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Epidemiology and Antimicrobial Resistance Patterns in Enteric Fever among patients in Garissa County, a Semi-Arid Region of North Eastern Kenya

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ABSTRACT

Typhoid and paratyphoid fever continue to be important causes of illness and death, particularly among children and adolescents in developing countries where enteric fever is associated with poor sanitation and unsafe food and water. Quantification of disease burden is crucial for policy making about the deployment of enteric fever prevention measures and vaccines. This cross-sectional study was undertaken to determine the epidemiology and antimicrobial resistance pattern in bacterial aetiologies of enteric fever among patients attending Garissa County Referral Hospital, (GCRH) located in a semi-arid region of North Eastern Kenya. Blood and stool samples were obtained from 379 consenting patients and a detailed sociodemographic questionnaire was administered. Isolation and identification of *Salmonella* Typhi, *S.* Paratyphi A and *S.* Paratyphi B were obtained by convectional culture, PCR and Vitek-2 compact detection method. Antimicrobial susceptibility testing was done using Kirby-Bauer's disc diffusion method. Multidrug resistance was defined as co-resistance to ampicillin, chloramphenicol and co-trimoxazole. Eight of the 379 (2.1%) participants were positive for *Salmonella* spp. Of the 8 *Salmonella* isolates were *S.* Typhi (n=2; 25%), *S.* Paratyphi A (n=2; 25%) and *S.* Paratyphi B (n=4; 50%). Resistance to ampicillin, tetracycline, gentamycin, chloramphenicol, nalidixic acid and trimethoprim-sulfamethoxazole was 100%, 87.5%, 75%, 50%, 25% and 25% respectively. No isolate showed resistance to ciprofloxacin. Half of all *S. typhi, S. paratyphi A* and B were multidrug-resistant. Risk factors including water and food (such as often eating outside homestead, family eating from a common plate, taking locally prepared cold drinks, family wash hands in common basin), low socio-economic status and availability of a previous laboratory confirmation of typhoid fever were associated with *S.* Typhi and *S.* Paratyphi infection. The isolation of a large proportion of MDR *S.* Typhi, *S.* Paratyphi *A* and B is worrying. Although these isolates were susceptible to fluoroquinolones, there is need for routine surveillance to monitor susceptibility to the initial first line antibiotics in clinical settings since the MDR strains have lately shown increased resistance. Addressing issues of contaminated food, water, sanitation and hygiene and low socio-economic status is likely to prevent and reduce the burden on enteric fever in this region.
Keywords: Enteric Fever, Molecular Epidemiology, Antimicrobial Resistance Pattern, Semi-Arid Region of North Eastern Kenya
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INTRODUCTION

The genus *Salmonella* comprises *Salmonella enterica* and *Salmonella bongori*. *Salmonella enterica* subspecies I includes nearly all pathogenic serotypes for humans (Pegues and Miller, 2015). The growth of *S. enterica* Typhi and *S. enterica* Paratyphi A, B, and C is limited to humans, and these organisms cause enteric fever (Pegues and Miller, 2015). Non-typhoidal *Salmonella* (NTS) cause acute gastroenteritis – salmonellosis – a foodborne disease that is prevalent worldwide (Harris and Brooks, 2013; Pegues and Miller, 2015). Enteric-fever is one of the major public health problems in developing countries including Kenya (Radhakrishnan et al., 2018). Globally, 14.3 million cases of typhoid and paratyphoid fevers occurred in 2017 with a case fatality estimates of 135.9 thousand (GBD 2017 Typhoid and Paratyphoid Collaborators, 2019). The incidence of enteric-fever ranges from 100 to 199.9 per 100,000 population in Kenya (Radhakrishnan et al., 2018), but these figures may be underestimates due to under re porting, as only severely ill patients seek treatment in hospitals (Breiman et al., 2012)

The risk of enteric fever is highest in infants, young children and young adults with underlying comorbidities, including severe anaemia, malaria, malnutrition and HIV infection (Whitaker et al., 2009). The case fatality rate is high in those with HIV infection and among those living in lower-income countries due to overpopulation and poor hygiene (Whitaker et al., 2009; Ao et al., 2010; WHO, 2018).

