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RESEARCH ARTICLE

Antibiotic Susceptibility Pattern of Enterobacteriaceae Isolated from Raw Meat and Ghanaian Coin Currencies at Cape Coast Metropolis, Ghana: The Public Health Implication

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Abstract:

Introduction:

The emergence and upsurge of multiple antibiotic resistant (MDR) Enterobacteriaceae in the environment is a cause of concern as this can result in an outbreak and spread to healthcare settings. MDR Enterobacteriaceae have been associated with high morbidity and mortality due to delay in selecting and delivering active therapy in time.

Aims & Objectives:

The study was conducted to investigate the level of contamination of raw meat and Ghanaian coins in circulation at Cape Coast Metropolis. In all, 10 raw meat were sampled each from chevron and beef from Kotokuraba market, and 400 Ghanaian coin currencies retrieved from food vendors, students, transport operators and banks were used in this study.

Methods & Materials:

The Enterobacteriaceae species isolated were tested for their susceptibility to Ampicillin, Tetracycline (TET), Gentamicin (GEN), Cotrimoxazole (COT), Cefuroxime (CRX), Cefixime (CXM), Cefotaxime (CTX), Penicillin (PEN), Cloxacillin (CXC), Erythromycin (ERY) and Amikacin (AMK) antibiotics using Mueller-Hinton agar antibiotic diffusion technique. Of the isolated Enterobacteriaceae, 30% and 62% from chevron and beef respectively and 14.17%, 13.75% and 10.63% from food vendors, students and transport operators respectively showed resistance to some of the antibiotics tested.

Results & Discussions:

8.6% of the *Escherichia coli* (*E. coli*) isolated from chevron were resistant to CRXr-CHLr-AMPr-COTr-GEMr and 15.5% of CRXi-CHLi-AMPr-TETr-COTr from beef. 40.0% of *E. coli* isolated from coin currencies were resistant to CRXr-CHLr-AMPr-TETr-CTXr, 50.0% of *Enterobacter spp* to CRXr-CHLr-AMPr-TETr-CTXr, 16.67% of *Proteus spp* to CRXi-CHLi-AMPr-TETr-AMKi, 40% *Pseudomonas spp* to CRXr-AMPr-TETr-AMKi and 100% of *Enterobacter spp* to CRXr-AMPr-TETi-CTXr.

Conclusion:

The multidrug-resistant Enterobacteriaceae isolates from circulating Ghanaian coins and raw meats in the Cape Coast metropolis is an indication of an impending danger which requires immediate attention to prevent a possible outbreak and spread from the society to the hospital setting.

Keywords: Multiple drug resistance (MDR), Extended-spectrum beta-lactamase (ESBL), Enterobacteriaceae, Meat source enterobacteriaceae, Ghana cedi, Cape coast.

Article History

Received: January 08, 2019

Revised: April 29, 2019

Accepted: May 02, 2019

1. INTRODUCTION

Enterobacteriaceae strains are the major foodborne and waterborne pathogens which cause approximately 2 million deaths each year in the developing countries [1, 2]. The

increasing spread of carbapenem-resistant Enterobacteriaceae could worsen the poor health conditions in the community within these countries [3 - 5]. The continuous isolation of low antibiotic sensitive Enterobacteriaceae pathogens from surfaces

of objects including currencies, beef and chicken and other substances are well reported [6 - 8]. The faecal contamination of antibiotic-resistant Enterobacteriaceae such as *Salmonella* spp., *Escherichia coli*, *Proteus*, and *Klebsiella* species is a major concern for food hygiene in developing countries such as Ghana [9].

The isolated Enterobacteriaceae from the environment in Ghana with decreased susceptibility to carbapenems require constant surveillance and the need to put in place measures to prevent a possible outbreak of antibiotic-resistant Enterobacteriaceae in Ghana [9, 10]. As such an outbreak can enter the primary healthcare system and cause infections in the hospital [11, 12].

Klebsiella pneumoniae, *E. coli*, *Enterobacter* spp., *Pseudomonas aeruginosa*, and *Acinetobacter* spp. have been shown to constitute major multi-drug resistant bacterial infections both in the community and hospital [13]. This multidrug-resistant Enterobacteriaceae have been isolated from the respiratory tract, urinary tract, bloodstream septic, post-surgical wound infections and pneumonia in the hospitals in Ghana [14]. A nationwide antibiotic resistant surveillance has reported over 70% antibiotic-resistance of all bacterial pathogens isolated from in-patient departments in Ghanaian hospitals [15].

Antibiotic resistances are associated with increased morbidity and mortality compared to antibiotic susceptible bacteria [16]. High mortality rates of up to 75% have been reported for bloodstream infection of antibiotic-resistant bacteria which are related to the delay in the timely selection and delivery of active therapy [17, 18]. In spite of the high burden of multidrug-resistant Enterobacteriaceae recorded in hospitals in Ghana, no obvious measures have been instituted to mitigate this surging problem [16].

