



## Prevalence of Multidrug Resistant Gram-negative Bacteria in Tissues of Diseased Chicken in Chitwan District, Nepal

Saraswati Poudel <sup>a\*</sup>, Alina Thapa <sup>a</sup>, Sharmila Pokharel <sup>a</sup>, Ranju Dhakal <sup>a</sup>,  
Sadikshya Subedi <sup>a</sup>, Anil Shrestha <sup>a</sup>, Lakh Kumar Rai <sup>b</sup>  
and Anup Muni Bajracharya <sup>a</sup>

<sup>a</sup> Department of Microbiology, Balkumari College, Tribhuvan University, Chitwan, Nepal.

<sup>b</sup> National Avian Disease and Investigation Laboratory (NADIL), Bharatpur, Chitwan, Nepal.

### Authors' contributions

This work was carried out in collaboration among all authors. Authors SP, AMB and AS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AT, SS and LKR managed the analyses of the study. Authors SP and RD managed the literature searches. All authors read and approved the final manuscript.

### Article Information

DOI: 10.9734/SAJRM/2021/v11i430255

#### Editor(s):

(1) Dr. Ana Claudia Coelho, University of Tras-os-Montes and Alto Douro, Portugal.

#### Reviewers:

- (1) Sheikh Adil Hamid, India.  
(2) Mohamed Idris Alshelmani, University of Benghazi, Libya.  
(3) Juliana Steffens, Brazil.

Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here:  
<https://www.sdiarticle5.com/review-history/72679>

Original Research Article

Received 25 July 2021  
Accepted 01 September 2021  
Published 27 December 2021

### ABSTRACT

For increasing productivity in poultry, antibiotics are overused. This increased use in antibiotics has raised the prevalence of Multidrug resistant (MDR) bacteria in poultry. Treatment of chicken infected with MDR bacteria is difficult to achieve, thereby increasing treatment cost and productivity cost. MDR bacteria of poultry can also infect humans if they are not handled properly. Thus, the purpose of this study was to find bacteria responsible for infecting chicken and prevalence of MDR bacteria in diseased chicken. Out of total 516 diseased chicken, 212(41.09%) chicken were infected by bacteria. The prevalence of *E. coli* (63.2%) was high in diseased chicken followed by *Salmonella* spp. (12.26%), *Pseudomonas* spp. (5.2%) and, *Pasteurella* spp. (4.7%). Out of total number of isolates, the prevalence of MDR was 42.5%. This study also showed that *Pasteurella* spp. isolates had high MDR with prevalence of 50%. It is thus concluded that there was high prevalence of MDR bacteria among diseased chicken in Chitwan district.

**Keywords:** Poultry; gram negative bacteria; Antibiotic Susceptibility Test; Multi-drug Resistant.

## ABBREVIATIONS

*SIM:* Sulfide, indole, motility

*MRVP:* Methyl-red, Voges Proskauer

*MDR:* Multi-drug-resistant

## 1. INTRODUCTION

Antibiotic resistance is a result of antibiotic use [1]. The greater the volume of antibiotics used, the greater would be the chances of arising antibiotic resistance population of bacteria [1]. There is growing scientific evidence that the use of antibiotics in chicken feeds leads to the development of resistant pathogenic bacteria that can reach humans through the food chain [2]. Recent reports have shown that different types of food and environmental sources harbor bacteria that are resistant to one or more of antimicrobial drugs used in human or veterinary medicine and food-producing animals [3,4]. Multidrug resistant (MDR) bacteria is defined as a bacteria that is resistant to different classes of antibiotics (three or more than three classes of antibiotics) which are structurally different and have different molecular targets [5]. The spread of MDR bacteria outside the hospital environment has posed a serious problem over the last few years, and now poultry with rather extensive use of antibiotics has become a possible source for multi-resistant bacteria [6]. Consequently, one possible transmission route for MDR bacteria from animal to a human being is food, especially meat and meat products. Poultry has been recognized as an important source of human infections [6].

Bacterial microorganisms of importance to public health, such as coliforms, especially *Salmonella* and *Escherichia coli* (*E. coli*), have been found as part of the normal flora in several domestic animals, including chickens [7]. Fowl cholera, caused by *Pasteurella multocida*, remains a major problem of poultry worldwide [8]. *Pseudomonas aeruginosa* causes high mortality in newly hatched chickens and death of an embryo at a later stage [9]. A wide variety of disease conditions are associated with pathogenic organisms involving bacterial, viral, parasitic, fungal, mycoplasma and other non-infectious diseases that have always been a threat to the growing poultry industry [10].