Problems are also emerging with the clinical treatment of typhoid in resource-poor settings. For many years, the antibiotics chloramphenicol, ampicillin, and cotrimoxazole formed the mainstays of typhoid treatment. In the past two decades, multidrug-resistant (MDR) strains of *S. enterica* have emerged worldwide (Phan et al., 2009). Reduced susceptibility to fluoroquinolones has been reported in Kenya (Kariuki et al., 2010). Changing trends in antibiotic resistance among *S. enterica* has appeared against ampicillin, co-trimoxazole, and chloramphenicol have also been reported in Kenya (Kariuki et al., 2006; Kariuki et al., 2010). Understanding local and regional antimicrobial susceptibility trends is vital in guiding empiric therapy. Monitoring and reporting of antimicrobial susceptibility can guide public health decision-making on the need for control strategies including vaccination.

In Kenya, MDR *S.* Typhi isolates from adults and school age children associated with sporadic outbreaks in resource-poor settings, especially in slum areas, have been reported (Kariuki et al., 2004). Unfortunately, data are scarce on the epidemiology and antimicrobial resistance pattern of *S.* Typh*i* and *S.* Paratyphi species in Garissa County. This geographical region is marked by lack of one or more of the following five amenities: access to improved water, access to sanitation, durable housing, sufficient living area, and secure tenure (UN-HABITAT, 2006) essentially presenting risk factors for transmission of *S.* Typhi and Paratyphi occurs through consumption of contaminated food or water via short-cycle or long-cycle transmission. Evidence from studies in Kenya, India, Egypt, and Bangladesh demonstrate that morbidity and mortality in such areas are much higher than the national averages (Kimani-Murage et al., 2014; Bassiahi et al., 2014). Against this backdrop, this study was undertaken to determine the epidemiology and antimicrobial Resistance Patterns of *S. enterica* serovars in cases of clinically suspected enteric fever among patients in Garissa County, a Semi-Arid Region of North Eastern Kenya

Materials and Methods

Study setting and design

This was a descriptive cross-sectional study design conducted between March and December, 2018 consented adult population attending Garissa Provincial General Hospital. Applying the formula for estimating the population proportion with specified relative precision described by Lemeshow et al (1990) setting the α at 0.05, and a detection rate of 50%, a total of 379 patients were recruited to achieve 0.95 power. Inclusion criteria included presenting with fever (38°C and above) lasting for at least three days and accompanied with either of the following symptoms; abdominal pain, vomiting, diarrhea, constipation, headache, weakness, arthralgia or poor response to antimalarial medications. Participants were subjected to a face to face interview and also provided 10 ml of venous blood and a loopful stool samples for culture. The samples were processed at Garissa County Referral hospital laboratory and only positive blood and stool specimens were characterized further for pathogenic *Salmonella* strains at Centre for Microbiology Research (CMR); Kenya Medical Research Institute in Nairobi. This study was approved by Ethical Review Committee of Kenya Medical Research Institute (KEMRI/SSC No.2464).

Blood isolation

The blood was cultured in broth media containing brain heart infusion and para-aminobenzoic acid, incubated at 37°C, and subcultured when turbid onto sheep blood agar and MacConkey plates.

Stool Culture

All stool samples were placed in Cary Blair media and then plated into MacConkey (MAC) and Deoxycholate Citrate Agar (DCA). Portions of whole stool were also placed into Selenite –F broth for subculture and incubated at 37ºC overnight. A subculture of Selenite broth on Mac Conkey agar, and xylose-lysine deoxycholate agar were made from the surface of the broth without disturbing the sediment. The plates were incubated at 37°C for 18-24 hours.

All suspected *Salmonella* colonies were picked from the agar plates subjected to biochemical tests, PCR amplification of invA gene and subsequently serotyped using the VITEK 2 system, Version 0.8.01 (bioMe´rieux, Inc., Hazelwood, MO).

Biochemical Tests

All suspected *Salmonella* colonies were picked from the agar plates and inoculated into the following biochemical test tubes for confirmation as described by Kebede et al., (2016): triple sugar iron (TSI) test (presumptive *Salmonella* colonies produce black colonies or colonies with black centers and red medium on TSI agar) (OXOID, England), citrate test (presumptive *Salmonella* colonies produce blue color for the citrate test), urease test (presumptive *Salmonella* colonies produce purple-red color for the urease test), lysine decarboxylase (LDC) agar (OXOID, England) test (presumptive *Salmonella* colonies produce purple-colored colonies on LDC agar), and

indole test (presumptive *Salmonella* colonies produce violet-colored colonies for the indole test). Plates were incubated for 24 or 48 hrs at 37°C. Colonies were also tested for catalase production

