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Isolation and antimicrobial susceptibility profile of *Salmonella* species from slaughtered cattle carcasses and abattoir personnel at Dessie, municipality Abattoir, Northeast Ethiopia

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Abstract

Background Antibiotic-resistant *Salmonella* is one of the main public health concerns in the world. Isolation of *Salmonella* in abattoirs has been considered the core source of infection in the community from meat. Still, there is limited information on the contamination rate of cattle carcasses.

Objective This study aimed to document the occurrence and antimicrobial susceptibility profile of Salmonella species recovered from cattle carcass and abattoir personnel at Dessie, municipality abattoir, Northeast Ethiopia:

Methods A total of 336 carcass swabs of abdomen, neck, and hind limb from cattle carcasses and 24 stool samples were collected from abattoir personnel using a systematic sampling method from February to April 2019. The collected samples were transported using Cary-Blair transport media and cultivated on Selenite cysteine F-broth, Brilliant green agar, and Xylose-lysine deoxycholate agar plates to isolate *Salmonella* species. Gram stain, colony morphology, and biochemical tests were performed to identify the isolated bacteria. An antimicrobial susceptibility test for *Salmonella* was performed using the Kirby-Bauer Disc Diffusion method. Descriptive statistics; both bivariable and multivariable logistic regression analysis was performed using SPSS version 25 software. *P*-value < 0.05 at 95% CI was considered statistically significant.

Results The prevalence of *salmonella* species was 8%(27/336) from all samples.'The prevalence of *Salmonella* isolates in cattle carcass and abattoir personnel was 8%(25/312) and 8.3%(2/24) respectively. The antimicrobial test showed that *Salmonella* species were 100% resistant to ampicillin, 59.3% to trimethoprim-sulfamethoxazole, 59.3% to tetracycline, and 55.6% to amoxicillin/clavulanate. From the total antimicrobial tested bacteria, 81.5%(22/27) were resistant to three and above classes of antibiotics (drug classes). Unwashed knives, carcasses, and hands of butchers during slaughtering were significantly associated ($p < 0.05$) with *Salmonella* found in carcasses.

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Conclusions *Salmonella* isolation rates from cattle carcasses were high, with the bacteria showing notable resistance to most tested antibiotics. Poor hygiene practices, unsanitized equipment, and unhygienic beef processing were contributing factors.

Keywords *Salmonella*, Beef, Abattoir personnel, Antimicrobial susceptibility

Introduction

Globally, foodborne diseases have become a big concern. According to a World Health Organization (WHO) report from 2010, there were 600 million foodborne illnesses and 420,000 deaths as a result of consuming unsafe food [1]. Every year, *Salmonella* causes approximately 93.8 million human gastroenteritis infections and 155, 000 deaths [2]. According to a Centers for Disease Control and Prevention (CDC) analysis, *Salmonella* bacteria cause about 1.35 million infections, 26,500 hospitalizations, and 420 deaths in the United States every year [3].

Non-typhoidal *Salmonella* (NTS) is one of the common foodborne pathogens that originate from cattle, sheep, and pigs [4, 5]. *Salmonella enterica* and *Salmonella bongori* are the predominant species of *Salmonella* isolated from food sources of meat [4]. In most parts of the world, *Salmonella enteritidis* and *Salmonella typhimurium* transmitted from animals to humans [6]. Humans can be infected with *Salmonella* from animal sources, environmental exposure, and ingestion of contaminated foodstuffs [7]. Depending on the strain of the pathogen, the severity of the disease caused by *Salmonella* varies from asymptomatic carriage to severe life-threatening conditions [8]. The diseases were gastrointestinal disorders and severe infections, such as bloodstream, and extraintestinal diseases like meningitis, septic arthritis, osteomyelitis, cholangitis, and pneumonia [9].

In most parts of Africa, a high proportion of NTS infection occurs: 88% in eastern Africa, 97% in southern Africa, and 87% in western and central Africa, while only 1% in northern Africa [10]. In Ethiopia, the prevalence of NTS in humans ranges from 6.2 to 13.63% [2, 11, 12]. Also, the isolation rate of *Salmonella* food from animal sources ranged from 1.3 to 13.3% [11, 13–16].

Factors that led to the contamination of carcasses meat by *Salmonella* were poor hygiene practices, slaughtering processes, and food preparation of animal products [17–19]. Additionally, knives, cloths, carts, boxes, surfaces, and other equipment increase contamination by *Salmonella*. These microorganisms begin to grow and spoil the meat if the environment is favorable for their development. Asymptomatic food handlers or personnel that have an active stage of the disease play a significant role in transmitting infection [14, 20].

