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RISK FACTORS TO ENTERIC BACTERIAL PREVALENCE AND ANTIMICROBIAL RESISTANCE AMONG FOOD HANDLERS IN NAIROBI COUNTY, KENYA

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ABSTRACT

Objectives: **Enteric bacteria's antimicrobial resistance expose humans to superbugs and biofilms producing strains. This study aimed at investigating the prevalence of enteric bacteria, antimicrobial resistance patterns and potential risk factors associated with enteric bacterial pathogens transmission among food handlers in Nairobi County, Kenya.**
Methodology: **A cross-sectional study was conducted and systematic random sampling used to obtain 355 stool samples from food handlers who presented to Centre for Microbiology, Kenya Medical Research Institute, for routine health assessment. The stool samples were cultured for E. coli, Salmonella typhi and Shigella flexneri and Vibrio cholerae using the standard enteric media. Questionnaires were administered to obtain sociodemographic data. Conventional biochemical tests were used in identification of the recovered isolates and antimicrobial susceptibility patterns determined. Factors associated with enteric bacterial infection were evaluated using logistic regression analysis.**
Results: **An overall enteric bacteria prevalence of 54(15.21%) was found. The most predominant enteric bacteria recovered were 39 (11%) Escherichia coli (11(53.85%) non-pathogenic E. coli, 13(33.33%) enterotoxigenic E. coli, 5(12.82%) enteroaggregative (E. coli), 11(3.1%), 11(3.1%) Shigella flexneri and 4(1.1%) Salmonella typhi. Amoxicillin clavulanic acid, nalidixic acid, cefuroxime and ciprofloxacin were the least effective antimicrobials while meropenem, chloramphenicol and gentamicin were most effective antimicrobials with 0%, 1.85% and 5.56% resistance. Insufficient hygienic food handling practices training was independently associated with enteric bacterial infection (AOR: 9.117; 95% CI: 2.157 – 18.534; P=0.003). However, the insufficient food handling**

practices training had low odds of antimicrobial resistance despite P-value indicating as statistically significant (AOR:0.118; 95% CI: 0.028 – 0.489; P=0.003). ***Conclusion*****: Enteric bacteria prevalence and resistance continue to soar among food handlers despite periodic medical assessment, threatening public health as potential source of transmission. Insufficient training on hygienic food handling practices was significantly associated with enteric bacterial infection and corresponding antimicrobial resistance.**

INTRODUCTION

The world is reporting a surge in resistant enteric bacteria strains, which threaten public health due to the likelihood of superbugs and biofilms emerging, whose management is extremely expensive. Inefficient water, sanitation and hygiene (WaSH) exacerbates enteric bacteria transmission especially majorly through Fecal-oral [1,2,3,4]. Human gastrointestinal bacterial populations' affinity for survival enhances multidrug resistance transmission through mutations and horizontal gene transfer [5].

Enteric bacteria prevalence in 2021 was 36.1%, predominant bacteria being Salmonella, Shigella, Eschericha coli and Vibrio cholerae [6,7]. Escherichia coli, commensal bacteria, has different invasive pathotypes: enteroaggregative E. coli, enteropathogenic E. coli and entorotoxigenic E. coli whose pathogenicity pose risk to humans [8]. Salmonella spp. can viably survive for three weeks on dry environment[9]. Salmonella typhi's is more invasive causing typhoid unlike Salmonella enterica serotyphe Enteritidis and Typhimurium as small Shigella spp. population easily cause shigellosis [10].

Antimicrobial resistance associated mortality cases have surpassed 1.6 million annually [8]. Predominant bacteria such as pathogenic E. coli spp., Shigella spp. and Salmonella spp. have developed resistance to different antibiotics classes including penicillin, β-lactams, amphenicols, macrolides and fluoroquinolones [5,11]. Nairobi County's enteric bacteria surge at 36.1% threatens public healthy safety with resistant bacteria threatening resurgence [7,12,13]. Inadequate sanitation practices training among food handlers has been associated with enteric bacteria transmission as periodic protozoans medications prescription develop resistant due to poor prescription dosage completion [7,14,15,16]. Therefore, there was need to evaluate on the enteric bacteria prevalence, antimicrobial resistance and the corresponding relative transmission risks among food handlers in Nairobi County.

METHODOLOGY

This was a cross-sectional study conducted at Center for Microbiology - Kenya Medical Research Institute- Centre for Microbiology (CMR-KEMRI) between March 2023 and January 2024. CMR, a satellite center in KEMRI, is located in Nairobi County and is approved for food handlers' medical health assessment under hospitality industry (HISP) program. Nairobi County borders Machakos County to the East, Kiambu County to the North and West and Kajiado to the South. CMR-KEMRI located at 1.304693S and 36.807458E houses the Antimicrobial Resistance (AMR) testing and Surveillance (pathogenic bacteria research unit). The study targeted food handlers in Nairobi County who seek health certification from CMR-KEMRI.

