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Prevalence and antibiotic susceptibility of salmonella at the human-chicken interface in Wau, South Sudan

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Abstract: A Cross sectional study was carried out in Wau municipality Western Bahr El- Ghazal State, South Sudan, to assess the magnitude of S*almonella* contamination in indigenous chicken and chicken keepers. The fecal samples were randomly collected from 145 chicken keepers and 198 chicken cloacal swabs from randomly selected household levels. The samples were transported on ice packs, to Microbiology Diagnostic Laboratory, College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University-Uganda for analysis. The samples were cultured on XLD agar for isolation of *salmonella* which was confirmed on a series of biochemical tests. Using SPSS-18 software, sample check list and laboratory results were analyzed using descriptive statistics to obtain frequencies and prevalence. Of the 198 chicken samples analyzed, 67.2% were from hens and 32.8% from cocks. Only 14 (9.7%) and 12(6.1%) samples were positive for *Salmonella* from chicken keepers and chicken samples, respectively. The antimicrobial susceptibility test was done using the Stander Kerby Bauer disc diffusion assay in which isolates were categorized as sensitive, moderately resistant or resistant based on standardized zones of inhibition. All the isolates from chicken keepers and chicken samples were sensitive to Chloramphenicol (30µg) but resistant to Colistin (10µg). Chicken keepers isolates 28.6% (n=14) were resistant to Nalidixic acid (30µg), Ampicillin (10µg) 14.3% and Tetracycline (30µg) while 33.3% and 25% (n=12) of chicken isolates were resistant to Tetracycline (30µg) and Nalidixic acid (30µg). The prevalence of *Salmonella* was heightened among chicken keepers who had primary level of education and those aged 19-35 years while keeping chicken, housing them with dogs and cats, addition of tetracycline feed additives in addition to chicken age group of 6 months and above increased their risk of salmonellosis infection. This study showed that there is a need to separate chicken housing from human Habitation, beside health education of chicken keepers about salmonellosis as a public health problem.
Keywords: Prevalence, *salmonella*, chicken, chicken keepers, Wau municipality, anti-microbial

INTRODUCTION

Background

Worldwide, *salmonella* are known to be among the most important food-borne pathogens of public health significance [1]. Chicken and chicken products are the frequent vehicles of these bacterial species to humans .The genus *salmonella* are a member of enterobacteriaceae family, they are gram-negative facultative and aerobic. There are many different *Salmonella* serotypes. Serotypes S. *typhimurium* and *S* enteritidis are the most common serotype reported in the world, the host range of this bacteria are wide and include human, chicken, swine and cattle [2]. In the Sudan, *Salmonella* gallinarum was isolated from chickens for the first time in 1943[3] .The same species was also isolated from chicken in Malakal which is a part of South Sudan now [4].

The worldwide overuse or misuse of antimicrobials in different fields, such as human medicine, veterinary medicine and agriculture, and as prophylactic supplements or growth-promoting agents in the feed has contributed to antimicrobial resistance [5]. A study in Sudan recovered 119 Salmonella isolates from stool of humans, cattle, camels and chicken feces. When tested most of them were susceptible to Ciprofloxacin, Gentamicin and colistin, while they showed high resistance to Ampicillin, Chloramphenicol, Tetracycline, Furazolidone and Sulfamethoxazole + Trimethoprim [6].

MATERIALS AND METHODS

Samples

Eight Bomas of Wau municipality were randomly selected for the study; including Sikka Hadid, Zugolona, Hai Dinka and Hai Fahal from Wau North Payam, and Jebel Kheir, Hai Kousi, Nazreath and Lokoloko from Wau South Payam. The households with chicken in these selected areas were registered (850 households keep chicken) prior to randomized selection using sampling ratio of 12.5% for each selected area to ensure representation. A total 385 households with more than 5 chickens, 107 were randomly selected using (simple random sampling technique) and visited in the present study. Fecal samples were collected from chicken and their respective keepers in the same selected household respectively. Chicken were selected randomly by age group (chicks, pullet, growers, adults) and gender balance (Cocks –Hen), while the chicken keepers were also selected depending on their contact with chicken, their age group (5 years and above) and gender balance (Male-Female).