Nowadays, Drug-resistant pathogens are a global public health concern and *Salmonella* is one of the microorganisms in which some resistant serotypes have emerged, affecting the food chain [21]. In Ethiopia, the antibiotic resistance level of *Salmonella* food from animals emerged high [22]. The rise of multidrug-resistant (MDR) *Salmonella* strains against commonly prescribed antimicrobials poses public health concerns in both veterinary and human medicine sectors [14, 23]. Widespread use of first-line drugs has contributed to the proliferation of MDR isolates, exacerbating this imminent issue [14]. Moreover, Ethiopia's prevalent consumption of raw meat fosters an environment conducive to community-wide infection development [24].

Thus, this study aimed to isolate and determine the antimicrobial susceptibility profile, and identify associated risk factors of *Salmonella* species recovered from cattle carcasses and abattoir personnel at Dessie, Municipality Abattoir, Northeast Ethiopia.

Materials and methods

Study area and design

A cross-sectional study was conducted from February to April 2019 at the Dessie town municipality abattoir. According to the 2007 Ethiopian population and housing census, the town had a total population of 151,094 [25]. The livestock population of the area comprises 18,724 cattle [26]. However, the Dessie municipality abattoir is the only abattoir that provides a slaughter service and distributes meat products for the town and nearby kebeles. It has 20 carcass processors, two meat inspectors, four abattoir cleaners, and seven supportive and administrative workers. On average, 37 cattle were slaughtered each day and the meat product was served to the community by 89 hotels, 27 butcher shops, 38 restaurants, 64 cafeterias, and other governmental and non-governmental organizations [27].

Sample size determination

For cattle the sample size was determined using a single population proportion formula as follows: $n=z^2\ p\ (1\text{-}p)\ /\ d^2$; where: n=The minimum required sample size; z=Standard normal distribution value at 95% CI, which is 1.96; P=the prevalence of *Salmonella* isolates in slaughtered cattle carcasses, beef taken from a previous study report at abattoir of Bahir Dar town which was 7.3% [18]; d=the margin of error taken as 5%.

Accordingly, the sample size was: $n = \frac{3.8416\times0.073\times0.927}{0.0025} = 104$

For abattoir personnel, the sample size was all abattoir workers who have contact with carcasses were taken.

Sampling technique

Cattle were selected using a systematic sampling method. On average 37 cattle were slaughtered daily. The sample was collected three days per week for 24 days within the study period. The number of samples collected each day is calculated as follows; N=total sample size to be collected which is 104; D=total number of sample collection days, which is 24 and n=number of samples to be collected each day.

$$n = N/D(104/24) = 4$$

Four cattle were selected each day using the identification numbers given to the animals. A total of 12 swab samples from meat, and three samples from the hind limb, abdomen, and neck region of each cattle carcass were taken. Totally, from 104 cattle a total of 312 samples were collected from the hind limb, abdomen, and neck region of each cattle to appreciate *Salmonella* distribution in different body regions and also to increase the isolation rate of *Salmonella*. The survey included all volunteer abattoir workers who had daily contact with beef. Stool samples were collected from 25 abattoir personnel.

A cattle carcass swab was collected according to the sample collection, isolation, and identification recommendations of the International Organization for Standardization (ISO) [28]. A total of 312 carcasses (one hundred-four from each cattle's hind limb, abdomen, and neck region) were collected from 104 selected cattle from Dessie town **Municipality**. About 100 square centimeters of surfaces around the hind limb (medial), abdomen (lateral), and neck region were swabbed by wiping with a sterile gauze swab soaked in nearly 10 milliliters of buffered peptone water (BPW) and rubbing over each sampling site horizontally and then vertically for 30 s. Upon completion of the rubbing process, the swab was placed into the BPW used to wet the swab in a universal bottle. Then a swab sample was transported from the site of collection to the Amhara Public Health Institute, Dessie Branch, Microbiology Laboratory Department using transport medium 2 h of collection. The swab samples were analyzed immediately for the isolation of *Salmonella* [28].

Stool sample collection

After being clearly instructed, the abattoir personnel brought stool samples by using a sterile, clean, tight-lid sample container at the municipal. The collected stool specimens were transported by using cary - Blair transport media to Amhara Public Health Institute's Dessie branch microbiology laboratory within two hours of collection [29]. Atotal of 25 stool samples were collected from abattoir personnel at dessie town municipal.