In a developing country like Nepal, routine microbiological tests for the detection of the

microorganism and its antibiotic susceptibility are not performed. Due to the prescription of antibiotics by veterinarians without the antibiotic susceptibility test, there is an increase in the resistance of bacteria towards the antibiotic. Thus, the main objective of our study was to identify the pathogenic bacteria according to breed, determine antibiotic resistance and multidrug resistant (MDR) pattern of identified bacteria from infected chicken samples.

## 2. MATERIALS AND METHODS

### 2.1 Study Design

Cross-sectional study design was used in the present study. All the diseased chicken which was presented in National Avian Disease and Investigation Laboratory (NADIL) from December 2017 to May 2018 were enrolled in the study. Study samples were diseased and dead chicken brought for disease diagnosis. Breeds of chicken enrolled in the study were layers, broiler, broiler parents and backyard chicken. A total of 516 samples of chicken breeds were included in this study.

### 2.2 Sample Collection

Tissues (Liver, lungs, trachea, and heart) were collected based on clinical findings and pathognomonic lesions observed during detailed postmortem examination of poultry at postmortem section of NADIL according to the chicken breed. Bacterial contaminations were observed according to chicken breed to find out which chicken breed is highly susceptible to gram negative bacteria (*E. coli*, *Salmonella*, *Pasteurella* and *Pseudomonas*). In most frequent forms, gram negative bacteria such as *E.coli*, *Salmonella*, *Pasteurella* and *Pseudomonas* were observed in upper respiratory tract, lungs, liver and heart [11,12]. Samples were collected into sterile petri dishes in postmortem section and immediately transported to the microbiology laboratory.

### 2.3 Isolation and Identification of Gram-negative Bacteria

The samples were taken from the diseased chicken and brought to Avian Laboratory for examination. Samples were washed with 70% alcohol to deplete aerosol contamination. Some

portion of the sample was flamed with a red-hot blade. Then swab was taken from the sample and enriched in peptone water and incubated at temperature of 37°C for 24 hours. The sample was inoculated in nutrient agar and MacConkey agar plate using a standard inoculating loop. The plate was incubated at temperature of 37°C for 24 hours. After overnight incubation, the colony was characterized.

## 2.4 Microscopic Observation

Microscopic examination was observed by Gram staining method. The organisms revealing pink-colored colonies with the rod-shaped appearance and arranged in single or in pairs were suspected as *E. coli* [13]. If growth was observed in nutrient agar but not in MacConkey agar, then the isolates from nutrient agar were again sub cultured on blood agar to confirm the purity of the culture. Pure colonies from blood agar were suspected as *Pasteurella* [14].

Cultural methods for the detection of *salmonella* spp. involved a non-selective pre-enrichment, followed by selective enrichment and plating onto selective and differential agars. After pre-enrichment, 1 ml of enriched cultures of sample types was transferred to 9 ml of selenite faeces broth and incubated at temperature of 37°C for 18 hrs. A loopful of culture from selenite faeces broth was streaked into plates of XLD and were incubated at temperature of 37°C for 18 hours [15]. The grown colonies on the nutrient agar and Muller- Hinton agar characterized by producing diffusible pigments and sweet grape odor (bluish-green or yellowish-green) were selected for further tests for *P. aeruginosa* [16].

## 2.5 Biochemical Test

A further biochemical test was performed for the identification of these bacteria. Bacteria were identified by performing standard biochemical tests (SIM test, MRVP test, urease test, citrate test) [17].

