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Practices of Pig Farmers and *Porcine Salmonella* Occurrence in Nasarawa State

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Abstract

Farming practices such as the use of antibiotics, feed and feed additives, housing as well as biosecurity measures are important factors contributing to the spread and persistence of infectious agents and pathogens in farms and the environment. The aim of this study was to assess pig farmers practices and the occurrence of *Porcine Salmonella* in Nasarawa state of Nigeria. A total of 637 farmers were assessed across the 13 Local Government Areas using structured questionnaires alongside 637 fecal samples collected from pigs to determine the association between management practices vis-a-vis *Salmonella* occurrence. The fecal samples were subjected to culture and isolation methods as described by ISO 6579: +A1:2007. Data from questionnaire responses were subjected to multivariate logistic regression analysis using Epi info version 7.2 to ascertain the risk factors. The study identified source of water, Feed and sanitation as risk factors to occurrence of *Porcine Salmonella*, irrational use of antimicrobials and corticosteroids (24.5%) and various farm practices by majority of respondents ranging from no keeping of farm records such as drug use, (69.1%), administration of growth boosters (56.8%) and usage of various unbranded veterinary products (57.1%) without proper treatment regimen (50.7%). The study observed gaps in knowledge and best farm practices such as farm sanitation, biosecurity, proper containment methods, feed and water administration capable of promoting the occurrence of *Porcine Salmonella*. A coordinated One-Health approached is recommended in order to curtail Salmonella transmission and safeguarding the environment from contamination and the health of pig farmers of Nasarawa State.

Keywords: Nasarawa State, pig farmers, occurrence, *Porcine Salmonella*

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Introduction

One of the significant public health pathogens that has generated a lot of concerns globally is *Salmonella*. Its presence in pig farms and the consumption of contaminated food, pork and pork productsposes considerable risks not only to animal health but also to food safety. *Salmonella enterica* is the most prominent species contributing to outbreaks of salmonellosis in humans. Farming practices employed by pig farmers play critical role in either mitigating and/or exacerbating the occurrence of this pathogen [1]. Recently, studies have highlighted various practices such as management of housing conditions, biosecurity measures, feed practices andtreatment or prevention of disease as major contributors to the rise of *Porcine Salmonella*. Another critical aspect of pig farming that influences *Salmonella* prevalence is housing and management practices as well as overcrowding of pig houses leading to increased stress levels in the animals, which in turn can compromise their immune systems and increase vulnerability to infections with bacterial like *Salmonella* [2, 3]. Other studies have identified mitigation practices such as cleanliness of housing environments to be pivotal in controlling *Salmonella* spread. However, many pig farms still face challenges of persistent occurrence [4].

Farm biosecurity which is a critical component in the prevention and control of *Porcine Salmonella* unfortunately, is lacking in many farms with such farms having no comprehensive biosecurity plans and means of controlling visitor access, disinfection and managing animal movements. This is contributing to increasing *Salmonella* prevalence with cascading effects on animal welfare and productivity [5, 6]. Feed and dietary practices have also been identified to play significant roles in influencing *Porcine Salmonella* occurrence. Poor feed quality or feed ingredients contaminated with pathogens facilitate the spread of *Salmonella* within pig populations. Recently, studies emphasized the importance of incorporating probiotics in stimulating a healthier gut microbiome. However, the levels of incorporation and administration of antimicrobials play significant roles in antimicrobial resistance and disease persistence, especially those caused by *Salmonella* [7]. Additionally, practices such asutilization of food waste and raw feed ingredientsmarkedly elevate the risk of *Salmonella* entering the food chain, particularly when these feeds are not adequately treated or sourced [8].