Fecal samples collection

A total of 343 samples (145 human stool and 198 chicken cloaca swabs) were collected. The chicken fecal materials were collected from the indigenous chicken and detailed information on the date of collection, age, sex, breed of the chicken were recorded prior to sample collection. Using sterile cotton swabs and clean sterile (Universal) BS4851 bottle 10 ml (NULGENE- England), fecal material was collected from the cloaca of randomly selected indigenous chicken in the randomly selected chicken rearing households. The swab samples were placed into BS4851 bottle that contained 9 ml Stuart's transport media (OXOID-UK) in order to stabilize any microorganisms present in the sample. The sample bottle was labeled using marker. The bottle with the collected sample were placed into a cool box that contained ice packs and then taken for stored in a refrigerator at 2- 4ºC for 72hr. The samples were then immediately dispatched by air to Uganda, followed by transportation to the Microbiology Laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University where laboratory analysis was done.

Individual consent was sought prior to stool collection through Community gate keepers such as Chiefs, Opinion leaders and elders, and also from the study participants. Detailed information on the participant's name, sex, age, occupation, education and the date of sample collection were recorded. Participant information was kept confidential and was replaced by codes on the sample containers. To avoid contamination of the transport media, clean sterile (Universal) BS4851 bottle (NULGENE- England) 50 ml without transport media were given to participant's household level to collect samples and collected the same day? These were immediately put on ice in a cool box, after which a technical nurse aseptically transferred them into clean sterile containers with transport media. By using the sterile spoon - spatula that comes within the sample collection bottle, the sample was picked into a clean sterile universal bottle that contained 45ml of Stuart's transport media (OXOID-UK). The samples were then placed into a cool box that contained ice packs before storage in a refrigerator at 2- 4Cº for not more than 72hr. The samples were then dispatched by air to Uganda within in 96hr after collection. They were then transported to Microbiology Laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University in 120hr where diagnostic analysis was done.

Samples shipping

All necessary documentations including import/export permits were sought for prior to sample shipment. General packaging for shipment of biological samples was followed. The samples were packed into sterile sample bags (ZIP LOCK) having their respective of their collection dates. These were packed in felon box and surrounded by ice packs. The felon box (POLAR TECH) was then properly sealed and placed into another soled box (CARD BOX) for more protection of the samples. The samples were transported by air from Wau to Juba, the Capital city of South Sudan within 96hr of collection, then from Juba to Entebbe-Uganda and then to Microbiology Laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University, Kampala- Uganda by day 5, after 120hr from collection where the analysis was done.

Bacteriological culture

The chicken samples (swabs) were pre-enriched in general-purpose liquid medium of 10 ml buffered peptone water (CONDA-Spain) at 37^{o}C for 24 hours. Aliquots of 1 ml from pre-enriched of chicken samples and one gram of chicken keepers stool were inoculated into 9 ml of selective enrichment liquid media, Rappaport-Vassiliadis broth (OXOID-UK) and then incubated for 18hr at 42^{o}C. A loopful of each broth was streaked on two petridishes of Xylose Dextrose Agar XLD (MAST GROUP LIMITED-UK) which were incubated at 37 ºC for 18hours. The suspected colonies of *salmonella* from each plate were collected for presumptive identification with biochemical tests.

Biochemical tests to identify *salmonella*

The tests employed included; Oxidase (–), Urease (–), H2S (black gas), Citrate (+/ –), Triple Sugar Iron Slant Agar TSI (CONDA-Spain) yellow butt with red slant. Slants for the above media were constituted in tubes, inoculated with suspect colonies and then incubated at 37 ºC for 24 hours. A single pure colony with biochemical profile of *salmonella* was then subjected to serological tests by the use of polyvalent serum against O and H *salmonella* antigens. Only colonies that agglutinated within one to two minutes were considered positive for *salmonella*. These were

then preserved in 0.25ml of 25% glycerol contained in 0.75ml of Brain Heart infusion broth at -40ºC, then kept for years for further analysis.