## 2.6 Antibiotic Susceptibility Test of Isolated Bacteria

Clinical and Laboratory Standards Institute (CLSI) recommended Modified Kirby-Bauer disk diffusion method was used for antibiotic susceptibility test [18]. Agar plates placed right side up in an incubator were heated to the temperature of 37°C for 10 to 20 minutes with the covers adjusted so that the plates were

slightly opened. All agar plates were inoculated with their respective test organisms as follow; dip a sterile cotton swab into a well-mixed saline test culture and removes excess inoculated by processing the saturated swab against the inner wall of the culture tube. Allow all culture plates to dry for about 5 minutes. Gently, press each disc down with the wooden end of a cotton swab or sterile, forceps to ensure that the discs adhere to the surface of the agar. Finally incubate all plate cultures in an inverted position for 24 hours at 37°C [19]. After overnight incubation, the plates were examined for confluent growth. The diameter of the zone of inhibition was measured and interpreted by referring to the zone of diameter. Ciprofloxacin, Gentamicin, Amoxicillin, Amikacin, Cotrimoxazole, Doxycycline and Levofloxacin were the antibiotics used as they are the antibiotics of choice for treatment of bacteria- infected disease. In this present study, antibiotic discs used were purchased from Himedia, India.

## 3. RESULTS

Out of total 516 samples, 212(41.09%) were found to be positive and the rest of them did not show any growth on culture media (Fig. 1). Furthermore, the samples were separated according to their breed as shown in Fig. 2. Out of 300 samples from layers, 114 (38%) samples showed growth whereas 30 (54.54%) broilers out of 55 samples showed growth on media. In addition, the samples included 51 broiler parents who had 23 (45%) positive growths and 110 backyards who had 45 (40.9%) samples that showed growth. Here, Backyards included local chicken, Giriraj, Lohmann, Hyline-brown, etc. The results have shown that bacterial growth was found to be higher in broiler chicken followed by broiler parents, backyard, and layers, respectively.

The growth of *E. coli* was higher among pathogenic bacteria in all breeds. Out of 212 growth samples, 134 (63.2%) samples had growth of *E. coli*, 10 (4.7%) *Pasteurella* spp., 11 (5.2%) *Pseudomonas* spp., and 26 (12.26%) *Salmonella* spp. The results also pointed out the growth of other bacteria such as *Staphylococcus* spp., *Klebsiella* spp., *Campylobacter* spp., *Serratia* spp., etc. which were not included in the present study (Table 1). Further, the samples were separated according to the division of pathogenic bacteria as well as the breed, *E.coli* were more susceptible to broilers, *Pasteurella* and *Pseudomonas* were susceptible to broiler

parents and *Salmonella* were susceptible to backyard (Table 2).

We performed an antibiotic susceptibility test of that Pathogenic bacteria using seven common antibiotics (Gentamicin, Cotrimoxazole, Levofloxacin, Amoxicillin, Amikacin, Doxycycline, and Ciprofloxacin). Out of seven antibiotics used in this study, Gentamicin was found to be the most effective against *E. coli*, whereas Levofloxacin was found to be least effective. Most of the isolates of *Pasteurella* were susceptible to the Cotrimoxazole whereas resistant to Levofloxacin and Amoxicillin. *Pseudomonas* spp. were sensitive to Gentamicin, whereas resistant to Levofloxacin and Amikacin was more effective against *Salmonella* but resistant to ciprofloxacin (Table 3). Out of total isolates, multidrug resistant of *Pasteurella* were found to be higher (50%) followed by *E. coli* (48.5%), *Pseudomonas* (18.2%) and *Salmonella* (13.9%) (Table 4).

#### 4. DISCUSSION

In this study, *E. coli* isolated from tissues (Liver, trachea, and heart) of chicken was 63.2%. The

high prevalence was because *E. coli* have rapid multiplication rate and are predominantly found in excreta of humans and animals [20]. Some strains of *E. coli* are acid tolerant which makes it more adaptive to extreme condition [20]. *E. coli* can also form biofilm to protect itself from antibiotics, chemical disinfectants, desiccation, predators and ultraviolet radiation [20]. The biofilm also provides nutrition to *E. coli* making *E. coli* predominant in environment [20]. In the previous study, the prevalence of *E. coli* was reported as 35.31% [21]. Our study showed high prevalence of *E. coli* infection in chicken in Chitwan district. The favorable temperature for *E. coli* is greater than 30°C and Chitwan belongs to subtropical region with temperature range of 7° C to 42.5°C [20,22]. Either, the prevalence of *E. coli* was reported as 32.5% in backyard chicken, while in this study higher number of *E. coli* of 51.11% was reported [23]. Likewise, the prevalence of 53.4% *E. coli* among broilers have been reported [24] while in our study 38.18 % prevalence of *E. coli* was seen among broilers. The difference in prevalence of *E. coli* infection in chicken might be due to the difference in geographical condition and climate.