The usage of antibiotics for treatment and disease prevention is faced with inappropriate usage both in animal husbandry and human medicine, and overuse has led to antibiotic resistance, complicating the

treatment of infections including those caused by *Salmonella* [1]. The reliance on prophylactic and growth-promoting antibiotics not only fosters resistant strains, but also encourages the persistence of *Salmonella* in farm environments. As resistance patterns evolve, the urgency for alternative approaches to disease management is increasingly clear, with the need for integrated disease management strategies that will not solely depend on pharmacologicalinterventions [9, 10], but other strategies like farmer training and education in implementing best practices and increased awareness among pig farmers regardingthe risks associated with *Salmonella*. Such approaches promote greater responsibility in animal health management and could result in reduced *Salmonella* rates and safer pork products for consumers.

This study was therefore carried out to assess the knowledgeand practices of pig farmers in Nasarawa State in order to provide data for informed mitigation strategies that will improve overall health of the populace and minimize *Porcine Salmonella* prevalence.

Materials and Methods

Study design

A cross-sectional study was conducted, during which a total of 637 structured questionnaires were administered to pig farmers after obtaining their informed consent. Also, 637 freshly voided fecal samples were collected from pigs (49 samples from each Local Government Area) across the 13 Local Government Areas of Nasarawa State. The samples were transported on cold chain to the laboratory and subjected to standard methods for the detection and isolation of *Salmonella* [10]. Briefly, for pre-enrichment, one gram (1 g) of freshly voided fecal samples was added into 10 mL of Buffered Peptone water (BPW) and incubated at 37°C for 24 h. For enrichment, 1 mL of the broth culture was added to 9 mL of Muller-Kauffmann Tetrathionate Novobiocin (MKTTn) broth and incubated at 37°C for 24 h. An aliquot of 0.1 ml of the culture was then inoculated onto the surface of freshly prepared Xylose Lysine Deoxycholate (XLD) agar using streak plate method, and incubated again at 37°C for 24 h as described by ISO 6579: +A1:2007 [11]. After incubation, typical colonies of *Salmonella* on XLD agar had a black center and a lightly transparent reddish zone. The suspected *Salmonellae* were transferred onto nutrient agar plates, incubated at 37°C for 18-24 h and subsequently subjected to preliminary identification by oxidase and indole test, Triple Sugar Iron (TSI) test for gas and hydrogen sulphide (H_2S) production, citrate and urease utilization, sugar fermentation (glucose, lactose, sucrose, maltose, dulcitol, mannitol, inositol, ramnose, sorbitol, mannose, arabinose, malonate, and trehalose) and lysine decarboxylation. The *Salmonella* isolates were further confirmed using Polymerase Chain Reaction.Data obtained from questionnaire responses was entered into Microsoft Excel 2007, and all possible errors were checked to obtain a clean data set. The data was entered into Epi info version 7.2 to analyze data generated from farmers responses. The association between management practices, biosecurity practices and general hygiene alongside *Salmonella* occurrence were determined using multivariate logistic regression analysis (P-value ≤0.05) to ascertain risk factors such as type of feed consumed by pigs, type of feeding trough and source of water [3].

