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## **A survey of farm-level biosecurity practices of pig farmers in selected communities affected by African Swine Fever in Umuahia South, Abia State, Nigeria**

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**Running title: A survey of biosecurity practices of African Swine Fever affected farms**

### **Abstract**

African Swine Fever (ASF) is a transboundary viral infection, that affects domestic and wild pigs with severe socio-economic impact. Nigeria, including Abia State, has witnessed substantial sporadic ASF outbreaks in recent years. Accordingly, the lack of an approved vaccine necessitates strict biosecurity as the only effective tool for preventing ASF in domestic pig farms. This study aimed to determine spatial point locations of pig farms and evaluate the level of biosecurity measures in commercial pig farms located in Umuahia South. A cross-sectional survey of 180 pig farms was conducted, and primary data were collected through face-to-face interviews with farmers and field observation. Spatial point locations of pig farms were captured using Global Positioning System (GPS). Numerical and spatial data were analysed with Stata 14 and ESRI's ArcGIS 10.8. The survey results showed that 80% (144/180) of the farms had experienced outbreaks, and 98% (113/115) of neighbouring farms reported outbreaks following an outbreak on a nearby farm. The proportion of biosecurity measures, including selling pigs on the farm (95%, 112/118), confirming outbreaks by personal judgment (80%, 76 /95), and practising extensive farming (84%, 78/180), was high; however, the differences were not statistically significant.

Furthermore, the proximity analysis at 750m, 1000m and 1500m distance radii around 120 pig farms showed that more than 90% of the farms fell within the distance radius, which violates the 3km biosecurity zone and also, reflects the rurality of the study area. In conclusion, the spatial aggregation of farms, coupled with the practice of extensive or semi-intensive farming systems in the study area, supports the continuous dissemination of the ASF virus among domestic pig populations that frequently interact. These conditions make it challenging to implement conventional biosecurity measures effectively.

Key words: African Swine Fever; Biosecurity; Outbreaks; Spatial distribution

### **Introduction**

Pigs significantly contribute to the economic welfare of the smallholder farmers in Nigeria.

They are particularly important to the rural households in many Nigerian villages. Diseases that affect these species are therefore of great importance to food security and the economic

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wellbeing of these farmers. African swine fever (ASF) is a haemorrhagic disease of domestic and wild pigs caused by a DNA arbovirus of the genus *Asfivirus* and family *Asfarviridae* (Owolodun *et al.*, 2010). It is ranked first as the cause of disease-related pig mortality, with epidemics characterized by a high case fatality rate, often up to 100 per cent (WOAH, 2020). Globally, ASF is a notifiable disease due to its transboundary nature, with severe global socio-economic impact (Lee *et al.*, 2021). It is highly contagious with the ability to spread over long distances and survive on fomites (Penrith *et al.*, 2013; WOA, 2020). In Africa, from 1989 to 2017, about 35 African countries including Nigeria, were reported to have suffered ASF outbreaks (Penrith *et al.*, 2019).

In Nigeria, the main transmission pathway is the domestic pig transmission cycle, driven by several factors, which include socio-economic factors, limited knowledge among farmers about pig management, poor feeding habits, and restricted access to veterinary services. All these factors undermine the pig producers' capacity to implement effective control measures for better management of ASF (Penrith *et al.*, 2019). Thus, human behaviours play a crucial role in spreading this pig disease (Fasina *et al.*, 2012; Penrith *et al.*, 2013).

In 2020, Nigeria reported 50 confirmed outbreaks of ASF in 12 states including Abia State (Chieloka and Gloria, 2021). Abia State has a high density of pig farms and a history of multiple

ASF outbreaks in recent years (Omonijo *et al.*, 2021). Since 2015, there have been numerous reported outbreaks of ASF in Abia State, including the 2015 and 2022 pig farm outbreaks in Umuahia North LGA (Omonijo *et al.*, 2021; Adenaike *et al.*, 2022). Likewise, in 2016, more outbreaks were reported in Umuahia South LGA, with cases confirmed in backyard and commercial farms (Ogbu & Ogbodo, 2018).