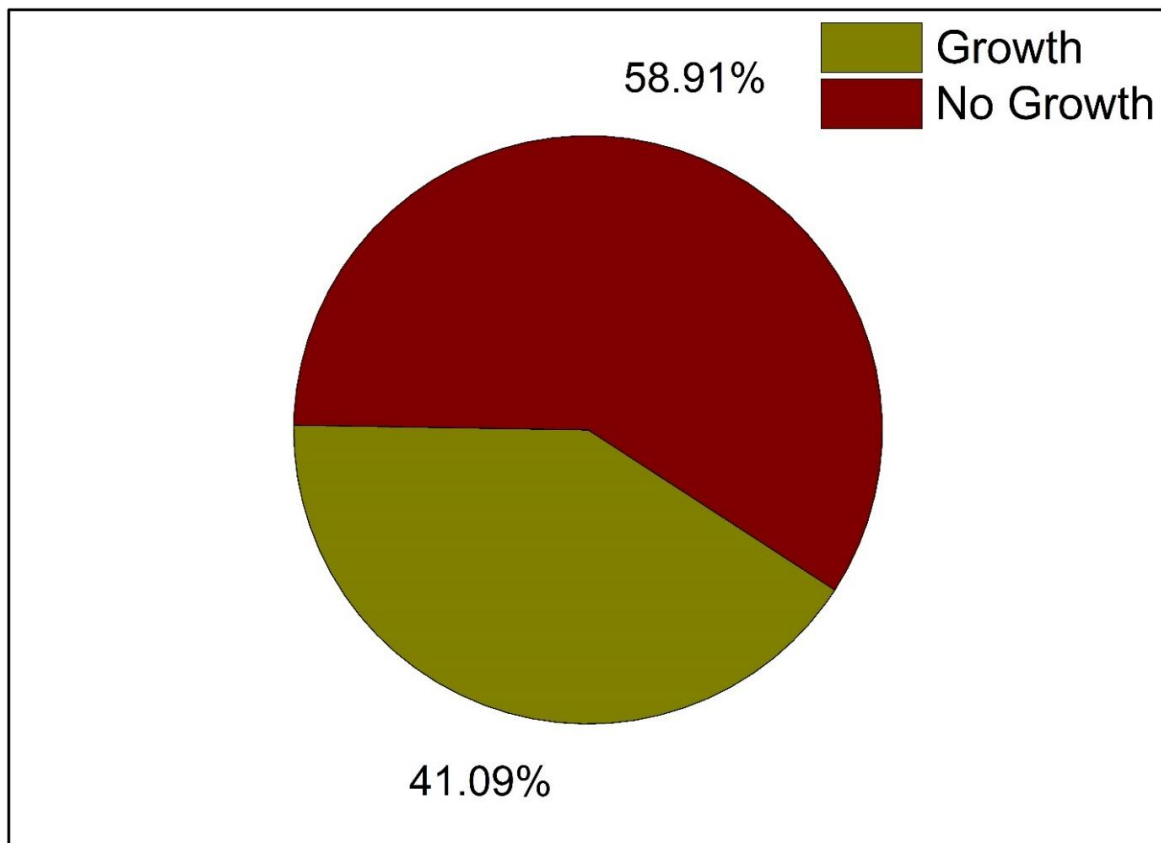


Fig. 1. Prevalence of pathogenic bacteria in the total sample

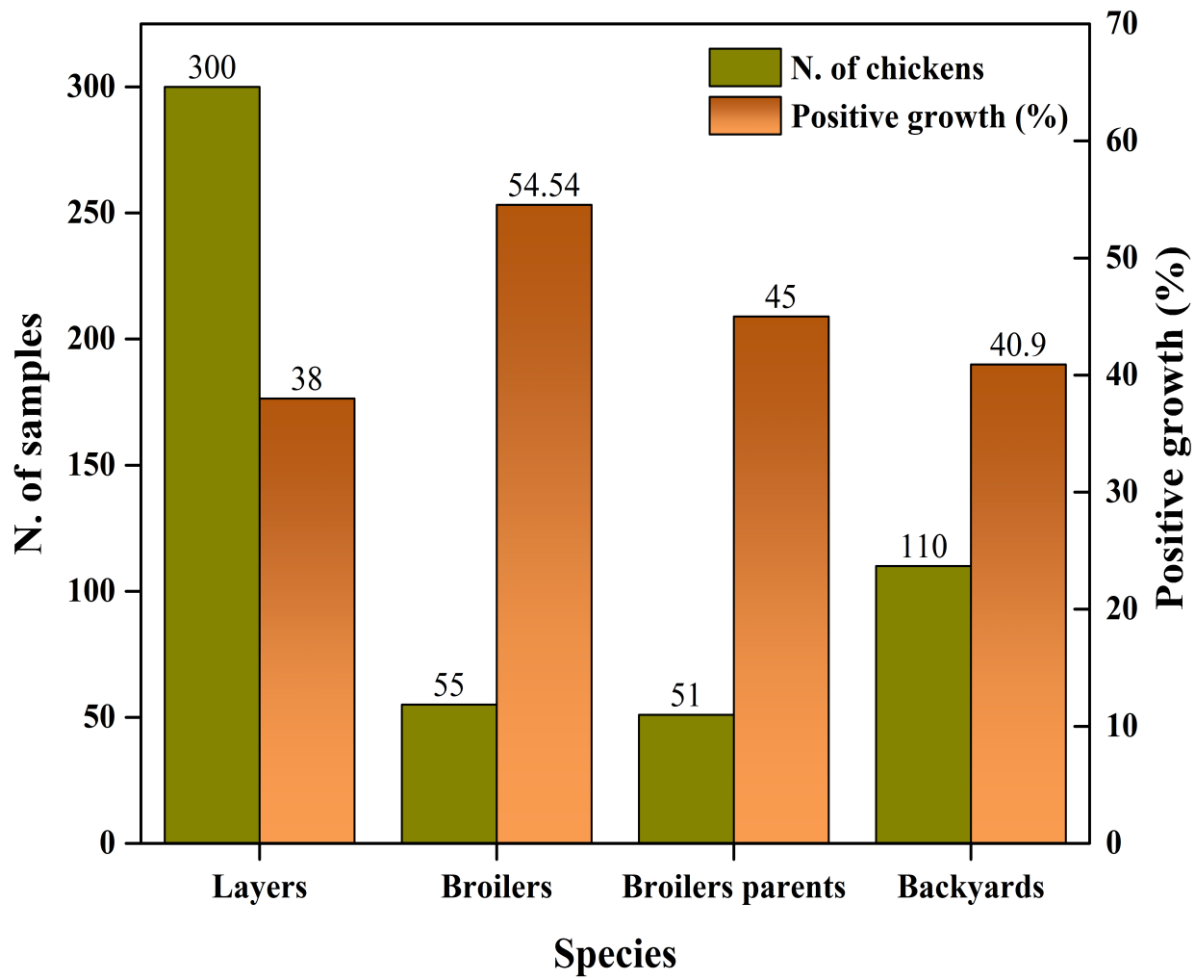


Fig. 2. Prevalence of chicken disease according to breed

Table 1. Prevalence of pathogenic bacteria in poultry diseases

Isolated bacteria	No. of isolated bacteria (%)
<i>Escherichia coli</i>	134 (63.2)
<i>Salmonella</i> spp.	26 (12.26)
<i>Pseudomonas</i> spp.	11 (5.2)
<i>Pasteurella</i> spp.	10 (4.7)
Others	31 (14.6)
Total Number of isolated bacteria	212

Table 2. Prevalence of pathogenic bacteria according to breed

Bacteria	<i>E. coli</i> (%)	<i>Pasteurella</i> spp. (%)	<i>Pseudomonas</i> spp. (%)	<i>Salmonella</i> spp. (%)	Others (%)
<b>Breed</b>					
Layers	74 (64.91)	5 (4.38)	6 (5.26)	15 (13.17)	14(12.28)
Back yard	23 (51.11)	1 (2.22)	1 (2.22)	8 (17.77)	12(26.67)
Broiler	21 (70)	0 (00)	2 (6.67)	2 (6.67)	5(16.67)
Broiler parent	16 (69.57)	4 (17.39)	2 (8.7)	1 (4.53)	(00)