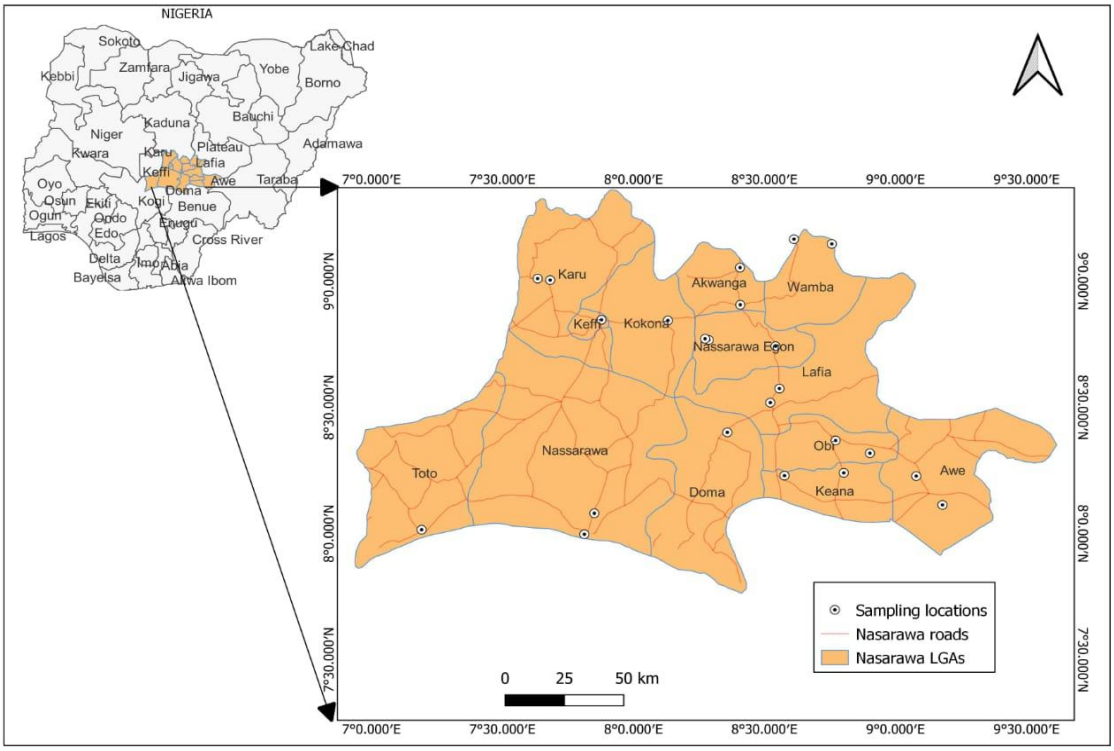

Figure 1: Map of Nasarawa State showing the sampling locations

Results and Discussion

Health practices of pig farmers in Nasarawa state

Result of the health practices of pig farmers is presented in Table 1. A total of 3.3% of the farmers allow their farm workers or helpers to administer medication to their animals, 13.3% employ the services of veterinary doctors, 44.3% of the farmers used the services of animal health technicians while 39.1% administered medications to their pigs themselves. Total of 71.9% of the respondents sell their animals when they do not have access to medication to treat sick animals, while 28.1% allow the animals to recover on their own or to die when there is no access to medications for treatment.

Majority of the respondents represented by 69.1% do not keep records of treatment failures, while 30.9% recorded treatment failures to various medications given to their animals. More respondents administered growth boosters to their animals 56.8% while 43.2% do not administer growth boosters. A total of 16.8% of respondents administer powdered growth boosters, 26.1% administer tablets, while 57.1% administered various veterinary solutions. A total of 8.2% of respondents administered Maxi growth veterinary products, 24.5% administer Dexamethasone, 8.5% of respondents administer Grow Max Veterinary product while 58.9% administer Molasses. More respondents administered growth boosters anytime they wish 50.7%, 32.9% administered growth boosters weekly while 16.3% administered growth boosters on monthly basis.

Health practices are major determinants in infection as well as occurrence of *Salmonella* especially in animal populations [12]. These findings showed a concerning trend in the occurrence of *Salmonella* and in health practices of pig farmers in Nasarawa State. The 13.3% who employ the services of veterinary doctors represent a small percentage capable of providing adequate animal care services thereby undermining animal health management capable of limiting infections and disease spread thereby increasing the risk of *Salmonella* occurrence [13]. The significant 71.9% of farmers who resort to selling off sick animals lacking treatment options and the 39.1% who self-administer medications reflects a gap in professional healthcare support for livestock capable of serving as a major factor in disease occurrence and in this case, *Salmonella* as reported by Akinyele *et al*. [14]. The reliance on animal health technicians (44.3%) raises concerns on the adequacy of training and resources available for these practitionersas inadequate veterinary care could exacerbate the risk of antibiotic resistance and disease spread, therefore the need for One-Health mitigation approach involving the health care delivery systems [15].