Antimicrobial susceptibility test

The standard Kerby-Bauer disc diffusion method as described by [7] was employed for the assessment of antimicrobial susceptibility of the *Salmonella* isolates. Antimicrobials that were tested included; Ampicillin (10µg), Chloramphenicol (30µg), Ciprofloxacin (5µg), Colistin (10µg), Gentamicin (10µg), Nalidixic Acid (30µg), Sulfamethoxazole + Trimethoprim (75µg) and Tetracycline (30µg). The eight antimicrobials were chosen according to previous studies [6] and also the fact that they are the commonly used antimicrobials in South Sudan. Pure colonies of the *Salmonella* organism were suspended in sterile normal saline to a turbidity equivalent to that of a 0.5 McFarland turbidity standard. This turbidity standard is equivalent to approximately 1.05 x 10^8 CFU/ml. A loopful of the organism suspension was then spread onto the surface of Mueller Hinton Agar (MHA). The antibiotic discs (CONDA-Spain) were then aseptically placed at equidistant points on the inoculated MHA surface. The plates were then incubated for 18hr at 37 ^{0}C. The inhibition zone diameters were measured and recorded in millimeter. These diameters were then compared to those Adapted from the antimicrobial usage chart from National Committee for Clinical Laboratory Standards (NCCLS) approved standard [8].

Data Analysis

The raw data comprising the sample check list and laboratory results was entered into SPSS-18 Statistical package for analysis. Descriptive statistics were computed to obtain frequencies and prevalence of salmonella infection both in indigenous chicken and chicken keepers. The results were presented in tables and prevalence expressed as percentages.

RESULTS

Demographic characteristics of chicken

Of 198 chicken sampled, (28.3%) were aged between >1-59 days, 60-119 days (69.7%) and few number aged greater than 120 days (2%). There were more hens (67.2%) compared to cocks (32.8%) of which their feeds were supplemented mostly with Tetracycline (25.3%) followed by salt (11%) and least with multivitamins (2%). However, 61.1% were not fed on feed additives. The largest numbers of chicken were kept together with cats and dogs (32.8%). An overall prevalence of 6.1% salmonella infection in chicken was obtained as shown in table 1 below.

Table 1: Summary statistics of chicken in Wau, South Sudan

Variables	Percentage %	Frequency
Sex		
Hen	67.2	133
Cocks	32.8	65
Age		
>1-59day	28.3	56
60-119day	69.7	138
>120day	2.0	4
Feed Additives		
None	61.1	121
Salt	11.0	23
Tetracycline	25.3	50
Multivitamin	2.0	4
Other Animal		
None	48.0	95
Other Bird	8.6	17
Dog and Cat	32.8	65
Sheep, goat and Donkey	10.6	21

Demographic characteristic of chicken keepers

A total of 145 chicken keepers participated in the study, with more females (53.1%) compared to males (46.9%). The largest number of chicken keepers were aged < 18 years (52.4%), followed by 19-35 years (29.7%), 36-54 years (13.1%) and mention the exact percentage that were aged >55 years. The participants were in close contact with chicken mostly through feeding (87.6%), followed by cleaning chicken shelter (11.7%) and least via cooking (0.7%). There were more chicken keepers with formal education at primary level (41.4%) and secondary level (30.3%) compared to those with none (illiterate) (11%). There were more participants who engaged in this activity of keeping chicken for as long as >18 months (49.7%) followed by 7-12 months (39.3%) compared to those in the same activity for 13-18 months (3.4%). 78.6% of the chicken keepers had a flock size of less than 20 chickens while the least number of them, 1.4% kept about 41- 60 chickens. An overall prevalence of 9.7% salmonellosis in chicken keepers was obtained as shown in table 2 below.