PCR detection of Salmonella spp

The boiling method was used to extract Salmonella plasmid or DNA template. Briefly, a single bacterial colony was picked from the Luria–Bertani (LB) agar plate, boiled in 50 µl distilled water for 10 min and immediately cooled on ice for 5 min. After a short spin, 4 µl of this solution was used as PCR template as described by Kebede et al., (2016). The bacterial DNA template was amplified using 0.5 µM primers specific for invA gene comprising of: forward primer GAG GAA GGG AAATGA AGC TTT T and reverse primer TAG CAA ACT GTCTCC CAC CAT AC, PCR buffer [10 mM Tris/HCl (pH 8,3), 50 mM KCl, 3 mM MgCl, and 0.01% gelatin], 200 µM of each dNTP, and 1.0 U AmpliTaq Gold enzyme (Roche Molecular Systems, Inc, Brachburg, New Jersey, USA). The mixtures were amplified under the following cycling condition: 40 cycles at 94ºC for 1 minute, 55ºC for 1 minute, and 72ºC for 2 minutes, with a final extension at 72ºC for 10 minutes in an automated thermal cycler (Control system PC- 710; Astec; Tokyo, Japan). An aliquot of 10 µl of each amplified product was visualized in 2% (wt/vol) agarose gel electrophoresis.

Serotyping

The bacterial isolates positive by the genus-specific PCR were serotyped by slide agglutination test targeting specific flagellar antigens. Further, serotyping was done using the VITEK 2 system, Version 0.8.01 (bioMe rieux, Inc., Hazelwood, MO) according to the manufacturers instruction.

Antimicrobial susceptibility testing

Each isolate was tested for susceptibility to antimicrobials by a controlled disk diffusion technique on Diagnostic Sensitivity Testing (DST) agar (Oxoid Ltd., Basingstoke, United Kingdom) plates containing 5% lysed horse blood. *Salmonella* isolates were tested for susceptibility to the following 7 antibiotics (OXOID, England): ampicillin (10 μg), tetracycline (30 μg), trimethoprim/sulfamethoxazole (30 μg), chloramphenicol (30 μg), gentamicin (10 μg), ciprofloxacin (5 μg), and nalidixic acid (30 μg) using the disk diffusion method according to guidelines set by the Clinical Laboratory Standards Institute (CLSI, 2017). Antibiotic impregnated discs were dispensed on the surface of cultures of Muller-Hinton agar and incubated at 35°C for 20 hrs. The diameters of the zones of inhibition were recorded to the nearest mm and classified as resistant, intermediate, or susceptible according to established interpretive chart (CLSI, 2017). *Escherichia coli* ATCC 25922 was used as a reference strain in the disk diffusion susceptibility tests.

Data Analysis

Frequency (%), mean and standard deviation, were used to describe the qualitative and laboratory parameters. Chi-square or Fisher's exact test were used to test for significance where applicable. In bivariate analyses, odds ratios (OR) and 95% confidence intervals (CI) for the association between enteric fever infection and socio-demographic, hygienic and environmental characteristics were calculated using Poisson regression. In multivariate analyses, a manual backward elimination approach was used to reach the most parsimonious model, including factors that were associated with infection of enteric fever at the significance level of P 0.05. All statistical analyses were performed using STATA v 13 (StataCorp LP, College Station, TX, USA).

RESULTS

Baseline characteristics

Analyzable data were available for all the 379 participants recruited. The mean (± standard deviation - SD) age of the participants was 37.3 (±13.3) years ranging (18 to 95 years). The majority of the participants 39.8% were aged 18- 30 years, 54.4% were female, 58% married, 39.3% had secondary level education, 45.1% were in business for their occupation. Table 1 summarizes the characteristics of the study population. Further, the majority of participants 67.3% had household population of 1 to 5 people, 16.6 % kept chicken, 67.5% had <20,000.00 kshs monthly income, 75.2% had body temperature >37.1ºC, while 58.8% had headache. About 9.8% of the participants reported receiving treatment, only 7.4% had laboratory confirmation of typhoid while 35.1% had history of typhoid of fever. Only 10% had history of contact with typhoid patient in the last one year, 20.1% often eat outside with 19.8% eating from common plate while 13.2% who took locally prepared cold drinks. The majority 91.8% reported frequently washing their hands with 15% washing their hands in a common basin. The majority 72.8% obtained their drinking water from wells, 72.3% treated their drinking water and 67% had access to a modern toilet for the sanitation.