Alarmingly, the use of growth boosters is prevalent among pig farmers, with 56.8% of farmers in this study administering them at irregular intervals. The indiscriminate use of growth promoters including Maxi growth products and Dexamethasone poses additional risks due to theability of these antimicrobial agents to promote occurrence, distort bacterial susceptibility to antibiotics and contribute to zoonotic transmissions [16]. The haphazard approach to medication administration without comprehensive record-keeping (69.1% do not maintain treatment records) agrees with reports of Idowu *et al*. [15] that these practices complicate best management practices, making tracking of treatment efficacy and agricultural bioethics challenging and capable of promoting the persistence of pathogens.

Table 1: Health practices of pig farmers in Nasarawa State and *Porcine Salmonella* occurrence

Variables	N (637)	% of Respondent	*P. Salmonella* Positive (n=57)	*P. Salmonella* Negative (n=580)	Chi Square	P-value	Odds ratio	95% CI
Physician								
Farm worker	21	3.3	3	18	ref	ref	ref	ref
Vet Doctor	85	13.3	8	77	0.06	0.79	1.60	0.38-6.65
Animal health Technician	282	44.3	24	258	0.001	0.97	0.89	0.39-2.07
Farm owner (Myself)	249	39.1	22	227	0.00	1.00	0.93	0.39-2.18
Non-accessibility to medications								
Sell them	458	71.9	39	419	0.21	0.65	0.83	0.46-1.49
Allow them to recover	179	28.1	18	161				
Records of non-effectiveness of drugs								
Yes	197	69.1	12	185	2.37	0.12	0.57	0.29-1.10
No	440	30.9	45	395				
Giving of growth booster								
Yes	362	56.8	35	327	0.35	0.56	1.23	0.70-2.15
No	275	43.2	22	253				
Booster type								
Powder veterinary product	107	16.8	4	99	ref	ref	ref	ref
Tablets	166	26.1	41	396	0.002	0.97	1.10	0.49-2.43
Veterinary solutions	364	57.1	8	85	0.001	097	086	0.31-2.39
Product administers								
Maxi growth	52	8.2	4	48	ref	ref	ref	ref
Dexamethasone	156	24.5	40	389	0.08	0.78	1.21	0.55-2.67
Grow max	54	8.5	5	49	0.27	0.60	0.63	0.19-1.98
Molasses	375	58.9	8	94	0.00	1.00	0.98	0.28-3.42
Frequency of administration								
Weekly	210	32.9	1	9	ref	ref	ref	ref
Monthly	104	16.3	8	96	0.00	1.00	1.33	0.15-11.89
Anytime I wish	323	50.7	48	475	0.09	0.77	1.21	0.56-2.65

CI = Confidence Interval; N = Total number of samples collected

Biosecurity practices of pig farmers in Nasarawa State

Table 2 shows the biosecurity practices of pig farmers. A total of 41.1% housed their animals in mud pens, 31.4% keep their animals in pens constructed with wood/planks while 27.5% of the farmers keep animals in concrete pens. More farmers (76.1%) practice semi-intensive method of containment, while 23.9% practice intensive method of containment. More respondents accounting for 31.2% stock 4-6 animals in one pen, 31.1% of the farmers stocks 2-4 pigs per pen, 19.6% stock more than six pigs per pen, while the least stocking density was 1-2 pigs per pen (18.1%) respectively. Majority of the respondents (28.7%) use rubber containers as water troughs, 26.8% use metal containers, 25.7% uses concrete constructed troughs while 18.7% use wooden water troughs. A total of 48.7% respondents feed their animals with combinations of food wastes and grain offal, 47.1% feed their animals with grains offal, and 4.2% feed them cooked food wastes/left overs. More respondents (45.4%) use water from any source available for their animals, 19.0% used well water, 17.0% used bore hole water, 8.6% used tap (pipe borne water) while 5.0% used water from the river and ponds respectively. Foot dip which is an essential biosecurity barrier was not used by any (100%) of the respondents. Majority of the respondents (71.9%) don't use protective overalls and boots during farm activities, 27.6% occasionally use protective overalls while only 0.5% use protective overalls during farm activities at all times.