Again, environmental isolation of multi-drug resistant Enterobacteriaceae has been sparsely reported in Ghana [19]. However, comprehensive data covering surveillance on antibiotic-resistant bacteria and their transmission pathways, assessment of transmission risk, policy implementation and monitoring across hospital and environment acquired infections are lacking in Ghana [16, 19]. A similar observation was made by WHO in a recent review indicating lack of quality data on prevalence, level of resistant bacteria, isolation and characterization of bacterial resistance genes across humans, animals, food and community-acquired infections in low-income countries like Ghana [20]. The lack of evidence in the rapid emergence and dissemination of multi-resistant Enterobacteriaceae between the environment and hospital domains is a major challenge to awareness creation, effective management and implementation of appropriate control measures against drug-resistant bacterial infections in Ghana [21].

This study was conducted to assess the antibiotic susceptibility patterns among Enterobacteriaceae isolates from raw meat sources and Ghanaian coin currencies in Cape Coast

Metropolis, the regional capital of the Central region of Ghana. We report multiple antibiotic resistance patterns of the isolated Enterobacteriaceae in this study as a baseline data for future studies on the transmission dynamics of multiple resistant Enterobacteriaceae in Cape Coast, Ghana.

2. METHODOLOGY

2.1. Study Area

The study was conducted in Cape Coast Metropolis located in the central region of Ghana. Bacteria samples from freshly prepared meat from goat and cattle were taken from the slaughterhouse at Kotokuraba market, the main meat supplying source for the Cape Coast Metropolis and its neighbouring districts which covers an area of 122 square kilometres. Bacteria on coin currencies were also sampled from the University of Cape Coast campus and its environs which is located about five kilometres from the Kotokuraba market (Fig. 1).

2.2. Sample Collection from Meat and Coin Currencies

Freshly sacrificed meat of goat and cattle ready for the market was sterile swabs; 10 each from the slaughtering house at Kotokuraba market. Each sample was collected in duplicates from the flesh and the offals per meat. The samples were aseptically transported on ice to the microbiology laboratory and stored at 4 °C in a refrigerator.

A total of four hundred (400) Ghanaian coin currencies; three hundred and sixty (360) coins currencies in circulation were randomly collected from food vendors in the market, transport operators, and students together with forty (40) non-circulating coins currencies from the bank located within the University Cape Coast campus were aseptically collected and transported to the microbiology laboratory of Biomedical Sciences, University of Cape Coast and stored at 4 °C in a refrigerator.

2.3. Microbiological Analysis

2.3.1. Bacteria Isolation

All the samples were sterilely swabbed and dipped into sterile buffered peptone water for 12-16 hours at 37°C in a shaking incubator. The inoculums were sterilely streaked uniformly on Blood agar (Sigma-Aldrich) and MacConkey agar (Sigma-Aldrich) plates using wire loops and incubated at 37°C overnight to allow for bacteria growth [22]. All Gram⁻ negative, catalase positive, and oxidase negative isolates were further examined.

2.4. Biochemical Identification

Pure colonies were selected and sub-cultured on nutrient agar slant and were further processed for biochemical tests. Well-known traditional biochemical tests and selective media for bacteria identification were employed [23]. The isolates were identified using Endo agar (Sigma-Aldrich), MacConkey broth (Sigma-Aldrich), and Simmons citrate agar (Sigma-Aldrich), catalase, coagulase, oxidase, sugar fermentation (Triple sugar iron (TSI) agar), indole, citrate utilization, urease production, and motility tests. The identified bacterial species

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Fig. (1). The map showing the study sites at Cape Coast metropolis. Multiple drug resistant Enterobacteriaceae were isolated from meats collected at Kotokuraba market and the circulating coin currencies were obtained from transport operators, food vendors, students from University of Cape coast and banks within the Cape Coast metropolis. The map was adopted from Google maps.

were kept in a 20% glycerol/medium mixture at -80°C at the microbiology laboratory of Biomedical Sciences, University of Cape Coast, Ghana.

2.5. Antibiotic Susceptibility Test (AST)

Pure colonies were picked, emulsified in normal saline and compared with 0.5 McFarland solution to measure the bacteria turbidity [24]. Mueller-Hinton agar antibiotic diffusion technique (Kirby-Bauer NCCLS modified disc diffusion technique) was used for antibiotic susceptibility [25]. Ampicillin (Amp) ($10\mu\text{g}$), Tetracycline (TET) ($10\mu\text{g}$), Gentamicin (GEN) ($10\mu\text{g}$), Cotrimoxazole (COT) ($25\mu\text{g}$), Cefuroxime (CRX) ($30\mu\text{g}$), Cefixime (CXM) ($30\mu\text{g}$), Cefotaxime (CTX) ($30\mu\text{g}$), Penicillin (PEN) (10IU), Cloxacillin (CXC) ($5\mu\text{g}$), Erythromycin (ERY) ($5\mu\text{g}$) and Amikacin (AMK) ($30\mu\text{g}$) antibiotic discs were used to test for susceptibility of the isolated bacteria to the commonly used antibiotics. The dried Mueller Hinton agar plate was plated with the isolated microbes. The appropriate antimicrobial-impregnated disks were placed on the surface of the agar using sterilized forceps and incubated at 35°C overnight. The antibiotic inhibition zones were measured to the nearest

millimetre (mm) from the centre of the disk to a point on the circumference of the zone where a distinct edge was seen using a rule. The obtained values were multiplied by 2 to obtain the diameter of the inhibition zone.