Table 3. Antibiotic susceptibility tests of pathogenic bacteria

Antibiotics used	Isolated Bacteria Zone of inhibition (mm)											
	<i>E. coli</i>			<i>Pasteurella sp.</i>			<i>Pseudomonas sp.</i>			<i>Salmonella sp.</i>		
	S %	I%	R%	S%	I%	R%	S%	I%	R%	S%	I%	R%
Doxycycline	22.3	24.6	53.1	NT	NT	NT	NT	NT	NT	NT	NT	NT
Ciprofloxacin	27.9	20.5	51.6	14.3	00	85.7	18.2	27.3	54.5	38.7	13	48.3
Gentamicin	73.3	00	26.3	NT	NT	NT	91	00	9	73.5	00	26.4
Amikacin	71	12.2	16.8	NT	NT	NT	77.8	11.1	11.1	79.8	00	20.7
Levofloxacin	9	11	80	00	00	100	27.3	00	72.7	26.7	40	33.3
Amoxicillin	NT	NT	NT	00	00	100	NT	NT	NT	NT	NT	NT
Cotrimoxazole	NT	NT	NT	28.57	00	71.5	NT	NT	NT	NT	NT	NT

Note: S = sensitive, I= Intermediate, R = Resistant, NT = Not tested

**Table 4. Frequency of multidrug resistant (MDR) bacteria**

S. N	Bacteria	No. of MDR Bacteria (%)	No. of Non-MDR Bacteria (%)	Total No. isolated bacteria
1	<i>E. coli</i>	65 (48.5)	69 (51.5)	134
2	<i>Salmonella spp.</i>	5 (13.9)	21(86.1)	26
3	<i>Pseudomonas spp.</i>	2 (18.2)	9 (81.8)	11
4	<i>Pasteurella spp.</i>	5 (50)	5 (50)	10
Total		77 (42.5)	104 (57.45)	181

Our study found the prevalence of *Salmonella* spp. to be 26 (12.26%) which three times lower than the prevalence reported in Egypt (54.4%) [25]. Salmonellosis causes high mortality in chicken and high economic loss to farmers [25]. Any contamination of *Salmonella* spp. in human food may causes serious food borne infection [25]. In this study, the prevalence of *Pseudomonas* spp. and *Pasteurella* spp. were 5.2% and 4.7% respectively. One Study found the low prevalence of *Pseudomonas* spp. of 2.2% [26]. *Pseudomonas* spp. is distributed ubiquitous in nature [27]. Infection of *Pseudomonas* spp. in chicken is caused from contaminated vaccines, needles of injection and wounds [27].

In our study, gentamicin and amikacin were found to most effective in majority of bacterial infection. Our study found high sensitivity of gentamicin followed by amikacin in *E. coli* and *Pseudomonas* spp. In *Salmonella* spp., amikacin was found to be effective followed by gentamicin. Furthermore, levofloxacin and doxycycline were found to be ineffective in majority of bacterial species isolated from chicken. Similarly, a study found gentamicin as effective antibiotics for treatment of infection caused by *E. coli* [28]. In our study, 73.3% of *E. coli* were susceptible to gentamicin and similar pattern of about 60% of the *E. coli* isolated were earlier reported to be

sensitive to gentamicin [28]. Another study conducted by Thapa and Chapagain in Chitwan district found that amikacin was sensitive to 88.35% of *E. coli* [29]. Our study recommends use of gentamicin or amikacin for treatment of bacterial infection in chicken in Chitwan district.

Our study found that 48.5% of *E. coli* were multidrug resistant. A study conducted in Chitwan, Nepal found that 96.12% of total isolated *E. coli* from diseased chicken were MDR [29]. Multidrug resistance is emerging problem worldwide [5]. Sarkar et al (2019), Bashar et al (2011), Akond et al (2009) found that 100% isolates of *E. coli* were multidrug resistance [28,30,31]. Our study demonstrated the prevalence of MDR *Pasteurella* spp., *Pseudomonas* spp., *Salmonella* spp., as 50%, 18.2% and 13.9 %, respectively. Overall, our study found high prevalence of MDR bacteria among gram negative bacteria. The prevalence of MDR bacteria in our study was 42.5%. Earlier high prevalence (88.2%) of MDR bacteria in chicken have been reported [32]. Each year 700000 death are estimated to due antibiotics resistance and is expected to be increased by 10 million in year 2050 [33]. Gram negative bacteria can acquire antibiotic genes through different antibiotic resistance mechanism [33]. Under pressure of antibiotics, gram negative bacteria can undergo DNA mutation and can become

antibiotic resistance [33]. Another mechanism is that gram negative bacteria can also acquire antibiotic resistance gene from other bacteria present near to it through horizontal gene transfer [33].