In general, precise and up-to-date spatial point locations of livestock farms are fundamental to assessing the potential transmission dynamics of disease through livestock populations (Ngwira *et al.*, 2024). However, very little data exists on the spatial distribution of small farms particularly in rural areas where a large percentage of livestock farms are located (Perinth *et al.*, 2013; WOA, 2021). The Geographic Information System (GIS) is a computerized information system which can show many different kinds of data on one map and enables users to analyse and interpret data on different locations plotted on a map to understand relationships, patterns and trends (Bluemke *et al.*, 2017). Since the ASF virus has high resistance to environmental conditions, together with the lack of an approved vaccine, this necessitates the use of biosecurity as the only effective tool for prevention. Hence, this study aimed to determine spatial point locations of pig farms for assessing the risk of future outbreaks, while evaluating the level of biosecurity measures in commercial pig farms located in Umuahia South, Abia State.

## Materials and Methods

### Background of Study Area

The study was carried out in Olokoro and Ubakala communities, in the Umuahia South Local Government area of Abia State. Umuahia South Local Government has an area of 140 km<sup>2</sup>

and a population of 138,570 (NPC, 2006). Its headquarters is located in Apumiri town, Ubakala. Umuahia South is located within Longitude 7°22 – 7°33E and Latitude 5°26 – 5°34N, geographically. It is bounded in the north by Umuahia North, South by Isiala Ngwa, East

by Ikwuano, and West by Obowo and the Imo River. It is located within the tropical rainforest belt of Nigeria (Onumadu *et al.*, 2014). Agriculture is the main occupation, with indigenes rearing crops such as cassava, yam, maize and fruits. Palm oil production is also common. Also, livestock rearing such as piggery, poultry, and goat rearing is very common (Onumadu *et al.*, 2014).

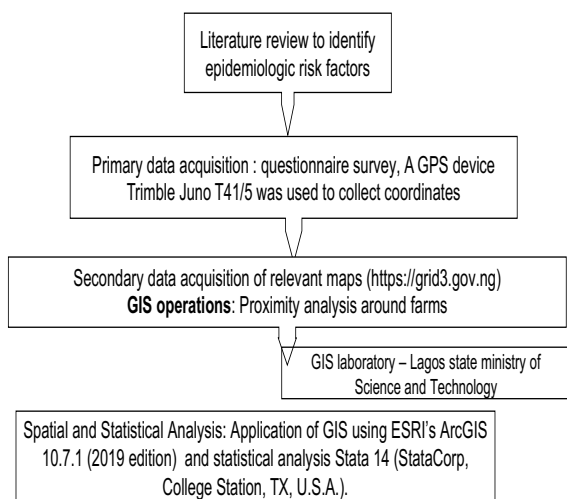


Figure 1. Flow chart showing study design

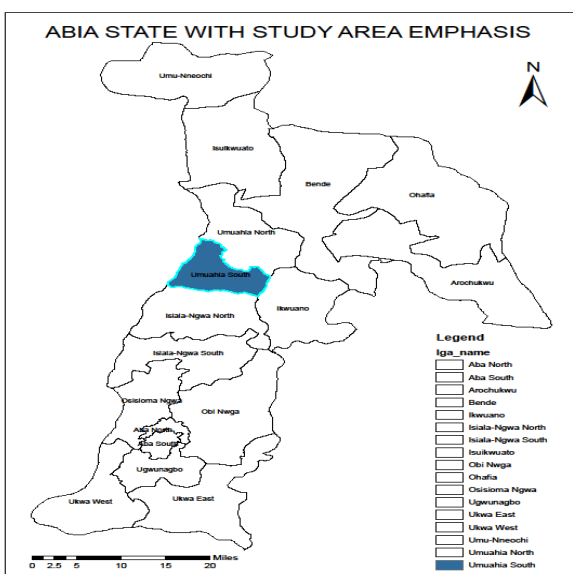


Figure 2. Abia state administrative map highlighting study area in blue.