Table 1: Baseline characteristics of study population

Variables	Unit	Frequency	Percentage
Gender	Female	206	54.4
Age (Years)	18 - 30	151	39.8
Marital status	Married	220	58
Education level	Secondary	149	39.3
Occupation	Bussiness	171	45.1
Religion	Muslim	303	79.9
Household population	1 to 5	255	67.3
Family owns cows	Yes	71	18.7
Family owns goats	Yes	88	23.2
Family owns chicken	Yes	63	16.6
Monthly income (Kshs)	<20,000.00	256	67.5
House building material	Concrete	230	60.7
Weight	> 51	328	86.5
Body Temperature	> 37.1	285	75.2
Days with Fever	< 3 Days	300	79.2
Signs and symptoms	Headache	223	58.8
Receiving treatment	Yes	37	9.8
Laboratory confirmation of typhoid	Yes	28	7.4
History of typhoid fever	Yes	133	35.1
Had contact (work colleagues, school mates, relatives, neighbours) with typhoid patients within one year before	Yes	38	10
Did you travel outside your community recently (three months ago)?	Yes	31	8.2
Often eat from outside	Yes	76	20.1
Family eat from a common plate	Yes	75	19.8
Take locally prepared cold drinks	Yes	50	13.2
Often wash your hands	Usually	348	91.8
Family wash hands in common basin	Yes	57	15
Sources of water supplies in the family	Wells	276	72.8
Treat drinking water	Yes	274	72.3
Method for water treatment	Chemical	146	38.5
Method for food storage	Fridge	38	10
Type of latrine do you have	Modern Toilet	254	67

Molecular and Serotype Identification of *Salmonella*

Among a total of 379 samples examined for bacteriological status, 8 participants were positive for *Salmonella*. The PCR amplifications gave products of 496 bp for the 8 isolates, expected size for samples positive for *Salmonella* by the genus-specific PCR reaction. Serotyping also revealed the same 8 isolates to be *Salmonella* spp. Out of the 8 *Salmonella* positive strains (n=2; 25%) were *Salmonella enterica* subspecies enterica serovar typhi, (n=2; 25%) were *Salmonella* Paratyphi A with the majority (n=4; 50%) being *Salmonella* Paratyphi B.

Antibiotic susceptibility profiles of *Salmonella* strains

Single and multiple resistance to most of the antibiotics tested were observed. The highest prevalence of resistance observed was to ampicillin with all 8 (100%) isolates being resistant. The next highest resistance was to Tetracycline, with 7/8 isolates (87.5%) being resistant and 1 being intermediate-resistant. There were 6/8(75%) isolates resistant to Gentamycin with two isolates 1(CMR_5722) and 2(CMR_6704) being susceptible and intermediate resistant respectively. Ciprofloxacin was the most effective antibiotics, all isolates (100%) were sensitive. Nalidixic acid and Trimethoprim-sulfamethoxazole were the second most effective antibiotics, except that 1 (CMR_6772 and CMR_6704) and 2 (CMR_8548 and CMR_5732) isolates were resistant to the two antibiotics, respectively. Fifty percent (4/8) of the isolates were found to be susceptible to Chloramphenicol (Table 2).

Table 2. Antibiotic disk diffusion susceptibility test results for salmonella strains

Isolate	Strain	Antibiotic susceptibility profiles						
		AMP	NA	CHLOR	GEN	CIP	SXT	TET
CMR_8530	*S. paratyphi A*	R	S	S	R	S	S	R
CMR_6772	*S. paratyphi B*	R	R	S	R	S	S	R
CMR_8548	*S. paratyphi B*	R	S	R	R	S	R	R
CMR_8574	*S. paratyphi B*	R	S	S	R	S	S	R
CMR_6704	*S. paratyphi A*	R	R	R	I	S	S	R
CMR_5792	*S. paratyphi B*	R	S	R	R	S	S	R
CMR_5722	*S. enterica*	R	S	S	S	S	S	I
CMR_5732	*S. enterica*	R	S	R	R	S	R	R

S - Susceptible; R - Resistant; I - Intermediate-resistant; AMP-Ampicillin; NA - Nalidixic acid; CHLOR - Chloramphenicol; GEN - Gentamycin; CIP - Ciprofloxacin; SXT - Trimethoprim-sulfamethoxazole; TET - Tetracycline

Multivariate analyses

After adjusting for confounders, Laboratory confirmation of typhoid (OR 66.6, 95% CI 5.8-757.2), often eating outside homestead (OR 5.3, 95% CI 1.4-12.4), family eating from a common plate (OR 6.1, 95% CI 1.2-21.2), taking locally prepared cold drinks (OR 6.9, 95% CI 1.4-32.3), family wash hands in common basin (OR 7.3, 95% CI 1.9-31.2) and the participants who had monthly income Kshs <20,000.00 (<200USD) (OR 0.2, 95% CI 0.003-0.8) were independently associated with pathogenic salmonella infection. Table 3 summarizes the multivariate analysis of factors independently associated with enteric fever.

