	CLSI	Hospital Wastewater		288	Korle Bu Teaching Hospital (KBTH).	Environmental

Table S4: Medically important bacteria isolated in the studies.

Bacteria Isolate	Human Studies (28) n (%)	Animal Studies (14) n (%)	Environmental Studies (6) n (%)	References
<i>Acinetobacter</i> spp.	7 (25)	1 (7.14)	2 (33.33)	[13,15,16,18,20,25,28] [40] [44,48]
<i>Campylobacter</i> spp.		4 (28.57)		[36,38,39,42]
<i>Candida</i> spp.	2 (7.14)			[14,22]
<i>Citrobacter</i> spp.	9 (32.14)	3 (21.43)	2 (33.33)	[3,5,8,13,14,18,19,22,27] [29,30,40] [44,48]
Coagulase-negative Staphylococci	5 (18.86)	1 (7.14)		[5,6,19,23,27] [32]
<i>E. coli</i>	19 (67.86)	8 (57.14)	5 (83.33)	[2,3,7,8,10,12–16,18–23,26–28] [29–31,33,35,37,40,41][43–45,47,48]
<i>Enterobacter</i> spp.	9 (32.14)	4 (28.57)	1 (16.67)	[3,8,13,15,16,18,19,21,27] [29,30,33,40] [44]
<i>Enterococcus</i> spp.	6 (21.43)		1 (16.67)	[10,16,18,23,27,28] [44]
<i>Klebsiella</i> spp.	18 (64.29)	5 (35.71)	2 (33.3)	[2,3,7–10,13–16,18–21,23,26–28] [29,30,33,40,41] [44,48]
<i>Neisseria</i> spp.	4 (14.29)			[3–5,22]
<i>Proteus</i> spp.	12 (42.46)	3 (21.43)	1 (16.67)	[3,8,10,13,14,16,18,19,21,22,27,28] [29,30,40] [44]
<i>Providencia</i> spp.	6 (21.43)	1 (7.14)	1 (16.67)	[3,7,13,15,18,19] [40] [44]
<i>Pseudomonas</i> spp.	14 (50)	1 (7.14)	4 (66.67)	[3,7,8,13–16,18–20,23,25,27,28][40] [44,45,47,48]
<i>S. aureus</i>	10 (35.71)		3 (50)	[1,5,10,16,18,19,21–23,27] [43,44,46]
<i>Salmonella</i> spp.	12 (42.86)	5 (35.71)	1 (16.67)	[2,3,8,13,14,17–22,24] [29,30,34,40,42] [44]

<i>Shigella</i>	2 (7.14)	3 (21.43)		[2,3] [29,30,40]
<i>Staphylococcus</i> spp.	4 (14.29)	1 (7.14)		[3,7,14,18] [29]
<i>Streptococcus</i> spp.	6 (21.43)	1 (7.14)	1 (16.67)	[3,5,10,18,21,23] [29] [44]
<i>Vibrio</i> spp.	3 (10.71)	1 (7.14)		[2,11,13] [40]

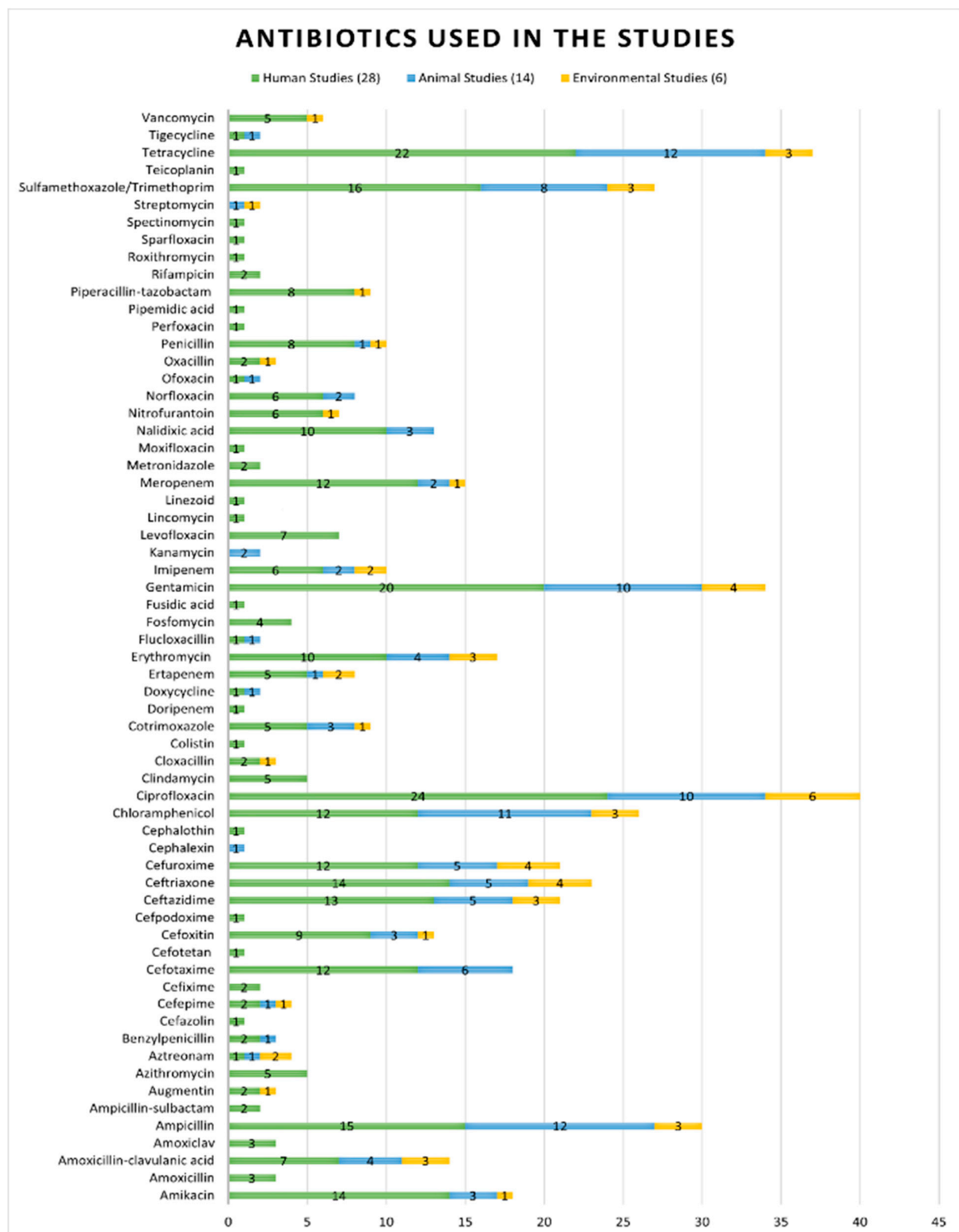


Figure S1. Antibiotic used in the studies.

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