Sampling Strategy and Sample Size

A systematic random sampling technique at 5 – individuals' interval was used to enroll eligible participants. The study sample size was 355. Eligible food handlers were thoroughly explained the study purpose before consenting as study participants. Study participants were orally interviewed on sociodemographic factors likely to influence enteric bacteria transmission.

The study incorporated the Fisher formulae in determining the sample size with a 36.1% prevalence [7].

$$N = \frac{Z^2 p (1-p)}{D^2}$$

Where:

N= Minimum sample size required

Z= 1.96 standard error

P= Enteric bacteria Prevalence in Nairobi County (36.1%) (Kariuki et al., 2021).

D= 0.05 the inverse of 95% confidence limit

$$= \frac{1.96^2\ 0.361\ (1-0.361)}{0.05 \times 0.05}$$

$$n = 354.47$$

Minimum sample size: 355

Sample Collection

All the 355 clean-catch stool samples were collected in wide mouthed sterile screw-capped poly pots and assigned unique identification codes linked to respective participant's questionnaire. The stool samples were stored at 4^{0}C and processed within 4 hours after collection for maximum organisms' recovery.

Sample processing and Laboratory procedures

Stool Culture

Stool samples were emulsified using sterile normal saline and vigorously shaken within the tightly screwed containers. A loopfull of the emulsified stool sample was inoculated in MacConkey culture media (OXOID, UK) and incubated for 18-24 hours at 37^{o}C to differentiate lactose-fermenting (pink colonies) identified as potential E.coli and non-lactose fermenting gram-negative bacteria (yellow colonies). E. coli ATCC-25922 was used as the positive quality control strain, and S. aureus ATCC 25923, the negative control.

In a sterile selenite F broth, a loopfull of emulsified stool sample of the same participants were inoculated and incubated for 10-12 hours at 37^{o}C for Salmonella and Shigella enrichment. A loopful sample from turbid Selenite F broth after incubation were inoculated in Salmonella-Shigella agar and incubated for 18- 24 hours at 37^{o}C, for Shigella (non-lactose fermenters yellow colonies) and Salmonella spp. (black-centered round colonies) isolation. S. typhi ATCC 6539 and S. flexneri ATCC 12022 were used as positive quality control and E.coli ATCC 25922 as negative quality control.

Gram Staining

Gram staining on all pure colony isolates subcultured on Mueller-Hinton Agar confirmed the potential E. coli, Shigella spp. and Salmonella spp. isolates as gram-negative colonies.

Biochemical Tests

Each potential colony isolates were tested across the conventional biochemical tests; triple sugar iron test, citrate utilization test, methyl red-Voges-Proskauer test, lysine indole motility test, urea utilization test and hydrogen sulfide test for E. coli, Salmonella typhi and S. flexneri. E. coli identification. All recovered E.coli were tested for pathotypes using conventional Polymerase chain reaction (PCR).

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed in accordance to Kirby-Bauer disc diffusion method on Mueller-Hinton agar (OXOID, UK) aligned to the recommended Clinical Laboratory Standards Institute protocol. A bacterial suspension was prepared and turbidity compared with 0.5 McFarland tubes using the McFarland reader. The following antibiotic panels were used; Plate A: (amoxicillin clavulanic acid (AMC, 10 µg), cefuroxime (CXM, 30 µg), cefotaxime (CTX, 30 µg), ceftazidime (CAZ, 30 µg), cefepime (CPM, 5 µg) and meropenem (MEM, 30µg)) and plate B: (nalidixic acid (NAL, 30 µg), ciprofloxacin (CIP, 5 μg), gentamicin (GEN, 10 μg) chloramphenicol (CHL, 30 μg). All the plates were incubated at 37^{0} C for 18-24 hours and results reported as sensitive, intermediate and resistant determined using the measurement of zone of inhibition according to CLSI standard 2022. Isolates resistant to three or more antibiotics were considered multidrug resistant.

Data Analysis

Data were analyzed using Microsoft Excel spreadsheet; descriptive statistics with binomial confidence intervals using frequencies and percentages of Enteric bacterial prevalence. Antimicrobial resistance were analyzed and interpreted using the M 100 Clinical and Laboratory Standards Institute (CLSI 2022) supported by WHONET software; computed as the proportion of resistant against the isolates and presented using frequencies and percentages. The Microsoft Excel spreadsheet filed data was analyzed using Statistical Package for Social Sciences (SPSS) version 27, 2020 for sociodemographic risk factors association with enteric bacteria using logistic regression for adjusted odds ratios generation with 95% confidence intervals at alpha less than 0.05 (>0.05) consideration as significant.