### Criteria for selecting the study area

The study area was selected due to the May 2020 outbreak that was reported by the National Veterinary Research Institute (NVRI) in Abia State <https://dailyassest.ng/african-swine-fever-hits-abia/>.

### Participant Selection and Development Testing and Validation of the Semi-structured questionnaire (Interview guide)

The target population includes pig farmers in Olokoro and Ubakala communities, in Umuahia South LGA, in Abia State, categorized by farm size (pig population):

- **Smallholder farms:** Fewer than 50 pigs
- **Medium holder farms:** 50 to 100 pigs
- **Large holder farms:** Over 100 pigs

A cross-sectional survey of pig farms across Olokoro and Ubakala communities, in Umuahia South LGA, in Abia State was conducted from April to December 2022. The sample size for simple random sampling was calculated using the formula (Choran, 1977).

$$Sample\ size = \frac{(Zscore)^2 \times p \times (1 - p)}{(d)^2}$$

where 95% – Z Score is 1.96, p is the proportion of the population possessing the desired attribute (i.e., pig farmers), assuming 50% of the population and d is the desired precision of 5%. The required sample size was 384, however, only 180 questionnaires were completed by commercial pig farmers who willingly participated in the study.

A structured questionnaire was developed, divided into three parts:

Part A: Background Information

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Part B: Risk Factors for farm level infection

Part C: Biosecurity Measures/Management Practices

The questions were developed through a comprehensive literature review of the epidemiology and biosecurity measures of ASF.

### Questionnaire validation

**Validation Process:** The questionnaire was validated through expert review to ensure that it accurately captures relevant data. Feedback from experts was incorporated into the final version.

**Pre-testing:** A pre-test was conducted with a sample of 20 pig farmers from different farm sizes to assess the clarity and relevance of the questions. This pretest helped to identify any ambiguities or difficulties in understanding the questions, as well as the willingness of the farmers to participate.

### Data Collection

Data were collected using the interview schedule method, i.e. interviewer-administered questionnaire, where the interviewer verbally asked all the questions (Harvey, 2012). The interviewer explained the purpose of the study and obtained informed consent before proceeding.

A GPS device (Trimble Juno T41/5) was used to collect the coordinates of farm locations. Only 120 farm coordinates were captured with the GPS device.

### Statistical Analysis

### Results

Demographic data: The majority 85% (153/180) of our respondents were males, 79.44% (143/180) of whom had secondary level education. Farming

### Scoring of responses

Scoring System: Each question was scored based on its relevance to ASF risk factors and biosecurity practices. For binary questions (Yes/No), a score of 1 was assigned for "Yes" and 0 for "No."

Equal Weights: All questions carried equal weight, contributing equally to the overall assessment of farm risk factors and biosecurity measures. For instance, a farmer with a higher score indicates better biosecurity practices or higher risk factors associated with ASF.

Descriptive statistics was used to summarize the demographic, farm characteristics and potential risk factors of African Swine Fever. The relationship between ASF potential risk factors and the occurrence of ASF outbreak was assessed using Pearson's  $\chi^2$  or Fisher's exact tests. All P values less than ( $<0.05$ ) were considered to be statistically significant. All the statistical calculations were performed using Stata14 (StataCorp, College Station, TX, U.S.A.).