2.6. Statistical Analysis

The data was entered, validated and analyzed using Excel and Access 2016 (Microsoft Corporation) and SPSS 16.0 software.

3. RESULTS

Enterobacteriaceae isolates from chevron (30%) and beef (62%) were resistant to some of the antibiotics tested. 120, 80, 160, and 40 of Ghanaian coin currencies were collected from food vendors, students, transport operators and the banks representing 30%, 20%, 40%, and 10%, respectively. *E. coli*, *Enterobacter spp*, *Shigella spp*, *Klebsiella spp*, *Pseudomonas spp*, *Enterobacter spp*, and *Proteus spp* were the Enterobacteriaceae isolates from the sampled coin currencies. Among the isolates, 4.17%, 3.75%, 1.25%, and 0% had multiple antibiotic resistance while 6.67%, 6.25%, 1.25% and

Table 1. Antibiotic sensitivity pattern of Enterobacteriaceae on Ghanaian coin currencies in circulation at Cape Coast Metropolis.

Antibiotic non-susceptible pattern of Isolates		Food Vendors	Students	Transport	Bank
		N (%)	N (%)	N (%)	N (%)
<i>Escherichia coli</i>	Pos	5 (4.17%)	3 (3.75%)	2 (1.25%)	0 (0.0%)
	Neg	8 (6.67%)	5 (6.25%)	2 (1.25%)	0 (0.0%)
<i>Enterobacter spp</i>	Pos	1 (0.83%)	1 (1.25%)	2 (1.25%)	0 (0.0%)
	Neg	3 (2.5%)	7 (8.75%)	12 (7.5%)	0 (0.0%)
<i>Shigella spp</i>	Pos	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	Neg	1 (0.83%)	1 (1.25%)	1 (0.63%)	0 (0.0%)
<i>Klebsiella spp</i>	Pos	1 (0.83%)	0 (0.0%)	1 (0.63%)	0 (0.0%)
	Neg	5 (4.17%)	2 (2.5%)	9 (5.63%)	0 (0.0%)
<i>Pseudomonas spp</i>	Pos	2 (1.67%)	2 (2.5%)	1 (0.63%)	0 (0.0%)
	Neg	13 (10.83%)	6 (7.5%)	23 (14.38%)	0 (0.0%)
<i>Proteus spp</i>	Pos	8 (6.67%)	5 (6.25%)	11 (6.88%)	0 (0.0%)
	Neg	5 (4.17%)	7 (8.75%)	12 (7.5%)	0 (0.0%)
<i>Total coins collected</i>		120 (30.0%)	80 (20.0%)	160 (40.0%)	40 (10.0%)

0% were sensitive to the antibiotic tested among the *E. coli* isolates from food vendors, students, transport operators and the bank, respectively. The isolation of *Enterobacter spp*, *Shigella spp*, *Klebsiella spp*, *Pseudomonas spp*, *Enterobacter spp*, and *Proteus spp* also showed multiple antibiotics resistance (Table 1).

The percentages of multiple antibiotic resistant Enterobacteriaceae isolated from meat sources (beef and chevron) and Ghanaian coin currencies were interpreted using clinical and laboratory standards institute (CLSI) breakpoints as shown in Table 2 and 3. In all, 4.8% and 8.6% of the *E. coli* isolated from chevon were resistant to Cefuroxime, Chloramphenicol & Ampicillin (CRXr-CHLr-AMPr) and Cefuroxime, Chloramphenicol, Ampicillin, cotrimoxazole and Gentamicin (CRXr-CHLr-AMPr-COTr-GEMr), respectively whereas *E.coli* from beef source showed 15.5% and 6.4% resistance to Cefuroxime,

Chloramphenicol, Ampicillin, Tetracycline, and cotrimoxazole (CRXi-CHLi-AMPr-TETr-COTr) and Cefuroxime, Chloramphenicol, Ampicillin, Tetracycline, and cotrimoxazole (CRXr-CHLr-AMPr-TETr-COTr), respectively. 3.9% of *Enterobacter spp*; 2.7% of *Proteus spp*. isolates from chevron, 6.2% and 12.4% isolates from a beef source and 3.5% *Pseudomonas spp*. showed multiple antibiotic resistance (Table 2).

40.0% of *E. coli* isolated from the coin currencies were resistant to Cefotaxime, Chloramphenicol, Ampicillin, Tetracycline, and Cefuroxime (CRXr-CHLr-AMPr-TETr-CTXr); 50.0% of *Enterobacter spp*. were resistant to CRXr-CHLr-AMPr-TETr-CTXr; 16.67% of *Proteus spp*. resistant to CRXi-CHLi-AMPr-TETr-AMKi; 40% *Pseudomonas spp*. resistant to CRXr-AMPr-TETr-AMKi and 100% of *Enterobacter spp*. resistant to CRXr-AMPr-TETi-CTXr (Table 3).