Ethical Consideration

Ethical approval was obtained from Jomo Kenyatta University of Agriculture and Technology Institutional Ethics Review Committee (ISERC) (JKU/ISERC/02316/0843) and license obtained from the National Commission for Science and Technology and Innovation (NACOSTI) (NACOSTI/P/23/26801).

RESULTS

Prevalence of Enteric Bacteria and Antimicrobial Resistance Patterns

In total, 355 study participants recruited; 180 (50.7%) females and 175 (49.3%) males. The predominant age category was 20-30 years.

Bacterial Isolation

An overall prevalence of 54(15.21%) enteric bacterial pathogen was found. At least one pathogenic bacterial type was identified in 50 individuals although 4(8%) individuals had dual infections. The predominant bacteria recovered were: 39(11%) Escherichia coli (17(43.59%) non-pathogenic E. coli, 13(33.33%) Enterotoxigenic E. coli (ETEC) and 5(12.82%) Entero-aggressive E. coli (EAEC)), 11(3.1%) Shigella flexneri and 4(1.1%) Salmonella typhi. However, 4 (10.26%) individuals had ETEC and EAEC dual infection.

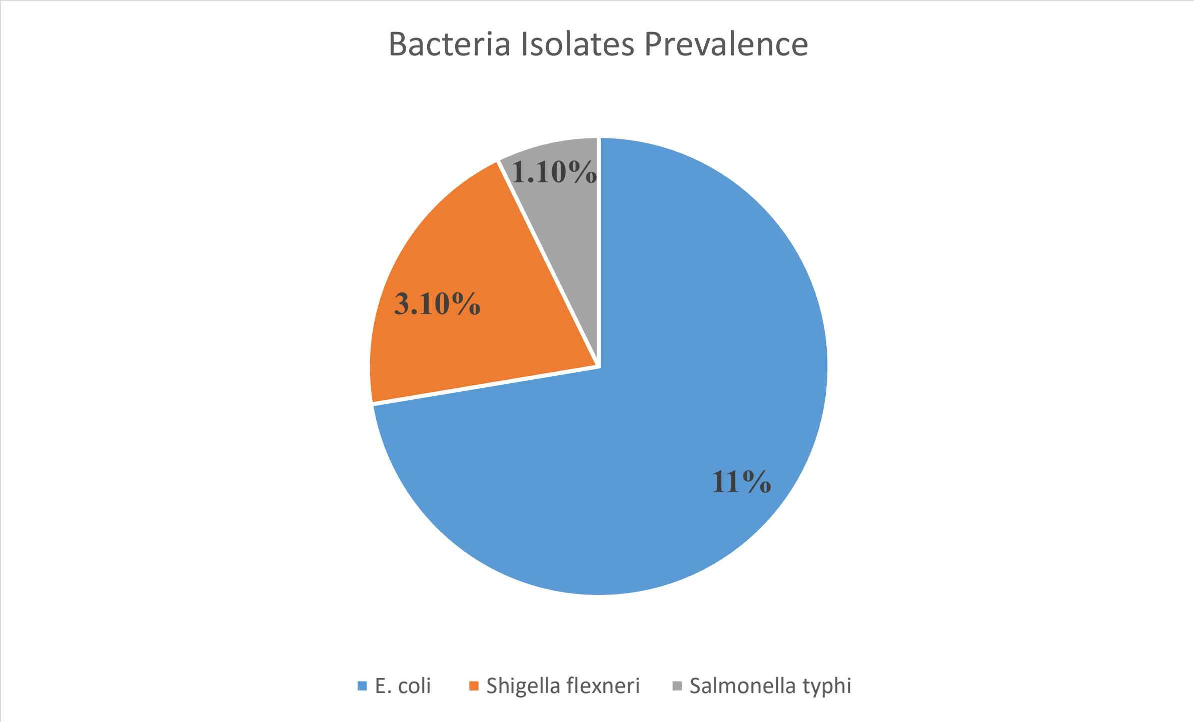

Figure 1. Distribution of bacteria isolates obtained

Sociodemographic and Socioeconomic Factors Associated with Bacterial Infection

All the potential sociodemographic and socioeconomic risks showed no significant association with enteric bacterial infection.