### Spatial Analysis

Relevant geospatial data from the internet web (<https://grid3.gov.ng/state/abia>) and GPS coordinates from Excel were imported into Environmental Systems Research Institute's (ESRI's) ArcGIS 10.8 (2019 edition) to perform several operations including proximity analysis i.e. buffering operations around pig farms and spatial regression analysis. The analysis was carried out at the Lagos State Ministry of Science and Technology, Lagos, Nigeria.

was the primary occupation of 50% (90/180), and the number of pigs on the farm varied between 1-



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**Table 3. Potential Risk Factors of African Swine Fever in Pig Farm in Umuahia South**

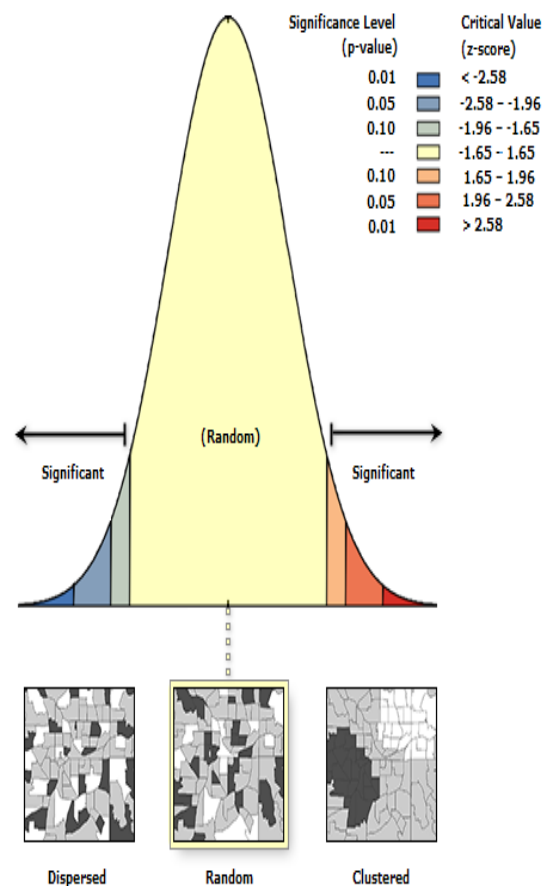
Variable	Category	Observation	Frequency	(%)
How do you market your pig		118		
	Buyers come to the farm	112	94.92	
	Slaughter at home	3	2.54	
	Take to the market	3	2.54	
Experienced outbreak		118		
	Yes	94	79.66	
	No	24	20.34	
How did you confirm the outbreak		95		
	Personal judgement	76	80	
	Consult Veterinarian	12	12.63	
	Others	7	7.37	
Outbreak reporting		95		
	Nil	79	83.16	
	State ministry/Veterinarian	16	16.64	
Post Outbreak measures		95		
	Disinfect & restock	54	56.84	
	Abandoned piggery	38	40	
	Restock only	3	3.16	
Carcass disposal method		94		
	Burn/bury	84	89.36	
	Sold	10	10.64	
Complete loss post-outbreak		94		
	yes	10	10.64	
	No	84	89.36	
Neighbouring farm outbreak		115		
	Yes	113	98.26	
	No	2	1.74	
Use of foot dips		118		
	Yes	68	57.63	
	No	50	42.37	
Visiting other farms		117		
	Yes	45	38.46	
	No	72	61.54	
Contact wild birds/rodent		118		
	Yes	29	24.58	
	No	89	75.42	
Presence of ticks		118		
	Yes	40	33.9	
	No	78	66.1	
Borrowing equipment		118		
	Yes	7	5.93	
	No	111	94.07	

confirming outbreaks by personal judgment (80%, 76 out of 95) (Table 3).

The univariate analysis of potential risk factors with ASF outbreak revealed, no significant association between potential risk factors and the occurrence of outbreak. (Table 4).

Only 120 pig-farm point locations were captured for this study. The spatial autocorrelation with a Moran's Index (I) value of (- 0.018342), which is very close to zero, suggests that there are no clear

spatial patterns in the residuals, i.e. randomly distributed pig farm pattern.