The 100% of respondents (pig farmers) not utilizing foot dips which is a critical practice for reducing disease transmission in livestock production as observed by Owoade *et al*. [17], justifies the occurrence of *Porcine Salmonella,* therebynecessitating holistic mitigation approach such as the "One-Health" between different health care sectors. Furthermore, the lack of protective gear use amongst (71.9%) of respondents during farm operations presents a heightened risk of *Salmonella* infection and transmission for both farmers and livestock as well as environmental contamination with these pathogens as observed by Randolph *et al*. [18]. The majority of farmershousing their pigs in mud (41.1%) or wooden pens (31.4%) rather than concrete (27.5%) raises additional concerns about hygiene and *Salmonella* prevalenceas these structures are often harder to clean and may harbor pathogens as observed by Cha *et al.* [19].

Feeding practices observed in this study revealed a mixture of food waste and grain offal (48.7%) often fed to pigs and these combinations often times do not undergo adequate processing or preparations such as cooking that will inhibit bacteria such as *Salmonella*. This practice does not only increase the potential for introducing pathogens intolivestock, but also challenges food safety [20]. This practice along-side the use of unclean water sources by 48.3% of farmers emphasizes the need for interdisciplinary collaboration between the humans, animal farmers and the food safety agencies in orderto improve animal feed and water sanitation measures to mitigate the risk of *Salmonella* infection among pigs and other animal populations [21].

Table 2: Biosecurity practice of pig farmers and *Porcine Salmonella* occurrence in Nasarawa State

Variables	N (637)	% of Respondent	*P. Salmonella* Positive(n=57)	*P. Salmonella* Negative(n=580)	Chi–Square	P-value	Odds ratio	95% CI
Type of Housing								
Concrete	175	27.5	13	162	ref	ref	ref	ref
Mud	262	41.1	21	241	0.001	0.97	0.92	0.45-1.89
Wood/Planks	200	31.4	23	177	1.22	0.27	1.49	0.80-2.78
Type of containment								
Intensive	152	23.9	13	139	0.001	0.97	0.94	0.49-1.79
Semi intensive	485	76.1	44	441				
Stocking density								
1-2	115	18.1	7	108	ref	ref	ref	ref
2-4	198	31.1	20	178	0.19	0.66	1.29	0.58-2.86
4-6	199	31.2	20	179	0.18	0.67	1.28	0.58-2.84
More than 6	125	19.6	10	115	0.15	0.74	0.75	0.27-2.03
Feeding/water trough								
Wooden	119	18.7	8	111	ref	ref	ref	ref
Concrete	164	25.7	19	145	3.47	0.06	2.27	1.02-5.03
Metal	171	26.8	20	151	3.66	0.05	2.29	1.04-5.05
Rubber	183	28.7	10	173	0.04	0.83	1.25	0.48-3.26
Type of feed								
Grain offal	300	47.1	14	286	ref	ref	ref	ref
Left over foods	27	4.2	17	10	254.46	0.00	0.001	0.002-0.06
Combination of left overs/grain offal	310	48.7	26	284	134.50	0.00	0.009	0.002-0.35
Source of water								
Bore hole	108	17.0	10	98	7.61	0.005	0.06	0.01-1.46
Well	163	19.0	18	145	6.63	0.01	0.08	0.01-0.53
Pipe borne water	55	8.6	4	51	7.78	0.005	0.05	0.01-0.41
River	5	5.0	3	2	ref	ref	ref	ref
Pond	5	5.0	0	5	1.90	0.17	0.00	Undefined
Any source available	301	45.4	23	278	11.26	0.000	0.06	0.01-0.35
Presence of Foot dip								
Yes	0		0	0	Undefined	Undefined	Undefined	Undefined
No	637		57	580				

CI = confidence Interval N= Total number of samples collected

Table 3: Sanitary practices of pig farmers and *Porcine Salmonella* occurrence in Nasarawa State