Table 2. Multiple antibiotic resistant pattern of Enterobacteriaceae isolated from meat source at Kotokuraba market in Cape Coast Metropolis.

Isolates	Sources	Drug Resistant pattern	% isolates
<i>Escherichia coli</i>	GT1	CRX _r -CHL _r -AMP _r	4.8
<i>Enterobacter spp</i>	GT2	CRX _r -AMP _r -COT _r	3.9
<i>Escherichia coli</i>	GT3	CRX _r -CHL _r -AMP _r -COT _r -GEM _r	8.6
<i>Proteus spp.</i>	GT4	CRX _r -CHL _r -AMP _r -TET _r -AMK _i	2.7
<i>Proteus spp.</i>	BF1	CRX _r -AMP _r -TET _r	6.2
<i>Proteus spp.</i>	BF2	CRX _r -CHL _r -AMP _r	12.4
<i>Escherichia coli</i>	BF3	CRX _r -CHL _r -AMP _r -TET _r -COT _r	15.5
<i>Pseudomonas spp</i>	BF4	CRX _r -AMP _r -TET _r -CTX _r -GEN _r	3.5
<i>Escherichia coli</i>	BF5	CRX _r -CHL _r -AMP _r -TET _r -COT _r	6.4

GEN_r= Gentamicin resistant/intermediate COT_r=cotrimoxazole resistant/intermediate AMK_i= Amikacin resistant/intermediate CTX_r= Cefotaxime resistant/intermediate TET_r=Tetracyclin resistant/intermediate AMP_r=Ampicillin resistant/intermediate CHL_r=Chloramphenicol resistant/intermediate CRX_r= Cefuroxime resistant/intermediate GT= chevon (Goat carcass) BF=Beef (Cattle carcass)

Table 3. Antibiotic resistant phenotypes of Enterobacteriaceae isolated from circulating coin currencies.

Isolates	Drug-resistant pattern	Number	%
<i>Escherichia coli</i>	CRX _r -CHL _r -AMP _r	1	10.0%
	CRX _r -CHL _r -AMP _r -TET _r -COT _r	2	20.0%
	CRX _r -CHL _r -AMP _r -TET _r -CTX _r	4	40.0%
	CRX _r -AMP _r -COT _r -CTX _r	3	30.0%
<i>Enterobacter spp</i>	CRX _r -AMP _r -COT _r	1	25.0%
	CRX _r -CHL _r -AMP _r -TET _r -CTX _r	2	50.0%
	AMP _r	1	25.0%
<i>Proteus spp</i>	CRX _r -CHL _r -AMP _r -TET _r -AMK _i	4	16.67%
	CRX _r -AMP _r -TET _r	2	8.33%
	CRX _r -CHL _r -AMP _r	4	16.67%
	CRX _r -AMP _r -TET _r -CTX _r	8	33.33%
	CHLi-AMP _r -COT _i	6	25.0%
<i>Pseudomonas spp</i>	CRX _r -AMP _r -TET _r -CTX _r -GEN _r	1	20.0%
	CRX _r -AMP _r -TET _r -AMK _i	2	40.0%
	AMP _r	2	40.0%
<i>Klebsiella spp</i>	CRX _r -AMP _r -TET _i -CTX _r	2	100%

4. DISCUSSION

Antibiotic-resistant Enterobacteriaceae contamination of meat sources and circulating currencies had been widely reported [10, 25]. This suggests that meat sources and circulating currencies allow pathogens to disseminate and cause infections in the environment with possible transmission into hospital settings [26]. Multi-antibiotic resistance to β -lactams such as Ampicillin, Penicillin, and the first and second generation cephalosporins by Enterobacteriaceae have been isolated and reported in Ghana [27, 28]. The incidence of multi-antibiotic resistant Enterobacteriaceae poses a serious threat to the healthcare system in Ghana as these organisms can spread from the environment to the hospital setting leading to nosocomial infections. This study assessed the extent to which raw meat and circulating currencies in the Cape Coast Metropolis are contaminated with multi-antibiotic-resistant Enterobacteriaceae.

The high prevalence of multi-resistant *E. coli* and non-*E. coli* Enterobacteriaceae from raw meat and coin currencies in circulation at Cape Coast metropolis is an indication of the complex nature of emerging antibiotic resistance by Enterobacteriaceae and its implication on the limited resourced health facilities in the study area [29]. In this study, we isolated *E. coli*, *Enterobacter spp*, *Shigella spp*, *Klebsiella spp*, *Pseudomonas spp*, and *Proteus spp* with resistance to second and third generation cephalosporins, an effective antibiotic against Enterobacteriaceae species. This suggests selection and emerging resistance to extended-spectrum β -lactamase (ESBL)-producing Enterobacteriaceae in Cape Coast [30, 31]. ESBL resistant Enterobacteriaceae in circulation should be a major concern since this limit the timely selection and treatment of infections.