**Figure 5: Spatial autocorrelation graph of pig farms affected by African Swine Fever in Umuahia South**

The spatial regression analysis showed that the coefficient for Complete Losses (0.733) was statistically significant ( $p = 0.00328$ ), suggesting that farms that experienced complete losses were strongly associated with the ASF outbreaks. Variables such as neighbouring farm outbreaks, use of foot dips, visiting other farms, and contact with wild birds/rodents have  $p$ -values  $> 0.05$ , indicating that they do not significantly contribute to ASF outbreaks.

**Table 4: Chi-square analysis of potential risk factors with the reported occurrence of African Swine Fever outbreaks in Umuahia South, Abia State (N = 180)**

Variable	Category	Frequency	(%)	P value
Farm location				0.362
	Olokoru	24	89	
	Ubakala	125	72	
Type of farm				0.723
	Extensive	78	84	
	Intensive	69	82	
	Mixed	2	67	
Source of pigs				0.52
	Inter-state	76	84	
	Neighbouring farm	35	85	
	Own farm replacement	38	78	
Type of pigs				0.066
	Mixed	147	84	
	Exotic	1	100	
	Local	1	33	
How pigs are sold				0.433
	Buyers come to the farm	139	83	
	Slaughter at home	5	100	
	Taken to market	5	71	
Number of pigs on the farm				0.532
	1 to 20	32	86	
	21 to 50	41	82	
	51 to 100	36	77	
	> 100	40	87	
Foot dips				0.341
	Yes	86	85	
	No	63	80	
Frequency of foot dip change				0.835
	Everyday	1		
	Weekly	83	85	
	Other	1		
Frequency of visits to other farms				0.599
	Everyday	1		
	Weekly	8	80	
	very rare	43	80	
Contact with wild birds/rodents				0.72
	Yes	34	81	
	No	115	83	
Presence of ticks on farm				0.329
	Yes	52	87	
	No	97	81	
Borrowing of equipment				0.193
	Yes	16	94	
	No	133	82	

**Table 5: Spatial regression analysis for pig farms affected by African Swine Fever in Umuahia South**

Variable	Coefficients	Standard error	Probability
intercept	0.70108	0.773537	0.363202
Complete losses post-outbreak	0.733111	0.242342	0.003280*
Neighbouring farm outbreak	0.094522	0.718205	0.895597
Use of foot dips	0.186124	0.161615	0.252653
Visiting other farms	-0.02625	0.157019	0.86762
Contact wild birds/rodent	0.106324	0.264113	0.688271

(\*Significant at  $p < 0.05$ )

The geospatial regression data in Figure 6. reveals the probabilities of ASF outbreaks in 120 pig farms located in the study area. Farms located in Mbara Akuma indicate a higher probability of an outbreak, followed by farms located in Ama Igbo, while, farms located in Nsudimo and Ama Akama show a lower probability of an ASF outbreak. Additionally, given that distance from other farms and their sizes - over a 3 km distance radius is low risk for most airborne diseases including ASFV (Li et al., 2023), and other natural routes of transmission (WOAH, 2020).

Accordingly, the geospatial data in Figures 7, 8 and 9 shows 750m, 1000m and 1500m proximity analysis, respectively. At 750m farm-point buffer distance, we observed spatial aggregation of pig farms distributed into six groups.

Likewise, at 1000m farm-point buffer distance, we observed spatial aggregation of pig farms distributed into five groups, and at 1500m farm-point buffer distance, we observed spatial aggregation of pig farms in one group.

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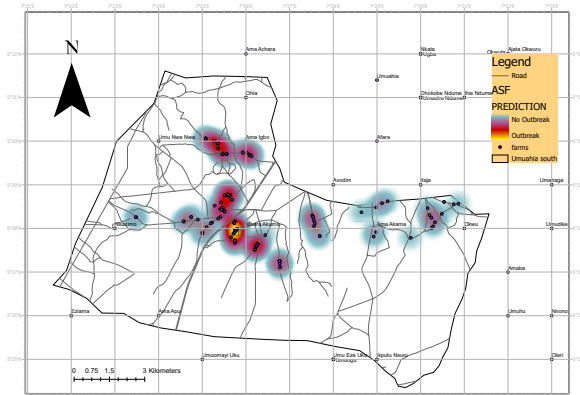


Figure 6: Spatial regression showing prediction of African Swine Fever outbreak in the study area, Umuahia South, Abia State.