Isolations and identification of *Salmonella*

Each carcass sample was collected in four areas: the neck, brisket, flank, and rump. The area sampled in each region was 100 cm^2, for a total area of 400 cm^2. Swabs were transferred to a sterile plastic cup containing 10 ml of buffered peptone water, and in addition, from abattoir personnel, one [1] gram of stool was collected and transferred into nine ml of buffered peptone water and manually homogenized in a one-to-nine volume with BPW water. Homogenized carcasses and fecal samples from cattle and personnel were incubated at 37 °C for 18 h. The enrichment broths were then transferred aseptically into 10 ml of selenite cysteine and 10 ml of Rappaport-Vassiliadis soy broth and incubated for 24 h at 37 °C and 42 °C, respectively. After incubation, a loop of each culture was streaked onto Brilliant Green Agar and Xylose Lysine Deoxycholate Agar plates and incubated for 24 to 48 h at 37 °C [28].

Gram staining was used to confirm the presence of Gram-negative, rod-shaped bacteria as well as their morphology and staining characteristics. Based on ISO recommendations fermentations of carbohydrates on triple sugar iron agar, deamination of lysine iron agar, utilizations of citrate, utilizations of urea, production acid bottom, and hydrogen sulfide on TSI, productions of indole motility were biochemical tests used to identify all gram-negative and *Salmonella* species [28].

Antimicrobial susceptibility testing

The isolates of *Salmonella* were tested on Muller Hinton agar(HMEDIA), for antimicrobial drugs by disc diffusion technique [30]. Single pure colonies were transferred to five mL normal saline tubes and compared to 0.5 McFarland turbidity standards. A sterile cotton swab was dipped into the adjusted suspension, and the excess was removed by gently rotating the swab against the tubes inside the wall. The swab was evenly inoculated across the entire surface of Muller Hinton agar and the plates were allowed to air dry for 15 min. The inoculated plates were incubated at 37ºC for 16–18 h after the antimicrobial discs were applied.

All isolates of *Salmonella* were tested with a total of 9 selected antibiotics discs (Oxide, UK) including amoxicillin-clavulanate (AUG) 10 µg, ciprofloxacin (CIP) 5 µg, chloramphenicol (CHL) 30 µg, kanamycin (K) 10 µg, ampicillin (AMP)10 µg, gentamicin (GM), tetracycline (TE) 30 µg, sulfamethoxazole-trimethoprim (TMP-SMX) 23.75/1.25 µg, streptomycin (S) 10 µ, amikacin (AK) 30 µg and cephalothin (CF) 30 µg. The antimicrobial agents were selected based on the CLSI 2019 guideline [30]. Finally, the inhibition zone diameters were measured to the nearest millimeter using a ruler. The result was interpreted as susceptible, intermediate, or resistant

based on the recommended CLSI results in interpretive standards [30].

Quality assurance

Before data collection about 5% of the questionnaire were pre-tested. All laboratory tests were done according to the standard procedures. The media sterility was checked by incubating 5% of the prepared batch media without inoculating bacteria overnight at 35–37 °C. Throughout the study, *Salmonella typhimurium* (ATCC 14028) and *E. coli* (ATCC 25922) were used as quality control to assess the media's ability to support bacterial growth and the quality of antibiotic discs. The quality of muller Hinton agar was checked by *Enterococcus faecalis* ATCC29212 [30].

Table 1 Socio-demographic and clinical characteristics of abattoir personnel working in Dessie municipality abattoir, northeast Ethiopia, 2019

Characteristics of study participants (n = 24)		Frequency	Percent (%)
Sex	Male	23	95.2
	Female	1	4.8
Age	18–34	6	25.0
	35–49	10	41.7
	> 49	8	33.3
Education level	No formal education	5	20.8
	Grade 1–4	2	8.3
	Grade 5–8	5	20.8
	Grade 9–12	7	29.3
	College/university	5	20.8
Marital status	Married	18	75.0
	Unmarried	6	25.0
Responsibility	Carcass processor	19	79.2
	Meat inspector	1	4.2
	Cleaner	4	16.6
Service year	< 1 year	4	16.7
	1–3 year	3	12.5
	4–8 year	6	25.0
	> 8 years	11	45.8
Job-related training	Yes	15	62.5
	No	9	37.5
Symptoms of salmonellosis (symptoms of Diarrhea)	Asymptomatic	21	87.5
	Symptomatic	3	12.5
Antimicrobial use within the past two weeks	Yes	0	0.0
	No	24	100
Hand washing after a visit to the toilet	Yes	19	79.2
	No	5	20.8
Type of handwashing practice applied	With soap and water	3	14.3
	With water only	18	85.7

Statistical analysis

To code data the data was entered into Epi-Data version 4.0.0.6 and analyzed by using SPSS version 25. To identify potential risk factors of *Salmonella* isolates bivariable and multivariable logistic regression analysis was performed. In bivariable analysis, variables with p-values less than 0.2 were candidates for multivariable analysis. The significance of the association between potential risk factors and the *Salmonella* isolates from cattle carcasses, the adjusted odds ratio at 95% confidence intervals (CI) with a *P* value of 0.05 was considered as statistical associations of contamination rate.