Table 1

Multivariate Analysis on Socio-Demographics and Socioeconomic Factors Association with Enteric Bacteria Infection

VARIABLE		COR				
					CI (95%)	
		No.	P value	OR	Low	High
AGE (years)	20-30	187 (52.7%)	1			
	31-40	148 (41.7%)	0.229	0.687	0.373	1.266
	41 & above	20 (5.6%)	0.393	0.519	0.115	2.344
Marital status	Come we stay	22 (6.2%)	0.855	0.888	0.248	3.176
	Divorced	9 (2.5%)	0.565	1.607	0.319	8.087
	Married	212 (59.7%)	1			
	Single	112 (31.5%)	0.984	1.007	0.532	1.906
Education	No formal education	6 (1.7%)	0.835	1.261	0.143	11.132
	Primary	9 (2.5%)	0.825	0.788	0.095	6.505
	Secondary	99 (27.89%)	0.203	1.497	0.805	2.784

	Tertiary	241 (67.9%)	1			
People living in the household	0-4	221 (62.3%)	1			
	5 & above	134 (37.7%)	0.673	0.878	0.479	1.608
Children present	1-2 children	150 (42.3%)	1			
	3 & above	100 (28.2%)	0.267	0.649	0.302	1.392
	0 children	105 (29.6%)	0.66	1.16	0.599	2.247
Water source	Borehole	29 (8.2%)	0.197	0.377	0.086	1.66
	Bottled	119 (33.5%)	0.758	0.907	0.487	1.689
	Tap	207 (58.3%)	1			
Water treatment	Yes	174 (49.0%)	1			
	No	37 (10.4%)	0.57	0.722	0.236	2.216
	NA	144 (40.6%)	0.466	1.252	0.684	2.292
Water treatment method	Chemical	151 (42.5%)	1			
	Boiling	65 (18.3%)	0.66	1.194	0.542	2.633
	Purifier	102 (28.7%)	0.651	1.173	0.588	2.337
	NA	37 (10.4%)	0.554	0.711	0.229	2.204
Water rationing	Yes	211 (59.4%)	1			
	No	144 (40.6%)	0.352	1.318	0.736	2.361
Rationing frequency	1-2 times a month	87 (24.5%)	0.34	0.689	0.32	1.481
	3-5 times a month	89 (25.1%)	0.746	0.889	0.435	1.817
	6 & above times a month	35 (9.9%)	1			
Toilet used	Flush	312 (87.9%)	1			
	Pit latrine	43 (12.1%)	0.807	0.892	0.357	2.229
Street food eating frequency	1-2 times a week	124 (34.9%)	0.548	0.808	0.404	1.618
	> 3 times a week	142 (40.0%)	1			
	Don’t eat	89 (25.1%)	0.62	1.196	0.59	2.424
Bacterial infection last 6 months	Yes	105 (29.6%)	0.328	1.357	0.736	2.503
	No	250 (70.4%)	1			

Completed prescription dosage	Yes	79 (22.3%)	0.12	1.69	0.871	3.28
	No	31 (8.7%)	0.342	1.597	0.608	4.195
	NA	245 (69.0%)	1			
Last diarrhea episode	1-3 weeks ago,	28 (7.9%)	0.215	1.885	0.692	5.14
	1-2 months ago,	145 (40.8%)	0.244	1.44	0.78	2.661
	> 3 months ago,	182 (51.3%)	1			
Last antibiotics use	1-3 weeks ago,	41 (11.5%)	0.125	1.983	0.826	4.758
	1-6 months ago,	153 (43.1%)	0.323	1.377	0.73	2.598
	> 6 months ago,	161 (25.4%)	1			
Antibiotics' Source	Over the counter	197 (55.5%)	1			
	Doctor’s prescription	135 (38.0%)	0.484	1.239	0.68	2.261
	Sharing	23 (6.5%)	0.879	0.905	0.252	3.249

Key: COR- crude odds ratio, AOR- adjusted odds ratio, CI- confidence interval, NA- Not Applicable
NOTE: There was no sociodemographic or socioeconomic variable which had COR with P<0.05, hence, multivariable logistic regression was not conducted for these factors.

Work-Environment Based Factors

Work Environment Association with Bacterial Infection

Of all the potential work environment risk variables, lack of training on food hygienic practices was independently associated with enteric bacterial infection (AOR: 9.117; 95% CI: 2.157 – 18.534; P=0.003).