Table 3. Adjusted factors associated with pathogenic salmonella infection

Variables	Total	Pathogenic Salmonella infection		P - value	Multivariate
		Frequency	Percentage		aOR (95% CI)
Laboratory confirmation of typhoid					
Yes	28	7	25	**0.001**	**66.6(5.8-757.2)**
No	351	1	0.3	Reference	Reference
Do you often eat from outside					
Yes	76	5	6.6	**0.03**	**5.3(1.4-12.4)**
No	303	3	1	Reference	Reference
Does the family eat from a common plate					
Yes	75	5	6.7	**0.039**	**6.1(1.2 - 21.2)**
No	304	3	1	Reference	Reference
Do you take locally prepared cold drinks					
Yes	50	5	10	**0.014**	**6.9(1.4 - 32.3)**
No	329	3	0.9	Reference	Reference
Does the family wash hands in common basin					
Yes	57	5	8.8	**0.022**	**7.3(1.9-31.2)**
No	322	3	0.9	Reference	Reference
Monthly income					
<20,000.00	256	8	2.5	***0.025***	***0.2(0.03-0.8)***
> 20,001.00	123	0	0		

OR - Odds ratio; CI - confidence interval; a - adjusted odds ratio; ND - Not done; P value- significant level

DISCUSSION

Epidemiological studies are essential in preventing and managing any disease/condition. This study, the first of its kind in Garissa county was a buildup of growing need for data on enteric fever given the lack of access to clean water, sanitation, proper housing and sufficient food in in this Semi-Arid Region of North Eastern Kenya (UN-HABITAT, 2006). These attributes are essential risk factors for transmission of *S.* Typhi and *S.* Paratyphi. Specifically, this study determined the serotypes, antimicrobial resistance and associated factors this region of Kenya. In this study, *S.* Typhi and *S.* Paratyphi A and B were isolated for a total of 25%, 25% and 50% of enteric-fever patients respectively. Thus, the ratio of isolation of *S. Typhi* and *S. Paratyphi* A and B was 1: 1: 2 which was in contrary to other studies conducted globally which reported ratio from 1.6: 1 to 4: 1 (Bhattacharya et al., 2011; WHO, 2012). Though the incidence of *S.* Typhi remains high, several recent studies have highlighted the progressive increased proportion of *S. Paratyphi* A in the past decade (Dutta et al., 2014; Makkar et al., 2018).

Clinically, typhoid and paratyphoid fever are indistinguishable. Furthermore, many other acute febrile illnesses such as dengue, leptospirosis, and malaria may present a clinical picture similar to that of typhoid fever (Radhakrishnan et al., 2018). The results from this and other studies inevitably shows the importance for accurate and early diagnosis of typhoid and paratyphoid fever. The accurate diagnosis requires laboratory confirmation (Parry et al., 2011; Radhakrishnan et al., 2018). The development of practical, affordable, and accurate (i.e., both sensitive and specific) diagnostic tools is key to typhoid fever management and control.

In this study, attributes related to water and food (such as often eating outside homestead, family eating from a common plate, taking locally prepared cold drinks, family wash hands in common basin) were found associated with *S. Typhi* and *S. Paratyphi* infection. As it is expected, Garissa is a semi-arid area marked by water shortage and poor sanitation hygiene. The association of food and water related behavior is not surprising. It should be noted that we did not distinguish if these factors were specific to either *S. Typhi* or *S. Paratyphi.* Similar to our study many authors investigating enteric fever do not distinguish factors coincide to either typhoid or paratyphoid (Vollaard et al., 2004). The assumption is that in paratyphoid fever, a higher dose of bacteria is required for infection than in typhoid fever; consequently, food is implicated as the major vehicle for transmission of paratyphoid fever, since *Salmonella* bacteria can multiply in food (Vollaard et al., 2004). Undoubtedly, risk factors for both typhoid and paratyphoid fever have been identified in several epidemiologic studies suggesting either waterborne or foodborne transmission (Sur et al., 2007; Anand et al., 2010; Khan et al., 2012; Mogasale et al., 2018). The odds of typhoid fever among those exposed to unsafe water ranged from 1.06 to 9.26 (Mogasale et al., 2018).