Results

Socio-demographic data of abattoir personnel

During the study period, a total of 24 meat abattoir personnel were enrolled in this study, of whom 23 (95.2%) were men. The median age was 42.5(35.3 ± 12.4) with the range of 24–58 years. About 19 (79.2%) of the abattoir personnel were assigned as a carcass processor (Table 1).

Hygiene status and sanitary condition of abattoir personnel (risk factors)

In multivariate analysis of the study subjects, carcasses not washed during slaughtering was 4.974 times more likely to have increased the risk of *Salmonella* isolates compared to carcass washed during slaughtering (AOR = 4.974; 95% CI, 1.076–22.994, *P* = 0.040). Besides, slaughtered personnel who have not washed their hands after separating intestinal content were 5.873 times increased *Salmonella* isolates compared to those who washed their hands after separating intestinal content (AOR = 5.873; 95% CI, 1.077–32.018, *P* = 0.041). All 24(100%) slaughter personnel wore garments and boots during slaughtering, and all 104(100%) cattle were inspected and their skin was not washed before slaughtering. However, there was no significant association, among other characteristics like slaughter personnel handwashing before slaughtering, washing animal carcasses after skinning, and sanitation of the slaughtering floor (*p*-value > 0.05) (Table 2).

Prevalence of *Salmonella* isolates from cattle carcass and abattoir personnel

From a total of 336 collected samples from cattle carcass and abattoir personnel, 27(8.0%) were culture positive for *Salmonella* isolates. We included 312 cattle carcass samples, in which 25 (8.0%) showed positive for *Salmonella* species, and relatively a higher growth of 10 (9.6%) of the isolates were observed from the abdomen regions. Of 27 *Salmonella* isolates, *Salmonella arizonae* 11 (40.7%), *Salmonella Group* A 9 (33.3%), *Salmonella* Typhi 6 (22.2%) and unspecified *Salmonella* 1 (3.7%) were identified. From 24 abattoir personnel, 2(8.3%) were positive

Table 2 Bivariate and multivariate analyses of risk factors associated with *Salmonella* isolates from cattle carcass in Dessie municipality abattoir, northeast Ethiopia, 2019

Characteristics (*n* = 104)		Positive *n* (%)	Negative *n* (%)	COR (95% CI)	*P*-Value	AOR (95%CI)	*P*-Value
Washing knife before slaughtering	No	5 (29.4)	12 (70.6)	5.625 (1.484–21.326)	0.011	5.629 (1.098–28.851)	0.038
	Yes	6 (47.4)	81 (52.6)	1			
Hand washing before slaughtering	No	3 (23)	10 (77)	3.112 (0.708–13.676)	0.133	0.592 (0.075–4.662)	0.619
	Yes	8 (8.8)	83 (91.2)	1			
Type of handwashing practice applied before slaughtering	With water only	7 (8.8)	73 (91.2)	0.959 (0.107–8.629)	0.970		
	With soap and water	1 (9)	10 (91)	1			
Washing animal carcass after skinning	No	4 (30.8)	9 (69.2)	5.333 (1.305–21.796)	0.020	1.318 (0.176–9.887)	0.788
	Yes	7 (7.7)	84 (92.3)	1			
Hand washing after separating intestinal content	No	6 (37.5)	10 (62.5)	9.960 (2.566–38.654)	0.001	5.873 (1.077–32.018)	0.041
	Yes	5 (5.7)	83 (94.3)	1			
Type of handwashing practice applied after separating intestinal content	With water only	4 (5.1)	75 (94.9)	0.427 (0.042–4.296)	0.470		
	With soap and water	1 (11.1)	8 (88.9)	1			
Washing carcass during slaughtering	No	5 (6)	78 (94)	6.240 (1.685–23.107)	0.006	4.974 (1.076–22.994)	0.040
	Yes	6 (28.6)	15 (71.4)	1			
Sanitized slaughtering floor	No	5 (26.3)	14 (73.7)	4.702 (1.261–17.531)	0.021	2.973 (0.609–14.521)	0.178
	Yes	6 (7.1)	79 (92.9)	1			