## 5. CONCLUSION

This study showed high prevalence of multidrug resistant gram-negative bacteria among different chicken breeds. This increase in multidrug resistant bacteria have increased mortality rate in chicken, increased antibiotic use, decreased productivity, and increased the cost of production. In Nepal, routine microbiology test is not performed for detection and antibiotic susceptibility for chicken pathogens. Veterinarians should prescribe antibiotics after performing antibiotic susceptibility test. To control the infection, farmers should be aware on proper use of disinfectants in farm before adding new chickens.

## LIMITATIONS

This study determines the prevalence of bacteria and multidrug resistant bacteria in diseased chicken. Further study should focus on detection of metallo-beta-lactamase, extended spectrum of beta lactamase enzyme producing bacteria from chicken tissues.

## AVAILABILITY OF DATA AND MATERIAL

All data obtained during this study are available within the article.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## CONSENT AND ETHICAL APPROVAL

Ethical approval was obtained from Research Ethics Committee of Balkumari College, Tribhuvan University, Nepal. The study protocol was verified by Research Committee of

Microbiology Department. No human sample was involved in this study and the animal samples were processed according to the animal research ethical guidelines. Informed written consent was obtained from all poultry farm owners included in the study.

## ACKNOWLEDGEMENT

We are deeply indebted to Dr. Daya Ram Chapagai, Senior veterinary officer of National Avian Disease Investigation Laboratory for his valuable suggestions, continuous encouragement and incredible support in providing the excellent working facilities to conduct the research work in microbiology.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCE

1. Gelband H, et al. The state of the world's antibiotics 2015. *Wound healing southern africa*, 2015;8(2):30-34.
2. Apata D. Antibiotic resistance in poultry. *International Journal of Poultry Science*, 2009;8(4): 404-408.
3. Kilonzo-Nthenge A, et al. Prevalence and antimicrobial resistance of pathogenic bacteria in chicken and guinea fowl. *Poultry science*, 2008;87(9):1841-1848.
4. Humam AM, et al. Effects of feeding different postbiotics produced by *Lactobacillus plantarum* on growth performance, carcass yield, intestinal morphology, gut microbiota composition, immune status, and growth gene expression in broilers under heat stress. 2019;9(9):644.
5. Shrestha A, et al. Multi-drug resistance and extended spectrum beta lactamase producing Gram negative bacteria from chicken meat in Bharatpur Metropolitan, Nepal. *BMC Research Notes*. 2017; 10(1):574.
6. Stern N, Robach M. Enumeration of *Campylobacter* spp. in broiler feces and in corresponding processed carcasses. *Journal of Food Protection*. 2003;66(9): 1557-1563.
7. Mpundu P, et al. Evaluation of bacterial Contamination in dressed Chickens at