In our study, previous laboratory confirmation of typhoid was independently associated with being positive for enteric fever infection. According to WHO, (2017) Laboratory confirmation should always be sought for clinically suspected cases. Confirmation by culture (or validated molecular methods, as available) is essential as typhoid fever, paratyphoid fever and other invasive salmonellosis can present as a non-specific febrile illness, and current serological tests lack diagnostic specificity. It can be argued that those patients who sought laboratory confirmation had clinical signs and symbols for enteric fever. Confirmation is essential to assess the proportion of enteric fever caused by these different organisms, determine antimicrobial susceptibility and do molecular epidemiology studies (WHO, 2017)

Participant's low income was a key predictor for *S. Typhi* or *S. Paratyphi* infection. This was similar to other reports. Mogasale et al., (2018) besides water-related risk, identified other risk factors related to socioeconomic aspects, type of food consumption, knowledge and awareness about typhoid fever, and hygiene practices.

Antibiotic susceptibility profiles of *Salmonella* strains

In this study MDR Salmonella resistant was observed to ampicillin, tetracycline, gentamycin and chloramphenicol which is similar to different studies. Increase in the incidence of MDR *Salmonella* resistant to ampicillin, chloramphenicol, cotrimoxazole, streptomycin, furazolidone and tetracyclines is an emerging problem and a matter of concern worldwide (Dutta et al., 2014; Pakistan, 2016, Makkar et al., 2018). Encouragingly, in this study ciprofloxacin, nalidixic acid and trimethoprim-sulfamethoxazole were still effective against *Salmonella* strain. This is contrary to other studies such as in India Makkar et al., (2018), observed higher level of resistance to ciprofloxacin, co-trimoxazole, ampicillin, and third-generation cephalosporins. Most typhoid fever infections diagnosed in the United States are fluoroquinolone nonsusceptible. therefore, health care providers should not use fluoroquinolones as empiric therapy, especially in returning travelers from South Asia (Date et al., 2016). Fluoroquinolone nonsusceptibility has been associated with treatment failure or delayed clinical response (Crump et al., 2015). The emergence of fluoroquinolone nonsusceptible strains that are resistant to third-generation cephalosporins, such as ceftriaxone has been observed in Pakistan and other countries (Ryan and Andrews, 2018). In recent data from Pakistan published as part of the surveillance for enteric fever in Asia project (SEAP), over half of all S. Typhi isolates were multidrug resistant. Fluoroquinolone resistance was noted in nearly 90% of *S. Typhi* and *S. Paratyphi* isolates (Qamar et al., 2018). A longitudinal study of typhoid fever trends at three large hospitals in India showed a fall in resistance rates for ampicillin, chloramphenicol, and co-trimoxazole between 2000 and 2014, as resistance to more widely used antibiotics has risen (Balaji et al., 2018). Near universal resistance to ciprofloxacin has been observed in recent isolates from India (Dahiya et al., 2017). In our study, the patients with suspected severe or complicated typhoid fever might need to be treated with a fluoroquinolone and carbapenem and the treatment regimens can be adjusted when culture and sensitivity results are available.

our findings indicate the occurrence of enteric fever in this region facing climatic and economic hardship where majority of the populations have limited access to diagnostic services. This is an indication that the disease burden is poorly quantified and policy makers have lacked the data needed to make decisions about the deployment of enteric fever prevention measures and vaccines. Further, isolation of the antimicrobial resistance *S.* Typhi and *S. Paratyphi* in this study points strongly to need to establish hospital antimicrobial policy and antimicrobial prescribing guidelines. Periodic monitoring of the antibiogram pattern along with the implementation of strict antibiotic policies and patient education are crucial. Proper feeding, sanitation and hygiene practices are also likely to prevent and reduce the burdened on enteric fever in this region.

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Competing interests

The authors declare no competing interests.

Authors' contributions

This work was part of Master of Science degree for KSS in Laboratory Management and Epidemiology of Jomo Kenyatta University of Agriculture and Technology. KSS, ZN and SK conceived the study. KSS collected and analyzed the data and prepared the draft manuscript. ZN and SK provided guidance and mentorship during the implementation of the study. All authors reviewed and approved the final manuscript.

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