Keys: COR (crude odds ratio), CI (confidence interval), AOR (adjusted odds ratio

Table 3 Isolation rate of *Salmonella* species from cattle, beef, and abattoir personnel in Dessie municipality abattoir, northeast Ethiopia, 2019

Type of sample		No. of samples tested	Salmonella isolates	
			Positive n (%)	Negative n (%)
Carcass swab	Abdomen	104	10 (9.6)	94 (91.4)
	Neck	104	7 (6.7)	97 (93.3)
	Hind limb	104	8 (7.7)	96 (92.3)
	Total	312	25 (8.0)	287 (92)
Personnel stool		24	2 (8.3)	22 (91.7)
Total		336	27 (8.0)	309 (92)

for *Salmonella* isolates with species of *Salmonella Typhi* 1 (50%) and *Salmonella* Group A1 (50%) respectively, (Tables 3 and Fig. 1).

Antimicrobial susceptibility profile of *Salmonella* isolates

The resistance patterns of all *Salmonella* isolates from cattle carcass were tested against nine antimicrobial agents. In this study, the highest degree of resistance among the tested antimicrobials was observed for ampicillin 100% (25/25) followed by trimethoprim-sulfamethoxazole 56% (14/25) and tetracycline 56% (14/25) from animal source and the least resistance were observed in chloramphenicol and amikacin 5 [20] each. The two (100%) isolates from humans were resistant to ampicillin and amoxicillin-clavulanate and however, two isolates were 100% susceptible to ciprofloxacin and cephalothin (Table 4).

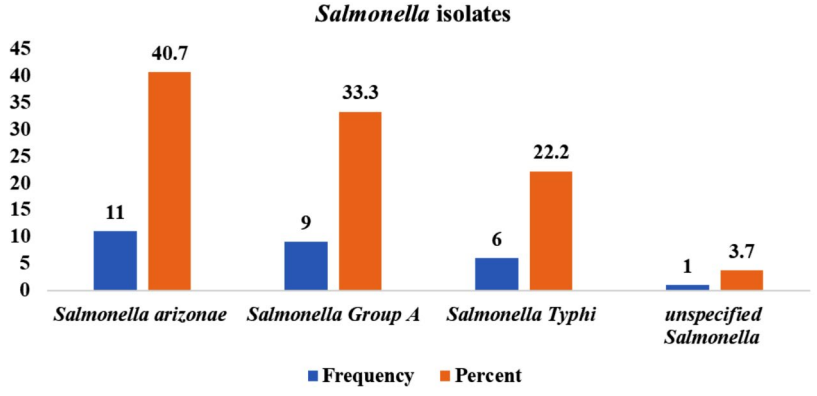

Fig. 1 Prevalence of *Salmonella* species from cattle, beef and abattoir personnel in Dessie municipality abattoir, northeast Ethiopia, 2019

Table 4 Antimicrobial susceptibility profile of *Salmonella* isolates from cattle carcass and personnel stool in Dessie municipality abattoir, northeast Ethiopia, 2019

Antimicrobial Agents	Antimicrobial Susceptibility profile (bacterial tested = 27)			
		Carcass isolates n (%)	Human isolates n (%)	Total n (%)
Ampicillin	Resistant	25 (100)	2 (100)	27 (100.0)
	Intermediate	0 (0)	0 (0)	0 (0.0)
	Susceptible	0 (0)	0 (0)	0 (0.0)
Amoxicillin-clavulanate	Resistant	13 (52)	2 (100)	15 (55.6)
	Intermediate	2 (8)	0 (0)	2 (7.4)
	Susceptible	10 (40)	0 (0)	10 (37)
Ciprofloxacin	Resistant	0 (0)	0 (0)	0 (0.0)
	Intermediate	1(4)	0 (0)	1 (3.7)
	Susceptible	24 (96)	2 (100)	26 (96.3)
Tetracycline	Resistant	14 (56)	2 (100)	16 (59.3)
	Intermediate	0 (0)		0 (0.0)
	Susceptible	11 (44)	0 (0)	11(40.7)
TMP-SMX	Resistant	14 (56)	2 (100)	16 (59.3)
	Intermediate	5 (20)	0 (0)	5 (18.5)
	Susceptible	6 (24)	0 (0)	6 (22.2)
Chloramphenicol	Resistant	5 (20)	2 (100)	7 (26.0)
	Intermediate	0 (0)	0 (0)	0 (0)
	Susceptible	20 (80)	0 (0)	20 (74.0)
Streptomycin	Resistant	10 (40)	1 (50)	11(40.7)
	Intermediate	2 (8)	0 (0)	2 (7.4)
	Susceptible	13 (52)	1 (50)	14 (51.9)
Amikacin	Resistant	5 (20)	1 (50)	6 (22.2)
	Intermediate	2 (8)	0 (0)	2 (7.4)
	Susceptible	18 (72)	1 (50)	19 (37.4)
Cephalothin	Resistant	13 (52)	2 (100)	15 (55.6)
	Intermediate	3 (12)	0 (0)	3 (11.1)
	Susceptible	9 (36)	0 (0)	9 (33.3)