Enterobacteriaceae cause infection in the bloodstream, surgical sites, urinary tract infections (UTIs), respiratory tract infections and also cause frequent infections in diseases such as cancer and diabetes [32, 33]. A similar occurrence of MDR Enterobacteriaceae between the hospital and community-

acquired infections has been reported [34]. The readily and easily spread of MDR Enterobacteriaceae from contaminated animal food sources and contact surfaces makes it a public health concern [35].

Isolation of ESBLs resistant *Shigella* and *E. coli* from raw meat and currencies is a warning ahead of the impending danger of emerging antibiotic resistance in enteric bacteria, a major cause of acute diarrhoea [36 - 38]. Acute diarrhoea is a health problem that causes the highest morbidity and mortality in children in developing countries [39]. *Shigella* colonizes the colonic mucosa and induces invasion resulting in a spectrum of dysentery (shigellosis) disease even in a healthy person with a lower dose of infection [40, 41]. Similarly, pathogenic *E. coli* causes severe intestinal and extra-intestinal diseases such as hemolytic uremic syndrome in humans [42]. The faecal-oral route transmission of both *Shigella spp.* and pathogenic *E. coli* should be a concern of public health especially with emerging ESBL resistance in a poor sanitation environment since infection of these drug-resistant pathogens can spread through contaminated foods or drinking water and also by person-to-person contact [43, 44].

ESBL resistant *Klebsiella* and *Enterobacter*, the causative agents of a variety of infections such as respiratory, urinary tract infections (UTI), bacteremia, sepsis, pneumonia, cystitis, pyelonephritis and lung abscess [45] were isolated from raw meat and currencies in this study. *Klebsiella* and *Enterobacter* infections are frequently acquired through hospital settings with multiple antibiotic resistant strains and they occasionally spread from the hospital environment into the community to cause infection in a healthy individual [46, 47]. The isolation of multiple ESBL resistant strains of *Klebsiella* and *Enterobacter* from coin currencies and raw meat requires prompt action to arrest its possible spread and spill-over unto the healthcare setting.

The isolation of uropathogens such as *Pseudomonas* and *Proteus* which are associated with polymicrobial infections during long-term catheterization [48]. The involvement of

these pathogens in polymicrobial infections has been associated with high mortality among patients [49]. The extensive resistance to the beta-lactamase antibiotics limits the choice of drugs and treatment options among infected patients with reduced immunity due to sickness. In some cases, severe and permanent renal damage such as of the bladder and kidney stones, increase the severity of cystitis, pyelonephritis, nephrosis, urolithiasis, and bacteremia can result from the infections of *P. mirabilis* [50].

The multidrug-resistant Enterobacteriaceae isolates from circulating Ghanaian coins and raw meats in the Cape Coast metropolis are an indication of impending danger which requires immediate attention to prevent a possible outbreak and spread from the society to the hospital setting. The emerging Enterobacteriaceae with multiple ESBL resistant strains in the community require public health response as it has a tendency to spread from the community to the surrounding clinics. Although there are no current outbreaks of multidrug-resistant Enterobacteriaceae in Cape Coast, these resistant pathogens could rapidly expand and spread across the entire Central region and Ghana as a whole. Such an expansion would be detrimental to public health due to limited treatment options and worsen the clinical outcomes in Cape Coast metropolis and the entire country as a whole.

Constant surveillance of ESBL resistant and carbapenemase-producing CRE Enterobacteriaceae is required to estimate the incidence of infection, the risk of infection, cost and possible treatment options available for these multidrug-resistant pathogens. In addition, it is important to identify the sources and the routes of contaminations coupled to the pattern of spread of this drug-resistant Enterobacteriaceae in Cape Coast metropolis for a proper understanding of the dynamics involved and measures to prevent outbreaks in the community. It is also important to understand the mechanisms underlying drugs resistant Enterobacteriaceae isolated from coin currencies and raw meat sources to have an idea of the pattern of the spread of these drug-resistant strains.

CONCLUSION

In conclusion, we report the isolation of multiple antibiotic resistant Enterobacteriaceae phenotypes from raw meat sources and Ghanaian coin currencies in circulation at Cape Coast metropolis. The high levels of ESBL and MDR isolated from currencies from food vendors, transport operators, and students should be a public health concern since Enterobacteriaceae have the ability to transfer their resistant genes (*mcr* gene) among strains to confer resistance to colistin and tigecycline, the only effective therapeutic drugs against ESBL-E. This finding requires immediate public health measures to avoid epidemic outbreaks within the metropolis. Personal hygiene and measures for proper handling of currencies are advised to reduce the spread of drug-resistant bacteria in the metropolis.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

This work was funded by the authors and supported by the Department of Biomedical Sciences, School of Allied Health Sciences, College of Health and Allied Sciences, University of Cape Coast, Ghana.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

AUTHORS CONTRIBUTION

All authors contributed equally

ACKNOWLEDGEMENTS

We thank the staff and laboratory technologists of the Department of Biomedical Sciences, School of Allied Health Sciences, College of Health and Allied Sciences, University of Cape Coast, Ghana for their assistance during the laboratory work. We also thank Dr. Yeboah Kwaku Opoku for his critical review and the correction of the manuscript.