Table 2: shows the summary statistics of chicken keepers in Wau, South Sudan

Variables	Percentage %	Frequency
Sex		
Female	53.1	77
Male	46.9	68
Formal Education		
None	11.0	16
Primary	41.4	60
Secondary	30.3	44
University	17.2	25
Contact with chicken		
Feeding	87.6	127
Cleaning	11.7	17
Cooking	.7	1
Duration of exposure		
<6 Months	7.6	11
7-12 Months	39.3	57
13-18 Months	3.4	5
>18 Months	49.7	72
Flock size		
<20	78.6	114
21-40	17.9	26
41-60	1.4	2
>61	2.1	3
Age group		
<18	52.4	76
19-35	29.7	43
36-54	13.1	19
>55	4.8	7

Prevalence of *Salmonella* at the human-chicken interface in Wau, South Sudan

The chicken keepers, stool and chicken swabs samples were collected from eight selected areas of Wau municipality, Western Bahr el Ghazal state, South Sudan that included; Kousti, Nazreath, Hai Fahal, Hai Dinka, Zugolona, Sikka Hadid, Lokoloko and Jebel Kheir). The overall prevalence of *salmonella* in chicken keepers was 14 (9.7%) out of 145 participants (table 3). The overall prevalence of 12 (126.1%) of *salmonella* was obtained out of 198 chicken sampled (Table: 3). Both Jebel Kheir and Lokoloko had higher infections of 4(9.1%) and 4 (8.0%) respectively while chicken from Nazreath, Haifa hall, Hai Dinka and Sikka Hadid were free of the infection as shown in table 3 below.

Table 3: **Shows the Prevalence of *Salmonella* at the human chicken interface in Wau, South Sudan**

Sub County	Proportion of Salmonellosis Human	Total	Proportion of Salmonellosis Chickens	Total
Kousti	*6 (21.4%)*	28	2 (4.44%)	45
Nazreath	2 (22.2%	9	0 (0.0%)	12
Lokoloko	2 (4.44%)	45	4 (8.0%)	50
Hai Denka	2 (33.3%)	6	0 (0.0%)	10
Sikka Hadid	1 (11.11%)	9	0 (0.0%)	17
Jebel Kheir	1 (2.70%)	37	4 (9.0%)	44
Hai Fahal	0 (0.0%)	2	0 (0.0%)	4
Zugolona	0 (0.0%)	9	2 (12.5%)	16
Total	**14(9.7%)**	**145**	**12(6.1%)**	**198**

Antimicrobial susceptibility pattern of *salmonella* isolates at human chicken interface

A total of 14 *salmonella* isolates from chicken keepers stool samples were screened for antimicrobial susceptibility of which all were highly susceptible to Sulfamethoxazole + Trimethoprim, Chloramphenicol, Ciprofloxacin, and Gentamicin (100%) table 4. However, 10 (71.4%) isolates showed resistance to Colistin, 4(28.6) to Nalidixic Acid, and Ampicillin 2(14.3%) whereas were resistant to Tetracycline

2(14.3%) table4. All the 12 (100%) isolates were susceptible to Chloramphenicol, followed by Ciprofloxacin and Ampicillin (91.7%) each. The isolates were resistance to mostly Colistin 10(83.4%), Tetracycline (33.3%) and Nalidixic Acid (25.0%) as shown in table 4 below.