Sanitary Practice	N (n=637)	% of Respondents	*P. Salmonella* Positive (n=57)	*P. Salmonella* Negative (n=580)	Chi–Square	P-value	Odds ratio	95% CI
Washing of feeding/drinking trough								
Daily	81	12.7	5	76	ref	ref	ref	ref
Weekly	154	24.2	19	135	1.56	0.76	2.14	0.77-5.96
Only when its visibly dirty	402	63.1	33	369	0.16	1.34	1.34	0.51-3.59
Cleaning of Pen								
Daily	110	17.3	18	98	17.46	0.000	4.87	2.27-10.46
Weekly	182	28.6	27	164	17.79	0.000	4.36	
Only when its visibly dirty	345	54.1	12	318	ref	ref	ref	2.15-8.84
Disinfection of Pen								
Daily	0	0.0	0	0				
Weekly	0	0.0	0	0	Undefine	Undefine	Undefine	Undefine
Monthly	12	1.9	1	11				
Not at all	625	98.1	56	569				
Disinfectant used								
Izal	7	1.1	0	7				
Hypochlorite	0	0.0	0	0				
Virkon	0	0.0	0	0	Undefine	Undefine	Undefine	Undefine
Others	5	0.8	0	5				
Nothing	625	98.1	57	568				
Litter management								
Throw away	444	69.7	44	400	1.21	0.25	1.52	0.80-2.81
Dry and sell as manure	193	30.3	13	180				

CI = Confidence Interval; N = Total number of samples collected

Sanitary practices of pig farmers in Nasarawa State

Details of the sanitary practices of pig farmers in Nasarawa State is presented in Table 3. Majority of the respondents 63.1% wash feeding/drinking troughs only when its is very dirty, 24.2% wash them weekly while 12.7% wash them daily. More of the respondents accounting for 54.1% clean their animal pen only when it is very dirty, 28.6% clean their animal pen weekly, and 17.3% clean their pen daily. Majority of the respondents (98.1%) do not disinfect the animal pen at all, while 1.9% disinfect their pens monthly. A total of 1.1% used Izal as disinfectant, 0.8% use other unbranded disinfectants while 98.1% do not disinfect animal pens. Majority of the respondents (69.7%) remove and throw away litters from their pens into the environment while 30.3% of the respondents dry and sell or used the litters as manure on their farms. Sanitation practices within farm environment are key for controlling disease spread. The 98.1% of farmers not disinfecting their animal pens can promote disease spread. The cleaning of troughs and pens only when visibly dirty by (59.2 and 54.2%) highlights a reactive rather than a proactive approach to hygiene management [22]. This insufficient sanitation gradient guarantees an environment conducive to the persistence and transmission of pathogens like *Salmonella*. The farmer's litter disposal methods with 69.7% opting to throw it into the environment further exacerbate public health risks contributing to environmentalpollution, food safety and hygiene threats [22]. The remaining 30.3% who dry and utilize litter as manure seem to have a better approach, yet these practices must be employed consistently and safely to mitigate the risk of contamination as reported by Jackson *et al*. [23].

Conclusion

The practices of pig farmers in Nasarawa State with regards towater and feed administered to pigs, animal health management, biosecurity practices, as well as sanitation are inadequate and are capableof increasing the risk of *Porcine Salmonella*occurrence and zoonosis. The high dependence on the services of unskilled personnel in administration of medications and weakdisinfection routine of animal houses (1.9%) are promoting *Porcine Salmonella* outcomes and highlights theneed for implementing One-Health mitigation strategies. Practical *Salmonella* transmission mitigation approach by environmental agencies, human and animal health authorities is needed. This approach should include enhancing veterinary care access, promotion of proper biosecurity education to pig farmers and enforcement of animal feed,water sanitation and pig litters disposal protocols that will safeguard both pigs, pig handlers and the environment which will reduce *Porcine Salmonella* occurrence and overall public health outcomes.

Conflict of interest: All the authors declare that they have no conflicting interest.

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