Multidrug resistance pattern

From the total isolates tested antibiotics classes, 27(100%) were resistant to all antibiotics. About 23 (85.2%) were resistant to two or more antibiotics classes. Multidrug resistance was detected in 22 (81.5%) of the total isolates. Multidrug resistance was detected in 20 (80%) of isolates from carcass (Table 5).

Table 5 Multidrug resistance pattern of *Salmonella* isolates from cattle carcass and personnel stool in Dessie municipality abattoir, northeast Ethiopia, 2019

Antibiotics resistance pattern	Antimicrobial agents	Isolates in carcass sample *n* (%)	Isolates in human stool sample *n* (%)
Ro	0 (0)	0 (0)	0 (0)
R1	AMP	4 (16)	0 (0)
R2	TET, AMP	1 (4)	0 (0)
R3	AUG, TET, K AUG, S, AMK S, AMK, AUG CE, AMK, AUG	11 (44)	0 (0)
R4	AMP, CE, AMK, CHL AMP, CE, AMK, S AMP, CE, AMK, TET AMP, TET, AMK, AUG	4 (16)	0 (0)
R5	CHL, AUG, TET, TMP- SMX, AMP CHL, AUG, TET, TMP- SMX, S CHL, AUG, K, TMP- SMX, AMP CHL, CE, TET, TMP- SMX, AMP CHL, K, TET, TMP- SMX, AMP	5 (25)	2 (100)
MDR		20 (80)	2 (100)
Total		25 (100)	2 (100)

Keys: (AK) Amikacin, (AMP) Ampicillin, (AUG) Amoxicillin-clavulanate, (CHL) Chloramphenicol, (CF) Cephalothin, Gentamicin (GM), (K) Kanamycin, (S) Streptomycin (TET) Tetracycline, (TMP-SMX) Trimethoprim-sulfamethoxazole, Ro (no antibiotic classes resistance isolate), R1-R5 (number of antibiotic classes resisted by isolates from 1 up to 5 respectively

Discussion

Abattoir contamination of cattle carcass imposes a huge impact on the occurrence of salmonellosis as well as the spread of resistant strains in the community. The overall prevalence of *Salmonella* from beef in this study was 8% (25/312) (95% CI: 4.8–11.2) which lies between the low prevalence rate of 0.25% (1/400) and the high rate of 75% (45/60) in different areas of the world [31, 32]. This finding revealed that there was a considerable rate of contamination of beef in the Dessie municipality abattoir, which potentially poses a risk of causing food-associated illness.

This prevalence rate was comparable to a study done in Wolayta Sodo 8% (8/100) [15], Addis Ababa 5.7% (4/70) [16], Mekelle 7.29% (7/96) [33] and Bahir Dar 7.6% (23/46) [18] and Nigeria 11% (11/100) [17]. This similarity could be due to the use of nearly similar technologies for slaughtering and beef processing, safety materials used by abattoir personnel, abattoir utensils used, and cleaning methods and agents used for cleaning [34]. However, our finding was lower than studies done in Jimma at 11.3% (22/195) [35], Gondar 35.6% (32/90) [28], Ghana at 75% (45/60) [32], South Africa at 30% (30/100) [36] and Egypt at 20% (5/25) [37] and higher than studies done in Hawassa 2.4% (6/250) [13], Addis Ababa 2.5%

(4/1590) [38] the United States 4.2% (172/4,136) [39], Ireland 0.25% (1/400) [31], Germany 0.7% (29/4,170) [40] and South Korea 2.04% (1/49) [41]. This difference might be related to sampling, stress during transportation to the slaughterhouse, hygienic conditions of holding pens, carcass processing practices, abattoir facilities, employee hygiene, the sanitary condition of the abattoir, post-slaughter operations such as transportation, handling, and processing by the distributors and retailers and the laboratory methods [42].