Table 4: Antimicrobial susceptibility pattern of *Salmonella* isolates from chicken and chicken keepers feaces

Drug name	**Resistance**		**Susceptibility**	
	Human Isolates	Chicken Isolates	Human isolates	Chicken Isolates
Sulfamethoxazole+ Trimethoprim	0 (0.0%)	2 (16.6%)	14 (100%)	10 (83.3%)
Tetracycline	2 (14.3%)	4 (33.3%)	12 (85.7%)	8 (66.7%)
Chloramphenicol	0 (0.0%)	0 (0.0%)	14 (100%)	12 (100%)
Ciprofloxacin	0 (0.0%)	1 (8.3%)	14 (100%)	11 (91.7%)
Nalidixic Acid	4 (28.6)	3 (25.0%)	10 (71.4%)	9 (75.0%)
Colistin	10 (71.4%)	10 (83.4%)	4 (28.6%)	2 (16.7%)
Ampicillin	2 (14.3%)	1 (8.3%)	12 (85.7%)	11 (91.7%)
Gentamicin	0 (0.0%)	2 (16.7%)	14 (100%)	10 (83.3%)

DISCUSSIONS

The first investigation for the prevalence of *Salmonella* infection in chicken in South Sudan was in Malakal region "by [9]. However, that study did not involve investigation of salmonellosis in chicken keepers. The present study aimed at investigating the prevalence of *Salmonella* infection in chickens and chicken keepers in South Sudan, since the first related study carried out in this new country by [9]. In Malakal region in South Sudan, who investigated the prevalence of *Salmonella* in chicken? In the current study there were more hens (67.2%) compared to cocks (32.8%) included in the study of which majority were aged between 60-119 days (69.7%) compared to those aged above 120 days (2.0%). The study had slightly more female chicken keepers (53.1%) than the male chicken keepers (46.9%) . However, depending on the observed. However, depending on obtained prevalence in chicken keepers *Salmonella* infection has been mainly attributed to lack of education (11.5%) since they lacked information about *salmonella* epidemiology, those aged between 19 and 35 years (14.0%) who were more engaged in chicken keeping and the females (10.4%). The use of tetracycline as a feed additive increased the prevalence of *salmonella* in chickens (10.0%) because this develops resistance to the same drug used in treatment, thus increased chances of re-infection. Keeping of other animals at home such as dogs and cats contributed 4.6% prevalence in chicken and chicken aged greater than 6 months (6.3%) as these are left to free range where they get exposed to salmonella.

The overall prevalence of *salmonella* in this study was (9.7%) and (6.1%) for chicken keepers and chicken respectively. which was much lower than that reported by [10] who recorded 70.1% chicken handlers and 18.1% chicken part reported by prevalence among chicken handlers and 18.1% in chicken [10] in a similar study. This difference in the prevalence reported in the latter study could be attributed to a higher sample size used that is sample size (996) and (sample) type used in analysis. However, higher prevalence rates have been reported by [11] in developing countries such as Thailand (72%), Ethiopia (68.2%), but lower in Argentina (51.2%) and Korea (25.9%). This study has justified the high prevalence of *salmonella* in South Sudan, despite the slight deviation with other related studies done in the other country which could probably be alleviated (attributed) from differences in sampling methods and detection techniques.

The current study obtained a prevalence of 14 (9.7%) chicken keepers Salmonella infection out of 145 stool samples and 12 (6.1%) chicken Salmonella infection in 198 chickens sampled. The prevalence of *salmonella* was higher in chicken keepers than chickens which was in agreement with studies conducted by [10] in Khartoum, Sudan. This might probably be due to the sample volume used in analysis of chicken keepers' stool which increased the recovery rate for *salmonella* compared to the chicken swabs which presented a very small sample volume. Furthermore, chicken keepers had many risk factors of acquiring *salmonella* such as contaminated food and water, unboiled milk, undercooked chickens and eggs than chickens which only acquired *salmonella* from other infected birds and contaminated feeding troughs.

In the current study, chicken keepers Salmonella infection prevalence was much lower than that reported by [10] who obtained 19 (70.4%) out of 27 sampled chicken handlers (fecal sample) in selected restaurants in Khartoum. This could be attributed to the fact that the chicken handlers were in direct contact with chicken and related products during slaughtering and preparing meals of the chicken thus increasing risk of exposure to the *Salmonella* infections.