Table 2

Work-Environment Factors’ Association with Enteric Bacteria Multivariate Analysis

VARIABLE		COR					AOR			
					CI (95%)				CI (95%)	
		No.	P value	OR	Low	High	P value	OR	Low	High
Type of premise	Government	21 (5.9%)	0.197	0.263	0.035	2.005				
	Private	313 (88.2%)	1							
	Own	21 (5.9%)	0.838	0.877	0.249	3.088				
Level of premise	High level	154 (43.4%)	1							
	Middle level	127 (35.8%)	0.534	0.813	0.423	1.562				
	Low level	74 (20.8%)	0.514	0.769	0.35	1.693				
	0-1 year	47 (13.2%)	0.552	1.293	0.554	3.015				

Duration working in food industry	2-5 years	155 (43.7%)	1							
	5-10 years	103 (29.0%)	0.521	0.788	0.381	1.63				
	> 10 years	50 (14.1%)	0.93	1.04	0.435	2.488				
Training on food hygiene	Yes	313 (88.2%)	1							
	No	42 (11.8%)	0.039	2.228	1.043	4.761	0.003	9.117	2.157	18.534
Handwashing facilities availability	Yes	351 (98.9%)	1							
	No	1 (1.1%)	0.59	1.874	0.191	18.359				
Presence of washrooms in premise	Yes	341 (96.1%)	1							
	No	14 (3.4%)	0.922	0.926	0.201	4.26				
When sick action taken	Sick leave given	273 (76.9%)	1							
	Continue working	82 (23.1%)	0.227	0.625	0.291	1.339				
Wear PPEs	Yes	340 (95.8%)	1							
	No	15 (4.2%)	0.056	2.969	0.973	9.059				
Frequency washing PPEs	1-3 days	145 (40.85%)	0.732	0.897	0.483	1.668				
	Daily	185 (52.11%)	1							
	Rarely	25 (7.04%)	0.264	1.771	0.65	4.823				
Valid food handling license	Yes	347 (97.7%)	1							
	No	8 (2.3%)	0.829	0.792	0.096	6.573				
Go home with PPEs	Yes	83 (23.38%)	0.177	0.592	0.277	1.268				
	No	272 (70.99%)	1							

Key: COR- crude odds ratio, AOR- adjusted odds ratio, CI- confidence interval, PPEs –Personal Protective Equipment

Antimicrobial Resistance Patterns

28(51.85%) Amoxicillin clavulanic acid (Amoxiclav), 22(40.74%) nalidixic acid and 12(22.22%) cefuroxime had highest resistance; least effective. Similarly, cefotaxime (16.67%), cefepime (16.67%), and ceftazidime (9.26%) had moderate resistance. The least resistance was observed across 0% meropenem, 1.85% chloramphenicol, and 5.56% gentamicin.

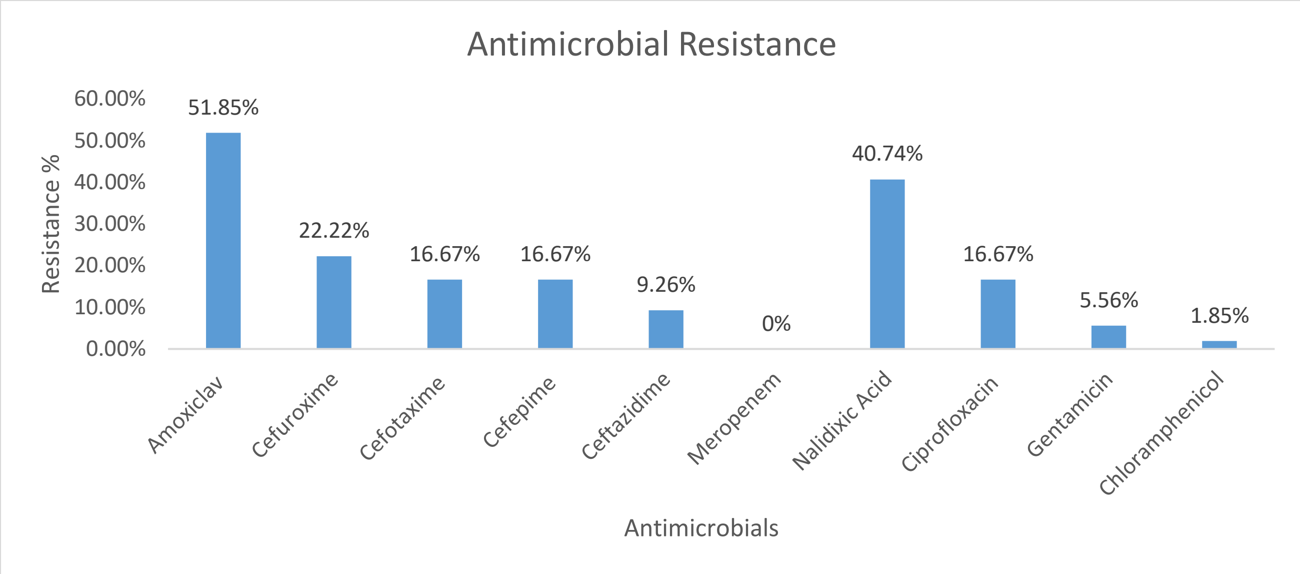

Figure 2: Antibiotic-resistant patterns (%) for the recovered enteric bacteria. (n/54) represents the number of enteric bacteria resistant to antimicrobials out of 54 bacteria subjected to AST.