REFERENCES

- [1] Dhama K, Rajagunalan S, Chakraborty S, *et al.* Food-borne pathogens of animal origin-diagnosis, prevention, control and their zoonotic significance: a review. *Pak J Biol Sci* 2013; 16(20): 1076-85. [<http://dx.doi.org/10.3923/pjbs.2013.1076.1085>] [PMID: 24506006]
- [2] Newell DG, Koopmans M, Verhoef L, *et al.* Food-borne diseases - the challenges of 20 years ago still persist while new ones continue to emerge. *Int J Food Microbiol* 2010; 139(Suppl. 1): S3-S15. [<http://dx.doi.org/10.1016/j.ijfoodmicro.2010.01.021>] [PMID: 2015 3070]
- [3] Tzouveleki LS, Markogiannakis A, Piperaki E, Souli M, Daikos GL. Treating infections caused by carbapenemase-producing Enterobacteriaceae. *Clin Microbiol Infect* 2014; 20(9): 862-72. [<http://dx.doi.org/10.1111/1469-0691.12697>] [PMID: 24890393]
- [4] Temkin E, Adler A, Lerner A, Carmeli Y. Carbapenem-resistant Enterobacteriaceae: biology, epidemiology, and management. *Ann N Y Acad Sci* 2014; 1323(1): 22-42. [<http://dx.doi.org/10.1111/nyas.12537>] [PMID: 25195939]
- [5] Pitout JD, Laupland KB. Extended-spectrum β -lactamase-producing Enterobacteriaceae: an emerging public-health concern. *Lancet Infect Dis* 2008; 8(3): 159-66. [[http://dx.doi.org/10.1016/S1473-3099\(08\)70041-0](http://dx.doi.org/10.1016/S1473-3099(08)70041-0)] [PMID: 18291 338]
- [6] Gebeyehu A, Yousuf M, Sebsibe A. Evaluation of microbial load of beef of Arsi cattle in Adama Town, Oromia, Ethiopia. *J Food Process Technol* 2013; 4: 1-6. [<http://dx.doi.org/10.4172/2157-7110.1000234>]
- [7] Nagajothi J, Jeyakumari D, Vigneshwaran S, Kumar RP, Bharatwaj RS, Bagyalakshmi R. Study of Prevalence of Microbial Contamination with its Antibiotic Resistance Pattern in Automated Teller Machine in and around Puducherry, India. *Journal of Earth. Environment and Health Sciences* 2015; 1(1): 27. [<http://dx.doi.org/10.4103/2423-7752.159924>]