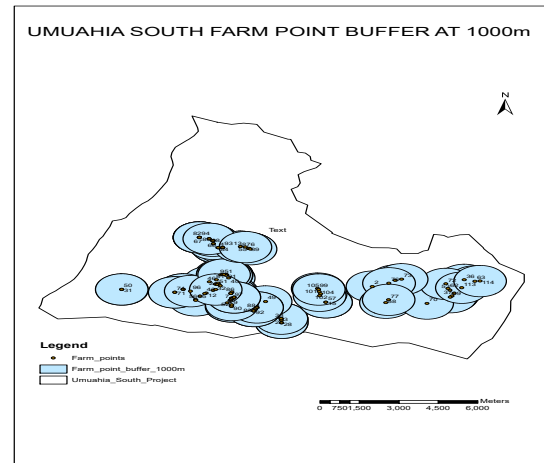


Figure 8. The 1000m farm-point buffer distance of 120 pig farms in Umuahia south

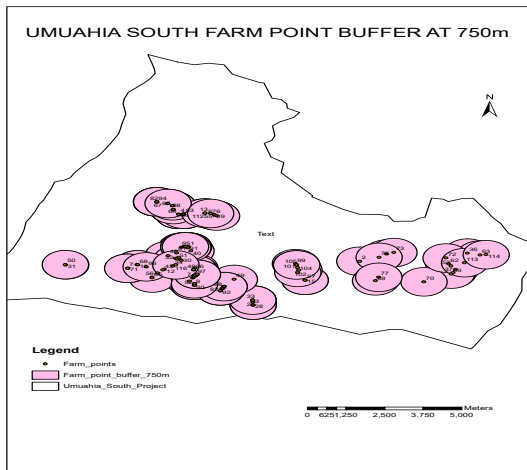


Figure 7. The 750m farm-point buffer distance of 120 pig farms in Umuahia south

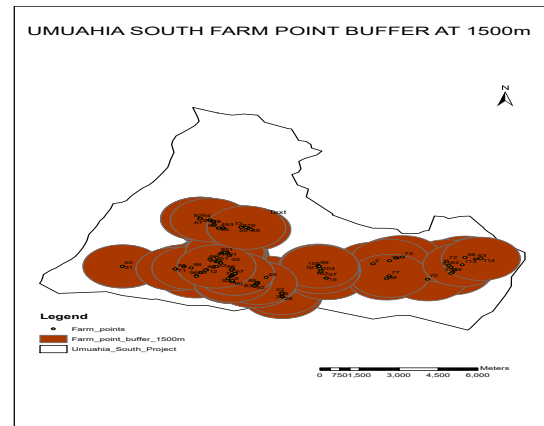


Figure 9. The 1500m farm-point buffer distance of 120 pig farms in Umuahia south

## Discussion

In this study, we assessed the biosecurity practices of selected pig farms in ASF outbreak communities in Umuahia South, Abia state. The demographic data shows that most of the respondents were males (85%), with farming as their primary occupation 50%, is supported by the reports of Igwe et al., (2013) in Aba and Umuahia north, 52% males and 65% farming as their primary

occupation. Similarly, Osondu et al., (2014) indicated 81.66% male pig farmers in six LGA in Abia state. The implication is that pig farming in Abia state may be a male-dominated industry, and expert opinion for sub-Saharan Africa suggests that women provide most of the labour associated with biosecurity, more than their male counterparts (Njuki and Sanginga 2013).

Therefore, greater efforts should be made to encourage increased participation of women in the industry. Additionally, this study revealed that 79.44% (143/180) of respondents had secondary level education, which is a little higher than the 76.67% reported for a study six LGA in Abia state (Osondu et al., 2014). High literacy levels hold promises for success for technical training and veterinary extension services in biosecurity measures in Abia state.