Genus-specific

E. coli were resistant to at least all antibiotics tested except meropenem against 28(71.79%) amoxiclav, 18(46.15%) nalidixic acid, and 11(28.21%) cefuroxime resistance. Shigella flexneri was resistant to 4 antimicrobials (3(27.3%), nalidixic acid 2(18.2%), cefotaxime 2(18.2%), and 1(9.1%) for ciprofloxacin and cefuroxime). Salmonella typhi had the least resistance; three antibiotics (2(50%) ciprofloxacin, (50%) ceftazidime and 1(25%) nalidixic acid).

Table 3

Antimicrobial resistance profile across the genera of the recovered bacterial enterics

Genus	**Antimicrobial resistance profiles: n (%)**										
	n	**AMC**	**CTX**	**CXM**	**CAZ**	**FEP**	**MEM**	**NAL**	**CIP**	**GEN**	**CHL**
E. coli	39	28(71.97)	7(17.95)	11(28.21)	3(7.69)	9(23.08)	0	18(46.15)	6(15.38)	3(7.69)	1(2.56)
S.flexneri	11	0	2(18.2)	1(9.1)	0	0	0	3(27.3)	1(9.1)	0	0
S. typhi	4	0	0	0	2(50)	0	0	1(25)	2(50)	0	0

Key: AMC– amoxicillin clavunalic acid, CTX-cefotaxime, CXM-cefuroxime, CAZ-ceftazidime, FEP-cefepime, MEM-meropenem, NAL-nalidixic acid, CIP-ciprofloxacin, GEN-gentamicin, CHL-chlromphenicol. E.coli-Escherichia coli, S.flexneri–Shigella flexneri and S. typhi–Salmonella typhi.

Multidrug/ Extended Drug Resistance

11 (20.37%) bacterial isolates were multidrug resistant (MDR) organisms' resistant to three classes of antibiotics (amoxiclav, cefuroxime, and cefotaxime) and were E. coli, although no extensively drug-resistant (XDR) to 6/7 antibiotics classes was reported.

Fluoro/Quinolones resistance was 27(50%).

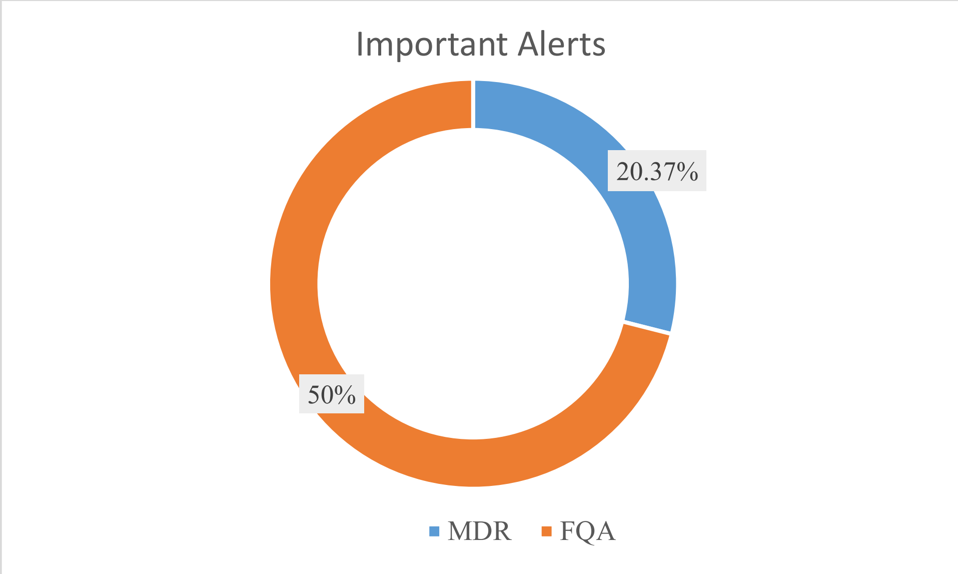

Figure 3. MDR – multidrug-resistant bacterial isolates, FQA- fluoro/Quinolones, Aminoglycosides phenotypes.

Variables Association with MDR, XDR

Lack of training on hygienic food practices was associated with significantly lower odds of antimicrobial resistance although P-value indicated as statistically significant (AOR: 0.118; 95% CI: 0.028 – 0.489; P=0.003).