- [8] Pickering AJ, Julian TR, Marks SJ, *et al.* Fecal contamination and diarrheal pathogens on surfaces and in soils among Tanzanian households with and without improved sanitation. *Environ Sci Technol* 2012; 46(11): 5736-43. [http://dx.doi.org/10.1021/es300022c] [PMID: 22545817]
- [9] Saba CK, Gonzalez-Zorn B. Microbial food safety in Ghana: a meta-analysis. *J Infect Dev Ctries* 2012; 6(12): 828-35. [http://dx.doi.org/10.3855/jidc.1886] [PMID: 23276735]
- [10] Alemu A. Microbial contamination of currency notes and coins in circulation: A potential public health hazard. *Biomedicine and Biotechnology* 2014; 2(3): 46-53.
- [11] Weinstein RA. Nosocomial infection update. *Emerg Infect Dis* 1998; 4(3): 416-20. [http://dx.doi.org/10.3201/eid0403.980320] [PMID: 9716961]
- [12] Seybold U, Kourbatova EV, Johnson JG, *et al.* Emergence of community-associated methicillin-resistant *Staphylococcus aureus* USA300 genotype as a major cause of health care-associated blood stream infections. *Clin Infect Dis* 2006; 42(5): 647-56. [http://dx.doi.org/10.1086/499815] [PMID: 16447110]
- [13] Bassetti M, Merelli M, Temperoni C, Astilean A. New antibiotics for bad bugs: where are we? *Ann Clin Microbiol Antimicrob* 2013; 12(1): 22. [http://dx.doi.org/10.1186/1476-0711-12-22] [PMID: 23984642]
- [14] Agyepong N, Govinden U, Owusu-Ofori A, Essack SY. Multidrug-resistant gram-negative bacterial infections in a teaching hospital in Ghana. *Antimicrob Resist Infect Control* 2018; 7(1): 37. [http://dx.doi.org/10.1186/s13756-018-0324-2] [PMID: 29541448]
- [15] Opintan JA, Newman MJ. Prevalence of antimicrobial resistant pathogens from blood cultures: results from a laboratory based nationwide surveillance in Ghana. *Antimicrob Resist Infect Control* 2017; 6(1): 64. [http://dx.doi.org/10.1186/s13756-017-0221-0] [PMID: 28630688]
- [16] Mauldin PD, Salgado CD, Hansen IS, Durup DT, Bosso JA. Attributable hospital cost and length of stay associated with health care-associated infections caused by antibiotic-resistant gram-negative bacteria. *Antimicrob Agents Chemother* 2010; 54(1): 109-15. [http://dx.doi.org/10.1128/AAC.01041-09] [PMID: 19841152]
- [17] Niederman MS. Impact of antibiotic resistance on clinical outcomes and the cost of care. *Crit Care Med* 2001; 29(4)(Suppl.): N114-20. [http://dx.doi.org/10.1097/00003246-200104001-00011] [PMID: 11292886]
- [18] Harms A, Maisonneuve E, Gerdes K. Mechanisms of bacterial persistence during stress and antibiotic exposure. *Science* 2016; 354(6318): aaf4268. [http://dx.doi.org/10.1126/science.aaf4268] [PMID: 27980159]
- [19] Rousham EK, Unicomb L, Islam MA. Human, animal and environmental contributors to antibiotic resistance in low-resource settings: integrating behavioural, epidemiological and One Health approaches. *Proc R Soc B* 2018; 285(1876): 20180332.
- [20] World Health Organization. Report of the 6th meeting of the WHO advisory group on integrated surveillance of antimicrobial resistance with AGISAR 5-year strategic framework to support implementation of the global action plan on antimicrobial resistance (2015-2019), 10-12 June 2015, Seoul, Republic of Korea
- [21] Pruden A, Larsson DG, Amézquita A, *et al.* Management options for reducing the release of antibiotics and antibiotic resistance genes to the environment. *Environ Health Perspect* 2013; 121(8): 878-85. [http://dx.doi.org/10.1289/ehp.1206446] [PMID: 23735422]
- [22] Ali AA. Isolation and Identification of lactic acid bacteria isolated from traditional drinking yoghurt in Khartoum State, Sudan. *Current research in Bacteriology* 2011; 4(1): 16-22.
- [23] Eddouaouda K, Mnif S, Badis A, *et al.* Characterization of a novel biosurfactant produced by *Staphylococcus* sp. strain 1E with potential application on hydrocarbon bioremediation. *J Basic Microbiol* 2012; 52(4): 408-18. [http://dx.doi.org/10.1002/jobm.201100268] [PMID: 22052657]
- [24] Coutant C, Olden D, Bell J, Turnidge JD. Disk diffusion interpretive criteria for fusidic acid susceptibility testing of staphylococci by the National Committee for Clinical Laboratory Standards method. *Diagn Microbiol Infect Dis* 1996; 25(1): 9-13. [http://dx.doi.org/10.1016/0732-8893(96)00070-3] [PMID: 8831039]
- [25] Girma G, Ketema T, Bacha K. Microbial load and safety of paper currencies from some food vendors in Jimma Town, Southwest Ethiopia. *BMC Res Notes* 2014; 7(1): 843. [http://dx.doi.org/10.1186/1756-0500-7-843] [PMID: 25424723]
- [26] Lopez GU. Transfer of microorganisms from fomites to hands and risk assessment of contaminated and disinfected surfaces. The University of Arizona 2013.
- [27] Adinortey CA. Antibiotic resistance, phylogenetic grouping and virulence potential of *Escherichia coli* isolated from clinical and environmental samples from the Cape Coast metropolis of the central region of Ghana (Doctoral dissertation, University of Cape Coast)
- [28] Duredoh FG. Antibiotic Resistance Patterns of *Pseudomonas Aeruginosa* and *Escherichia Coli* Isolates from Three Hospitals In Kumasi (Doctoral dissertation)
- [29] Zeighami H, Haghi F, Hajiahmadi F. Molecular characterization of integrons in clinical isolates of beta-lactamase-producing *Escherichia coli* and *Klebsiella pneumoniae* in Iran. *J Chemother* 2015; 27(3): 145-51. [http://dx.doi.org/10.1179/1973947814Y.0000000180] [PMID: 24571248]
- [30] Mitgang EA, Hartley DM, Malchione MD, Koch M, Goodman JL. Review and mapping of carbapenem-resistant Enterobacteriaceae in Africa: Using diverse data to inform surveillance gaps. *Int J Antimicrob Agents* 2018; 52(3): 372-84. [http://dx.doi.org/10.1016/j.ijantimicag.2018.05.019] [PMID: 29864500]
- [31] Tuo H, Yang Y, Tao X, *et al.* The prevalence of colistin resistant strains and antibiotic resistance gene profiles in Funan River, China. *Front Microbiol* 2018; 9: 3094. [http://dx.doi.org/10.3389/fmicb.2018.03094] [PMID: 30619173]
- [32] Falagas ME, Rafailidis PI, Matthaiou DK, Vartzili S, Nikita D, Michalopoulos A. Pandrug-resistant *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* infections: characteristics and outcome in a series of 28 patients. *Int J Antimicrob Agents* 2008; 32(5): 450-4. [http://dx.doi.org/10.1016/j.ijantimicag.2008.05.016] [PMID: 18768302]
- [33] Fridkin SK, Welbel SF, Weinstein RA. Magnitude and prevention of nosocomial infections in the intensive care unit. *Infect Dis Clin North Am* 1997; 11(2): 479-96. [http://dx.doi.org/10.1016/S0891-5520(05)70366-4] [PMID: 9187957]
- [34] Nordmann P, Poirel L. The difficult-to-control spread of carbapenemase producers among Enterobacteriaceae worldwide. *Clin Microbiol Infect* 2014; 20(9): 821-30. [http://dx.doi.org/10.1111/1469-0691.12719] [PMID: 24930781]
- [35] Pruden A. Balancing water sustainability and public health goals in the face of growing concerns about antibiotic resistance [http://dx.doi.org/10.1021/es403883p]
- [36] Brown D. Antibiotic resistance breakers: can repurposed drugs fill the antibiotic discovery void? *Nat Rev Drug Discov* 2015; 14(12): 821-32. [http://dx.doi.org/10.1038/nrd4675] [PMID: 26493767]
- [37] Stelling J, Sosa A. Framework for Use of Antimicrobial Resistance Surveillance in the Development of Standard Treatment Guidelines
- [38] Mahan MJ, Kubicek-Sutherland JZ, Heithoff DM. Rise of the microbes. *Virulence* 2013; 4(3): 213-22. [http://dx.doi.org/10.4161/viru.23380] [PMID: 23334178]
- [39] Osumanu IK. Household environmental and behavioural determinants of childhood diarrhoea morbidity in the Tamale Metropolitan Area (TMA), Ghana. *Geografisk Tidsskrift-Danish Journal of Geography* 2007; 107(1): 59-68. [http://dx.doi.org/10.1080/00167223.2007.10801375]
- [40] Kotloff KL, Riddle MS, Platts-Mills JA, Pavlinac P, Zaidi AKM. Shigellosis. *The Lancet* 2018; 391(10122): 801-12. [http://dx.doi.org/10.1016/S0140-6736(17)33296-8] [PMID: 29254859]
- [41] Anderson M, Sansonetti PJ, Marteyn BS. Shigella diversity and changing landscape: insights for the twenty-first century. *Front Cell Infect Microbiol* 2016; 6: 45. [http://dx.doi.org/10.3389/fcimb.2016.00045] [PMID: 27148494]
- [42] Katouli M. Population structure of gut *Escherichia coli* and its role in development of extra-intestinal infections. *Iran J Microbiol* 2010; 2(2): 59-72. [PMID: 22347551]
- [43] Brander RL, Watson JL, John-Stewart GC, *et al.* Correlates of multi-drug non-susceptibility in enteric bacteria isolated from Kenyan children with acute diarrhea. *PLoS Negl Trop Dis* 2017; 11(10): e0005974 [http://dx.doi.org/10.1371/journal.pntd.0005974] [PMID: 28968393]
- [44] Somda NS, Bonkoungou OJI, Zongo C, *et al.* Safety of ready-to-eat chicken in Burkina Faso: Microbiological quality, antibiotic resistance, and virulence genes in *Escherichia coli* isolated from chicken samples of Ouagadougou. *Food Sci Nutr* 2018; 6(4): 1077-84. [http://dx.doi.org/10.1002/fsn3.650] [PMID: 29983972]