The prevalence of *Salmonella* infection in chicken in the current study was higher than that reported by [3] and [9] in Sudan as 3.4% and 1.1% respectively. These studies were conducted more than 20 years back of which by then the isolation techniques couldn't be feasible enough to detect all the *Salmonella*,

using of additional sample sources of different chicken body parts. Consequently, this makes their studies not suitable for comparisons with the current prevalence. However, [10] obtained a prevalence of 18.1% that was greatly higher than that in the present study. In addition, higher *Salmonella* prevalence (19.2%) were reported in chicken carcasses in South Africa [12]. Moreover, other studies in Spain reported higher prevalence of chicken salmonellosis greater than 60% [13-15] and [1] who reported a prevalence of 35.83% in the same country. In addition, [16, 17] reported a prevalence range of 25-29% in UK which was also greatly higher than for the present study. The variation may have resulted partly from type of chicken (commercial), and in addition sampling sources of different chicken body part such as skin and muscle.

In the present study, the antimicrobial susceptibility profiles of both chicken keepers and chicken *salmonella* isolates (table 4) were investigated for with patterns that varied from susceptible, moderately resistant and resistant to antimicrobials. 10 (71.4%) of chicken keepers *Salmonella* isolates were resistant (table 4) to at least one or more antimicrobials. However, this was contrary to the results reported by [6] in a similar study conducted in Sudan where 81 (93.1%) isolates exhibited the same resistant pattern. However, in the present study 2 (14.3%),10 (71.4%),4 (28.6%) of the chicken keepers *Salmonella* isolates were highly resistant to Ampicillin, Colistin and Nalidixic acid respectively while only two isolates 2(14.2%) was resistant to tetracycline. This resistance pattern was greatly lower than that reported by (Fadlalla *et al*., 2012). Where resistance patterns to Ampicillin 29 (33.33%), Colistin 8 (9.2%), and Nalidixic acid 28 (32.18%) and Tetracycline 52 (59.77%) were obtained. Furthermore, (de Oliveira *et al*., 2005). Reported higher resistance to tetracycline (11.8%) and Sulfamethoxazole + Trimethoprim (88.2%).

The same isolates were susceptible 14 (100%) to Sulfamethoxazole+Trimethoprim, Chloramphenicol, Ciprofloxacin, Gentamicin and least to Ampicillin and Tetracycline with 12 (85.7%) each. This was in agreement with the results of (Fadlalla *et al*., 2012) except for Colistin which exhibited moderate resistance to most isolate 8 (57.1%). However, (de Oliveira *et al*., 2005) reported 88.2% isolates being resistant to Sulphonamides in a study conducted in Brazil which was comparable to our findings. There were 4(28.57%) isolates that showed multidrug resistance to more than one antimicrobial which was contrary to the findings of [6] who reported 41 (47.1%).

The cross resistance obtained among the isolates could reflect a prevalence of two resistance genes carried on plasmids as reported by [18]. These could be transmitted via food chain from animals and their products to humans [19]. Moreover, the continued use of Ampicillin, Colistin and Nalidixic acid chemotherapy could have brought resistance. Despite the plastic anemia effects caused by use of Chloramphenicol, the same drug in combination with Ampicillin were drugs of choice in the treatment of human salmonellosis [5] thus, it has been proscribed in human and food producing animals since 1970s' [5](de Oliveira *et al*.,2005) in Brazil.

Our findings showed that 10 (83.3%) chicken isolates were resistant to at least one antimicrobial which was lower than 37.5% reported by [6] . In addition, 5(41.7%) isolates were resistant to two or more antimicrobials which were comparable with 45 (37.82%) reported by [6] in Sudan. Also according to [20] in Ethiopia, a lower prevalence of (32.7%) multidrug resistant isolates was obtained compared to the present study. Furthermore, [5] and [21] reported a higher prevalence of (51.6%) in Brazil and 100% in Spain respectively. However, a lower percentage (18.0%) was reported by [22, 23] in USA compared to the present study.