Our study showed that the prevalence of *Salmonella* among abattoir personnel at the Dessie municipality was 8.3% (2/24). The current result found from abattoir personnel was in line with a study done in Addis Ababa 6.0% (18/300) [43]. However, it was higher than studies conducted in Jimma 0.9% [44], and Addis Ababa 3.4% (8/233) [45]. This prevalence indicates considerable proportion of the study participants were carriers of *Salmonella* with an increased probability of the transfer of infection to others through contamination of the cattle carcass. The current findings from personnel were lower than a study conducted in Jimma 18% (9/50) [35]. The possible factors that contribute to this variation might be due to the difference in environmental and personal sanitation, socioeconomic and living standards, availability of water supply, and awareness of safe food and meat handling and preparation among individuals.

In the current study, the predominant *Salmonella* species were *Salmonella arizonae* followed by *Salmonella Group* A (*Salmonella enterica serotype Typhi*). The distribution of *Salmonella* species among cattle had a difference over time, geographic regions, age groups, clinical manifestation, and production systems [46]. The majority of salmonellosis cases are caused by eating *Salmonella enterica*-infected food, which commonly infects cattle and poultry, but other animals such as domestic cats and hamsters have also been shown to be sources of infection for humans [18]. Also, animal infections by *Salmonella* can be caused by contact and ingestion of various reptile products and bird feces [47, 48]. In this study, the isolations of *Salmonella typhi* and *Salmonella group A* showed that the contamination from human origin was a result of poor personal hygiene during the handling and processing of the carcass. While, *Salmonella arizonae* contamination of cattle carcasses might be due to contamination from the slaughtering floor by bird feces, as well as from cattle contact with reptiles or ingestion of various reptile products, like snakes, and ingestion of bird feces with their feeds [49].

Antibiotic resistance in *Salmonella* isolates increases in both developing and developed countries. Antibiotic resistance is seen in both the veterinary and public health sectors [16, 50]. In this study, isolates from carcass samples showed relatively high resistance to antimicrobial agents such as ampicillin, amoxicillin-clavulanate, tetracycline, and TMP-SMX. All (100%) of the isolates tested were resistant to ampicillin. This high resistance of isolates for ampicillin is in line with studies conducted in Egypt 93% [51] and Jimma 100% [52]. The high rate of resistance for ampicillin in the study area might be due to its use as a broad-spectrum antimicrobial agent, its low expense, its oral administration, its frequent availability, poor drug regulation practices, the increasing rate of unprescribed utilization of antibiotics, and other factors that favor selection pressure, which increases the advantage of maintaining resistant genes in the bacteria. However, our finding contradicts a study done in Gondar [53] and South Korea [41] and in which isolates were susceptible to ampicillin. This difference might be due to restricted use of the antibiotic and technical differences.

In contrast to developed resistance, in the current study, 96.3% (26 of 27) of ciprofloxacin and 74% (20 of 27) of chloramphenicol have good antimicrobial activity against *Salmonella isolates* from both humans and cattle. ciprofloxacin and chloramphenicol have comparable antimicrobial activity with previous reports from animal and human isolates in Jimma [35]. Studies done in Wolayta Sodo 100% [15], Jimma 100% [52], United States 100% [39], and Ghana 100% [32] showed the resistance level of ciprofloxacin. This may be because the drug is not frequently prescribed by physicians. However, a study in Egypt found that only 63% of isolates were susceptible to ciprofloxacin [51]. This disparity could be attributed to the availability of drugs without a prescription, poor drug regulation practices, and the presence of drug-resistant bacteria in animals.

The emergence of multiple drug-resistant *Salmonella* to commonly used antimicrobials has become a threat in both public health and veterinary sectors [14, 23]. In our study, Multidrug resistance was detected in 81.5% (22/27) of the total isolates. Multidrug resistance was detected in 80% (20/25) of isolates from carcasses and 100% (2/2) from personnel. The occurrence of MDR in this study was consistent with a report from Addis Ababa 83% [54] and Latvia (100%) [55] and However, it was higher than studies conducted in Asella 50% [56], South Africa 25.32% [36], and Jimma 40.3% [35] and in Mexico 28.8% [57],. The high MDR observed in this study might be due to the administration of multiple antimicrobials for infections, indiscriminate use of antimicrobials, and extensive use of a drug in farm animals [58].

Different studies show that various hygiene practices of the slaughter personnel and the sanitary conditions of the abattoir have been described to be associated with increased isolation of *Salmonella* from cattle carcasses [18, 59]. In our study, habit of not washing knives before slaughtering was associated with contamination of carcasses by *Salmonella* isolates. This finding was consistent

with studies performed in Bahirdar [18], Sudan [59] and Modjo [60]. This can be explained by the fact that the unwashed knife used for slaughtering will be contaminated with *Salmonella* from the meat rumen and intestinal fluids as well as by the hands of carcass processors. However, this result differed from that of a Canadian study, which found no statistical difference between using a washed knife and the rate of *Salmonella* isolates from carcasses [61]. This variation might be due to the difference in slaughter personnel hygiene, slaughtering process, and use of different knives for different cattle and different processing steps.