Table 4

Multivariate Analysis on Variables Association with MDR, XDR

VARIABLE		**COR**				**AOR**			
				CI (95%)				**CI (95%)**	
		P value	**OR**	**Low**	**High**	**P value**	**OR**	**Low**	**High**
AGE(years)	20-30	1							
	31-40	0.281	1.402	0.759	2.59				
	41 & above	0.421	1.858	0.411	8.408				
Gender	Male	0.737	1.105	0.616	1.983				
	Female	1							
Marital status	Come we stay	0.855	1.126	0.315	4.027				
	Divorced	0.565	0.622	0.124	3.131				
	Married	1							
	Single	0.846	1.067	0.557	2.042				
Education	No formal education	0.81	0.766	0.087	6.766				
	Primary	0.851	1.225	0.148	10.122				
	Secondary	0.168	0.645	0.346	1.202				
	Tertiary	1							
	0-4	1							

People living in the household	5 & above	0.757	1.1	0.599	2.02				
Children present	1-2 children	1							
	3 & above	0.267	1.541	0.718	3.307				
	0 children	0.809	0.921	0.471	1.798				
Water source	Borehole	0.197	2.653	0.602	11.686				
	Bottled	0.609	1.179	0.627	2.217				
	Tap	1							
Water treatment	Yes	1							
	No	0.57	1.384	0.451	4.246				
	NA	0.572	0.839	0.456	1.543				
Water treatment method	Chemical	1							
	Boiling	0.877	0.938	0.417	2.111				
	Purifier	0.651	0.853	0.428	1.699				
	NA	0.554	1.407	0.454	4.364				
Water rationing	Yes	1							
	No	0.449	0.797	0.443	1.434				
Rationing frequency	1-2 times a month	0.41	1.382	0.64	2.982				
	3-5 times a month	0.851	1.071	0.522	2.2				
	6 & above times a month	1							
Toilet used	Flush	1							
	Pit latrine	0.848	1.094	0.437	2.735				
Street food eating frequency	1-2 times a week	0.548	0.808	0.404	1.618				
	> 3 times a week	1							
	Don’t eat	0.421	0.731	0.34	1.569				
Type of premise	Government	0.206	3.712	0.487	28.303				
	Private	1							
	Own	0.867	1.114	0.316	3.925				
Level of premise	High level	1							
	Middle level	0.633	1.174	0.608	2.265				
	Low level	0.594	1.24	0.562	2.739				
Duration working in food industry	0-1 year	0.48	0.736	0.314	1.723				
	2-5 years	1							
	5-10 years	0.615	1.206	0.581	2.506				

	> 10 years	0.842	0.915	0.381	2.197				
Training on food hygiene	Yes	1							
	No	0.033	0.437	0.204	0.935	0.003	0.118	0.028	0.489
Handwashing spot available	Yes	1							
	No	0.576	0.522	0.053	5.112				
Presence of washrooms in premise	Yes	1							
	No	0.945	1.055	0.229	4.855				
Bacterial infection last 6 months	Yes	0.28	0.712	0.385	1.317				
	No	1							
Complete dosage	Yes	0.098	0.57	0.293	1.11				
	No	0.306	0.604	0.229	1.588				
	NA	1							
When sick action taken	Sick leave given	1							
	Continue working	0.255	1.558	0.726	3.345				
Wear PPEs	Yes	1							
	No	0.05	0.329	0.108	1.004				
Frequency washing PPEs	1-3 days	0.836	1.068	0.572	1.993				
	Daily	1							
	Rarely	0.231	0.541	0.198	1.478				
Valid food handling license	Yes	1							
	No	0.846	1.234	0.149	10.238				
Go home with PPEs	Yes	0.201	1.644	0.767	3.525				
	No	1							
Last diarrhea episode	1-3 weeks ago	0.182	0.504	0.184	1.38				
	1-2 months ago	0.189	0.66	0.355	1.227				
	> 3 months ago	1							
Last times used antibiotics	1-3 weeks ago	0.125	0.504	0.21	1.21				
	1-6 months ago	0.406	0.762	0.402	1.445				
	> 6 months ago	1							
Source of antibiotics	Over the counter	1							

	Doctor's prescription	0.602	0.851	0.464	1.562				
	Sharing	0.879	1.105	0.308	3.963				

Key: COR- crude odds ratio, AOR- adjusted odds ratio, CI- confidence interval, MDR- multidrug resistant, XDR- extensively drug resistant.