In the current study, *Salmonella* isolates from chicken were found to be more resistant to Colistin 10 (83.3%) which was contrary to the findings of [6] in Sudan who reported its active with only one isolate being resistant. This change in susceptibility pattern could probably be due to the continued current miss use of the drug in the same region that the bacteria have developed resistance to it. Four (33.3%) isolate showed resistance to Tetracycline which was in agreement to findings [6] and [21] who reported a higher prevalence of (46.9%) in Sudan and (21.8%) in Spain. However, [5] from Brazil obtained a smaller number of *Salmonella* isolates that were resistant to Tetracycline (15.4%). Results obtained in the current study showed that 50 (25.3%) clearly showed a correlation between usage of Tetracycline as feed additive and prevalence of chicken salmonellosis as probable cause of heightened resistance to the drug due to continued misuse. In addition, because Tetracycline is the most widely used drug in both Veterinary and Human medicine practices [24], this result was anticipated and agreed with findings from Thailand [25] and Vietnam [26].

In our study, 3 (25.0%) and 2 (16.67%) *Salmonella* isolates from chicken were highly resistant to Nalidixic acid and to a combination of Sulphonamide + Trimethoprim respectively. The level of resistances to Nalidixic acid were in accordance to those of [24] in North Vietnam who reported 27.8%, as well as 7.7% reported by [5] in Brazil; however higher resistances were reported by studies in Portugal; [27], Thailand, [25] China; [28]. Nevertheless, *Salmonella* resistance to this drug was absent in UK [29], USA [30], and at relatively low levels of resistance were reported by [21] in Spain and [31] in Japan.

The chicken *Salmonella* isolates were highly susceptible to Chloramphenicol (100%), Ciprofloxacin

(91.7%), Ampicillin (91.7) and Gentamicin (83.3%). These results were consistent with the findings of [6] despite the 59.4% (19) isolates that were resistant to Ampicillin. Similarly, our results were in agreement to those [5] in Brazil who reported 94.5%, 98.9%, 98.9% isolates as highly susceptible to Gentamicin, Ampicillin and Chloramphenicol respectively. However, others studies encountered resistance patterns; 39.8% and 37.3% for Ampicillin and Chloramphenicol [32] & [24].

The increased prevalence and resistance pattern of *salmonella* could be attributed to continued consumption of contaminated foods of which most of them occur at multiple steps along the food chain; including production, processing, distribution and handling as suggested by [33]. Predisposing foods may include; consumption of eggs, chicken meat and chicken related products [34, 35]. In addition, there is significant evidence that the use of antimicrobials for growth promotion in feeds, treatment of chicken and agricultural production increases the prevalence of resistance in human pathogens. However, there should be consideration of several factors when comparing our results to those of other authors, such as antimicrobial agents used, time frame, differences in sample source and methods used for the determination of antimicrobial susceptibility.

CONCLUSIONS

The study findings concluded that, high prevalence of *Salmonella* among chicken and chicken keepers in the same household in addition to antimicrobial resistance.

Recommendations

Sensitization of chicken keepers about potential dangers for salmonellosis to public health and proper chicken husbandry practices are recommending. Further studies should be done on chicken salmonellosis and their respective keepers. A molecular characterization study to determine *salmonella* serotype found in South Sudan. Ciprofloxacin, Gentamicin was the most susceptible and recommended antimicrobial to the *salmonella* isolate from chicken and chicken keepers.

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Availability of data

Data including laboratory analysis results are available when it requested

Ethical consideration

The study was in absolute compliance with Ethical standards. Ethical approvals were obtained from the Ethical Review Committee at the School of Biosecurity, Biotechnical and Laboratory Sciences (SBLS), Makerere University and from the line ministries in the Republic of South Sudan. Indigenous chicken keepers' consents were sought prior to samples collection.

Conflict of Interest

Authors declared that there is no conflict of interest during the study and at the preparation of this manuscript

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