- Lusaka Abattoirs. *Frontiers in Public Health*. 2019;7:19.
8. Singh R, et al. Epidemiology of fowl cholera in free range broilers. *Avian Diseases*. 2014;58(1):124-128.
  9. Kebede F. Pseudomonas infection in chickens. *J Vet Med Anim Health*, 2010; 2(4):55-58.
  10. Julian RJ. Production and growth related disorders and other metabolic diseases of poultry—a review. *The Veterinary Journal*. 2005;169(3):350-369.
  11. Arné P, et al. Increased tracheal colonization in chickens without impairing pathogenic properties of avian pathogenic *Escherichia coli* MT78 with a fimH deletion. *Avian Diseases*. 2000;343-355.
  12. Roy SR, et al. Isolation and identification of bacterial flora from internal organs of broiler and their antibiogram studies. *Microbes and Health*. 2012;1(2):72-75.
  13. Zinnah M, et al. Characterization of *Escherichia coli* isolated from samples of different biological and environmental sources. *Bangladesh Journal of Veterinary Medicine*. 2007;25-32.
  14. Muhairwa A, et al. Occurrence of *Pasteurella multocida* and related species in village free ranging chickens and their animal contacts in Tanzania. *Veterinary Microbiology*. 2001;78(2): 139-153.
  15. AL-Iedani AA, Khudor MH, Oufi NM. Isolation and identification of *Salmonella* spp. from poultry farms by using different techniques and evaluation of their antimicrobial susceptibilities. *Bas. J. Vet. Res*. 2014;1(1):246-259.
  16. Al-Saffar MF, Jarallah EM. Isolation and characterization of *pseudomonas aeruginosa* from babylon province.
  17. Kebede A, et al. Isolation, identification, and antibiotic susceptibility testing of *Salmonella* from slaughtered bovines and ovines in Addis Ababa Abattoir Enterprise, Ethiopia: a cross-sectional study. *International Journal of Bacteriology*. 2016; 2016.
  18. C.L.S.I.C.P.s.f.a.s.t.t.i.s.M.-S.W.C; 2014.
  19. Rahman MA, et al. Isolation, Identification and Antibiotic Sensitivity Pattern of *Salmonella* spp from Locally Isolated Egg Samples. *Amer J. of Pure and Appl Biosci*. 2019;1(1):1-11.
  20. Jang J, et al. Environmental *Escherichia coli*: ecology and public health implications—a review. *Journal Of Applied Microbiology*. 2017;123(3):570-581.
  21. Ameen-Ur-Rashid SS, et al. Isolation of *Escherichia coli* from Poultry Liver and its Antibiogram Profile. *Res. J. Vet. Pract*. 2017;5(1):12-14.
  22. Khanal S, Kattel RR. Understanding farmers' perceptions and adaptations to climate change and variability in rice production at the kaski and chitwan districts, Nepal. *Asian Research Journal of Agriculture*, 2017;1-12.
  23. Sarba EJ, et al. Identification and antimicrobial susceptibility profile of *Escherichia coli* isolated from backyard chicken in and around ambo, Central Ethiopia. *BMC Veterinary Research*. 2019; 15(1):85.
  24. Ibrahim RA, et al. Identification of *Escherichia coli* from broiler chickens in Jordan, their antimicrobial resistance, gene characterization and the associated risk factors. *BMC Veterinary Research*. 2019; 15(1):159.
  25. Salem W, et al. Alterations in virulence and antibiotic resistant genes of multidrug-resistant *Salmonella* serovars isolated from poultry: The bactericidal efficacy of *Allium sativum*. *Microbial pathogenesis*, 2017;108:91-100.
  26. Amer MM, et al. Antibiotic Profile of Bacterial Species Isolated from Broiler Chickens with Cellulitis. *World*. 2019;9(4): 268-279.
  27. Badr JM, El Saidy FR, Abdelfattah AA. Emergence of Multi-Drug Resistant *Pseudomonas aeruginosa* in Broiler Chicks. *International Journal of Microbiology and Biotechnology*. 2020; 5(2):41.
  28. Sarker MS, et al. Antibiotic resistance of *Escherichia coli* isolated from broilers sold at live bird markets in Chattogram, Bangladesh. *Journal of Advanced Veterinary and Animal Research*. 2019; 6(3):272.
  29. Thapa, D, Chapagain A. Antibiogram of *Escherichia coli* Isolated from Avian Colibacillosis in Chitwan District of Nepal. *International Journal of Applied Sciences and Biotechnology*, 2020;8(1):52-60.
  30. Bashar T, et al. Enterotoxin profiling and antibiogram of *Escherichia coli* isolated from poultry feces in Dhaka district of Bangladesh. *Stamford Journal of Microbiology*. 2011;1(1):51-57.



31. Akond MA, et al. Antibiotic resistance of Escherichia coli isolated from poultry and poultry environment of Bangladesh. Internet Journal of Food Safety. 2009;11: 19-23.
32. Yassin AK, et al. Antimicrobial resistance in clinical Escherichia coli isolates from poultry and livestock, China. Plos One. 2017;12(9).
33. Koulenti D, et al. Infections by multidrug-resistant Gram-negative Bacteria: What's new in our arsenal and what's in the pipeline? International Journal of Antimicrobial Agents. 2019;53(3):211-224.

---

© 2021 Poudel et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<https://www.sdiarticle5.com/review-history/72679>