In the same vein, there was an increased rate of *Salmonella* isolation in the carcass that was not washed during slaughtering. This was also in agreement with reports in Bahirdar [18] and Pakistan [19]. This might be feces as well as soil, adhere to an animal's external surface and carry *Salmonella* into a slaughterhouse, which can serve as a source of contamination that potentially transfers to carcass surfaces during the decoding process. In addition to, fluids from eviscerated organs and intestinal content will contaminate the carcass with *Salmonella* during processing. So, carcass washing plays a great role in reducing the prevalence of *Salmonella* at the slaughterhouse [62].

We also found that the rate of *Salmonella* isolation was high in slaughter personnel who process the carcass without washing their hands after separating intestinal content. This result is in line with studies conducted in the Debre Zeit, Ethiopia [63], and Bahirdar [18], Sudan [59] and United Kingdom [64]. However, the United Kingdom reported that hand washing had no significant effect on the contamination of carcasses [65]. This variation might be from a difference in the use of safety materials, and environmental and utilities sanitary conditions. In the previous study done in Bahirdar [18] and Pakistan [19] and cattle slaughtered on the unsanitized floor were a risk for carcass contamination by *Salmonella*. However, in this study, it was not associated with carcass contamination of *Salmonella*. This variation might be due to the difference in the sanitary process of the floor, the use of detergent, the cleanness of the cleaning materials, and the smoothness of the floor [66].

Limitations of the study

Due to the unavailable of primers, the isolated *Salmonella species* were not molecularly characterized. Other limitations of this study were non-inclusions of the environmental sample.

Conclusions

The present study revealed that the rate of *Salmonella* isolate contamination was high in cattle carcass and that there was a considerable carriage rate of *Salmonella* isolates among personnel working at the Dessie municipality abattoir. High antimicrobial resistance was observed to ampicillin followed by trimethoprim-sulfamethoxazole and tetracycline. Multi-drug resistance in *Salmonella* isolates was detected for most antimicrobial drugs tested. Factors such as the use of un-sanitized abattoir utilities, unhygienic carcass processing, and poor personnel hygiene practices significantly increased carcass detection of *Salmonella* isolates. Local antibiotic policy and prescription practice should be required to decrease significant resistance for commonly used antibiotics. This highlights the need to treat potential Salmonella carriers and implement preventive measures. Improving hygiene is crucial to reduce cross-contamination from utensils, the working environment, and abattoir workers involved in slaughtering. Additionally, abattoir workers should undergo regular health checks to ensure ongoing safety.

Abbreviations

BPW	Buffered peptone water
CDC	Center for Disease Control
CI	Confidence interval
CLSI	Clinical and Laboratory Standard Institute
ISO	International Organization for Standardization
MDR	Multiple drug resistance
NTS	Non-typhoidal Salmonella
SCL	Selenite Cystine broth
SIM	Sulfide indole motility
SOP	Standard operating procedure
SPSS	Statistical package for social sciences
WHO	World Health Organization
XLD	Xylose lysine deoxycholate

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Author contributions

Alemayehu Tadesse, Bekele Sharew, Mihret Tilahun, and Yihenew Million were involved in proposal writing and designing the study; and participated in the analysis and interpretation of data. Alemayehu Tadesse, Bekele Sharew, and Mihret Tilahun were involved in the data collection and drafting of the manuscript. All authors finalized the write-up of the manuscript. Alemayehu Tadesse, Mihret Tilahun, and Yihenew Million authors critically revised the manuscript and read and approved the final manuscript for publication.

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Data availability

Data auxiliary to the conclusions of this article are within the manuscript.

Declarations

Ethics approval and consent to participate

Ethical clearance and permissions were obtained from the ethical review committee University of Gondar, College of Medicine and Health Sciences, School of Biomedical and Laboratory Sciences with protocol number SMBLS 2122/2011, and before data collection, support letters were obtained from Dessie Town administration health office and Dessie abattoir administration. After clarifying the objectives of the study, abattoir personnel provided verbal and written informed consent. For animals, informed consent was obtained from the owners. All data and samples obtained are kept confidential by using

codes instead of personal identifiers. Participants in the study who tested positive for *Salmonella* in their stool were advised to go to health institutes and consult clinicians, and they received the necessary medical treatment at the expense of the Dessie Town municipality administration.

Competing interests
The authors declare no competing interests.

Consent for publication
Non-applicable.

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