DISCUSSION

According to this study findings, food handlers harbor various enteric bacteria (15.21%), posing a transmission risk and differ from Northwest Ethiopia (13.2%), Arba Minch South Ethiopia (10%) and North India (13.3%) [17,18,19]. The low prevalence compared to similar study in Nairobi (36.1%), indicates reducing enteric bacteria prevalence [7].

11% Escherichia coli, 3.1% Shigella flexneri and 1.1% Salmonella typhi prevalence in this study was low compared to Northwest Ethiopia with 10.1% Shigella spp., 1.9% E. coli and 1.2% Salmonella spp. and Ghana with 13.3% E. coli although higher compared to Nairobi with 1.4% Shigella flexneri across Mukuru informal settlement [17,20,21]. The Salmonella typhi study findings in this study have remained consistent with previous study by Peter et al., among Mukuru informal settlement residents [22].

All the bacterial enteric were susceptible to meropenem under carbephenems, affirming of this medication choice as last resort against enteric bacterial infection. These findings differ from study reports from Arba Minch, South Ethiopia indicating high Salmonella spp. resistance to amoxicillin-clavulanic acid (33.3%) although 40% Shigella spp. resistant to amoxicillin clavulanic acid but susceptible to gentamicin and chloramphenicol, consistent with this study [18]. A study in Kawangware informal settlement differed with this study by indicating ampicillin (83%) and tetracycline (50%) resistance, as meropenem and chloramphenicol had least resistance among Shigella spp. and S. typhi isolates while another informal settlement study in Mukuru reported (85%) Trimethoprim-Sulfamethoxazole, (12.5%) ampicillin, (7.5%) azithromycin and (2.5%) ciprofloxacin resistance as amoxicillin-clavunalate, ceftazidime and ceftriaxone remained susceptible to S. Flexneri [12, 22].

This study found that cefepime, ceftazidime and chloramphenicol were susceptible across S.flexneri and S.tyhi unlike the E. coli with Ceftazidime resistance alongside Chloramphenicol, significantly lower than 92.8% resistance rate reported among E. coli isolated from poultry processing facilities [23]. Ciprofloxacin showed 100% susceptibility across S.flexneri and S.typhi unlike the 12.82% E. coli resistance, significantly higher than food handlers' study in Qatar's with 14.2% ciprofloxacin resistance and Nairobi with (3%) ciprofloxacin, (2%) ceftazidime, (5%) cefotaxime and (1%) cefepime resistance, indicating higher enteric bacteria resistance risks in Kenya[12, 24].

Slightly more than half of this study participants bought medications over the counter with 23% sharing with friends, slightly lower than similar study on food handlers in Nairobi, which indicated 76% of study participants bought medications from chemist of which 50% self-medicated, hence: an overview of antimicrobial drug accessibility over unstable universal healthcare coverage [25].

The current study has significantly associated inadequate training on hygienic food handling practices with enteric bacterial infections, similar to a study in Northwest Ethiopia[17]. However, food handlers lacking hygienic food practices training is significantly lower (11.8%) than 32.1% in Nigeria and 79.8% in Ghana [20, 26]. A food handlers' study in Nairobi differed with this study on lack of hygienic training association with enteric bacterial infection by indicating regular washing was the significant risk factor [27].

Inadequate training on food hygiene practices had a lower association with enteric bacteria resistance as reported in this study, contrasting with another study in Tamale metropolis, Ghana and Mombasa among street vendors [20,28]. The study findings on food handlers work environment further differ with similar food handlers study done in Nairobi, which indicated that 70.9% of the food handlers with inadequate food safety and hygiene practices training had high enteric bacteria antimicrobial resistance [29].

CONCLUSION

The high prevalence of enteric bacteria in this study indicates the magnitude of the infection risk posed by food handlers. Furthermore, antimicrobial resistance is significantly alarming, especially among amoxicillin-clavulanic, a commonly used antibiotic. Failure to wear Personal Protective Equipment (PPE) and inadequate training on hygienic food handling practices indicate the likely risks influencing enteric bacteria transmission and resistance.

RECOMMENDATION

The high prevalence of enteric bacteria in this study highlights the need for a comprehensive enteric bacteria assessment at various institutional levels to identify any statistical differences. Furthermore, there is a need for continuous monitoring of antimicrobial resistance patterns and transmission risk factors across different sites in Nairobi County, Kenya.

Limitations of the study

Although this study provides an insight into food handlers receiving health assessment certification from CMR-KEMRI, it lacks comparative data from other approved food handlers' certification centers in Nairobi County.

Future research gaps

Future studies should investigate food handlers in their off-routine medical assessment and quantify pathogenic E.coli and Extended Beta-lactamase genes for all resistant isolates.

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