- [45] Cerceo E, Deitelzweig SB, Sherman BM, Amin AN. Multidrug-resistant gram-negative bacterial infections in the hospital setting: overview, implications for clinical practice, and emerging treatment options. *Microb Drug Resist* 2016; 22(5): 412-31. [http://dx.doi.org/10.1089/mdr.2015.0220] [PMID: 26866778]
- [46] French GL. The continuing crisis in antibiotic resistance. *Int J Antimicrob Agents* 2010; 36(Suppl. 3): S3-7. [http://dx.doi.org/10.1016/S0924-8579(10)70003-0] [PMID: 21129629]
- [47] Keynan Y, Rubinstein E. The changing face of *Klebsiella pneumoniae* infections in the community. *Int J Antimicrob Agents* 2007; 30(5): 385-9. [http://dx.doi.org/10.1016/j.ijantimicag.2007.06.019] [PMID: 17716872]
- [48] Jacobsen SM, Stickler DJ, Mobley HL, Shirliff ME. Complicated catheter-associated urinary tract infections due to *Escherichia coli* and *Proteus mirabilis*. *Clin Microbiol Rev* 2008; 21(1): 26-59. [http://dx.doi.org/10.1128/CMR.00019-07] [PMID: 18202436]
- [49] Neshor L, Rolston KV. The current spectrum of infection in cancer patients with chemotherapy related neutropenia. *Infection* 2014; 42(1): 5-13. [http://dx.doi.org/10.1007/s15010-013-0525-9] [PMID: 23975584]
- [50] Armbruster CE, Smith SN, Johnson AO, *et al*. The pathogenic potential of *Proteus mirabilis* is enhanced by other uropathogens during polymicrobial urinary tract infection. *Infect Immun* 2017; 85(2): e00808-16. [http://dx.doi.org/10.1128/IAI.00808-16] [PMID: 27895127]

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