Notwithstanding that Nigeria and Malawi ranks first in pig population in Africa (FAO, 2023), however, like in most African countries, a majority of the pig population is raised by smallholders under extensive/semi-intensive systems in rural communities (Perinth et al., 2013; WOA, 2021). Consequently, the average herd size of 2-150 pigs (21% to 28%) observed in this study, coupled with the 51.67% (94/180) practice of extensive farming system, suggest a high presence of small to medium scale farming across the study population (Fasina et al., 2012; Ogundijo et al., 2023; Weka et al., 2023). Studies have shown that this system is usually characterized by minimum or no biosecurity systems in place (Perinth et al., 2013; Mutua and Dione, 2021).

Abia State is a region with a high density of pig-rearing facilities, with a history of multiple ASF epidemics in recent years (Omonijo et al., 2021). This is supported by the survey results which showed that 80% (144/180) of the farms experienced outbreaks. Additionally, 98% (113/115) of neighbouring farms reported outbreaks following an outbreak on a nearby farm. However, all biosecurity factors evaluated in

the univariate and spatial regression analysis did not support this, as they were not statistically significant. This limitation in the study may be attributed to the sample size, as it directly affects the statistical power of the analysis (Columb and Atkinson, 2016). Further studies with larger datasets may be needed to refine these findings. Even so, the proportion of some biosecurity factors was worthy of note, including the selling pigs on the farm (95%, 112/118) and confirming outbreaks by personal judgment (80%, 76 out of 95). These factors particularly, the pig farmer/pork producer production networks being characterized by outright deals among farmers and brokers, plays a crucial role in the spread of the virus (Penrith et al., 2013; WOA, 2020).

Precise and up-to-date spatial point locations of livestock farms are fundamental to assessing the potential transmission dynamics of disease through livestock populations (Bluemke et al., 2017; Ngwira et al., 2024). This study generated global positioning system (GPS) coordinates of 120 pig farms in Umuahia South, Abia state, which is a significant step towards the development of a spatial database to support epidemiological evaluation of the threat criteria that lead to African swine fever (ASF). The GPS technology improves the precision of disease reporting, which enhances contact tracing and delineation of hotspots for disease control. Given the minimum 3 km protection zone required for disease prevention and control (EC, 2020), we observed spatial aggregation of 120 pig farms distributed into six, five and one group patterns, just within minimum farm-distance buffers of 750m, 1000m and 1500m

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respectively. These results undermine the pig producers' capacity to apply effective interventions and heighten the risk of contact transmission, considering that in Nigeria, the main transmission pathway is the domestic pig transmission cycle (Penrith et al., 2019). This spatial aggregation is supported by Adedeji et al., (2021), who reported the practice of cluster farming by a large percentage of pig farmers and lends support to our results of 98% (95% CI: 95,100) reported as the occurrence of neighbouring farm outbreaks following a nearby farm outbreak. Additionally, this reveals the violation of the 3 km protection zone and reflects the rurality of the study area, suggesting a high density of smallholder farms in the study area.

Conversely, the observed spatial autocorrelation, which suggests a randomly distributed spatial pattern of pig farms could be attributed to the sample size of the recorded risk factors or the omission of

certain risk factors not included in the questionnaire survey.

### Conclusion

This study highlights that biosecurity gaps in the study area may be linked to the spatial clustering of pig farms. This clustering compromises the 3 km protection zone, increasing the potential for contact-based transmission—the primary transmission cycle of ASF in Nigeria. The continuous dissemination of the ASF virus among pig farms that frequently interact, where conventional biosecurity measures are ineffective, suggests that without radical interventions, eradication and effective management remain long-term challenges at best. Additionally, since the demographic data indicate that the majority of the respondents possess a secondary education, there is potential for successful awareness campaigns and veterinary extension services within the community.

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