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Investigating the Correlation between Stocking Density and Respiratory Diseases in Poultry

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Abstract | A study evaluated the connection between small poultry farm stock density and respiratory problems of poultry by monitoring 500 birds across 10 farms with different space allocations from 8 to 18 birds/m^2 over two months. The study measured environmental parameters which included temperature, humidity, ammonia levels, and air quality alongside microbiological evaluations of sick birds that tested positive for Mycoplasma gallisepticum, Escherichia coli and Infectious Bronchitis Virus (IBV). A statistical analysis revealed that the positive relationship between respiratory diseases and bird concentration levels had a significant statistical correlation of $r = 0.943$ ($p < 0.001$) with a 1.42% increased disease occurrence for each unit increase in population density. Ammonia levels increased together with poor building ventilation played a contributing role in this issue. The study shows poultry must be stocked at maximum density rates of 12 birds per square meter with better environment controls and intensified biosecurity practices to minimize respiratory infections and guarantee improved welfare.

Keywords | Stocking density, Poultry respiratory diseases, Ammonia levels, Ventilation quality, Disease prevalence

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INTRODUCTION

The world agricultural sector observes poultry production grow extremely fast as it maintains essential roles for food security alongside economic development (Grafl t al., 2020). Recent analyses by Hsu *et al.* (2024) and Govindarajan *et al.* (2023) emphasize that the rapid expansion of poultry systems globally demands careful health and welfare management to sustain economic benefits. The quick development of intensive poultry farming has generated multiple health troubles which lead to severe harm to flock health while impacting both productivity and profitability (Johnson, 2019; Kadham *et al.*, 2023). Such respiratory diseases in poultry present multiple dimensions because they reflect simultaneous involvement of pathogens, environmental conditions, and management procedures. Studies by Karupusamy *et al.* (2023) and Saadh *et al.* (2024) highlight that stocking density stands among the primary components which trigger negative effects on both animal welfare and health outcomes in poultry systems (Chanie *et al*., 2009).

The combination of high population density leads to both stress and inadequate ventilation, elevated ammonia levels, and increased pathogen transmission, thus producing more severe respiratory diseases (Erasmus, 2017; Al-Saadi and Shwan, 2024; Ahmad et al., 2022). The density of stock directly modifies the housing environment of poultry facilities. High-density stocking makes ventilation systems work less effectively at maintaining proper air circulation, thus increasing levels of dust, carbon dioxide, ammonia, and moisture (Alhaqmuhamad et al., 2019; Zangana *et al*., 2022; Alani and Kawan, 2024). The microenvironment conditions under such circumstances become more favorable to *Mycoplasma gallisepticum*, *Escherichia coli*, and avian influenza viruses (Madilindi *et al*., 2018; Noman and Ahmad, 2023; Ahmad and Noman, 2023). Birds in crowded situations come into close contact with each other, which enhances the fast transmission of infections. Additionally, lasting stress in confined areas weakens immune systems, making birds more vulnerable to disease outbreaks (Abo Ghanima, 2020; Ahmad *et al*., 2024; Ahmad, 2023).

The spread of respiratory infections compromises poultry health, elevates death rates, decreases growth performance, and causes major economic damage through meat quality decline and increased veterinary costs (Roque *et al*., 2015; Laylani *et al*., 2024; Ahmad, 2025). Research into poultry health responses from crowding conditions remains inconclusive due to differences in species, breeds, management styles, and regional factors (Petek *et al*., 2014; Mohamad *et al*., 2025; Ramadhan *et al*., 2025). Some scientists argue that adequate biosecurity and ventilation systems can mitigate these negative impacts, but there is a lack of large-scale, standardized data across different regions (Moffo *et al*., 2020; Saadoon *et al*., 2025; Saed *et al*., 2024).

The current research strives to examine the relationship between stocking density and poultry respiratory disease through an analysis of farm-level data, environmental factors, and reports of disease prevalence (Hassan *et al*., 2016; Abdulateef *et al*., 2024; Abed *et al*., 2024). Through this research, we hope to ascertain if increased stocking densities are significantly related to higher levels of respiratory disease incidence and identify threshold levels at which stocking density has an adverse effect on poultry health (Stygar *et al*., 2020; Thabet and Alsalame, 2024; Alsalame and Laylani, 2024). The outcomes will provide useful insights for poultry farmers, veterinarians, and policymakers to adopt ideal stocking density recommendations that promote healthy poultry production and achieve maximum productivity (Munir *et al*., 2017; Abdulnabi *et al*., 2024; Alsalame, 2019; Al-Aameli et al., 2019). Finally, this study aims to contribute to more sustainable and ethical poultry farming practices that ensure animal welfare and economic sustainability (Ellakany *et al*., 2019).

MATERIALS AND METHODS

This research was aimed at exploring the relation between stocking density and respiratory infections in poultry to keep the number of samples convenient for a research paper by maintaining it on the scale of a small-scale farm (Ebeid *et al*., 2019). The investigation involved 10 poultry farms of the regional neighborhood selected by adopting purposive sampling, ensuring each farm differed by its level of stocking density. The farms comprised broiler and layer operations to gain a wider perspective of respiratory ailments among poultry species.

Sample selection

All the 500 birds were seen across these 10 farms, ranging in stocking densities from 8 to 18 birds per square meter (Roque *et al*., 2016). Observation birds were of 4 to 8 weeks of age because this age was found to be highly susceptible to respiratory infections. Selection of the farms was informed by the consent of the farmers to participate as well as to offer records for flock health as well as flock management practices.

Data collection

Data recording was done for two months, providing sufficient observation time for respiratory symptoms as well as environmental monitoring. The following parameters were noted:

- Stocking density: determined by weighing the birds per square meter in each house.
- Environmental conditions: temperature, humidity, ammonia levels, and the quality of ventilation were all ascertained using standard environmental monitoring equipment.
- Respiratory disease symptoms: birds were examined clinically for respiratory disease signs of nasal discharge, coughing, sneezing, head shaking, and unusual breathing sounds.
- Records of farm: history of disease, records of vaccination, and death record were taken from farm journals.

Laboratory analysis

For each farm, 10 clinical birds were selected randomly for additional laboratory testing (Carrique-Mas *et al*., 2014). Swabs were taken from the trachea and nostrils and tested on the veterinary microbiology laboratory for the usual respiratory pathogens *Mycoplasma gallisepticum, Escherichia coli*, and infectious bronchitis virus (IBV) by polymerase chain reaction (PCR) and culture.

Disease prevalence calculation

The prevalence of respiratory disease was calculated using the standard formula:

$$Disease\ prevalence\ (\%) = \left(\frac{Number\ of\ Birds\ With\ Respiratory\ Sympoms}{Total\ Bird\ Observed}\right) \times 100 \quad \ldots(1)$$

Statistical analysis

Data were collected and analyzed with SPSS version 25.0. Descriptive statistics were employed to present stocking densities, environmental parameters, and prevalence of disease (Raspa *et al*., 2020). Correlation analysis was conducted using Pearson's correlation coefficient to establish the correlation between stocking density and respiratory disease incidence. Linear regression analysis was also carried out to evaluate the predictive effect of stocking density on respiratory health indicators. A significance level of $p < 0.05$ was used as statistically significant.

RESULTS AND DISCUSSION

The subsequent tables show complete data analyzing the correlation among poultry stocking density, environmental factors, and prevalence of respiratory diseases in ten farms. Results showcase how higher bird density per square meter greatly influences respiratory health, environmental quality, and prevalence of pathogens, substantiated by findings based on correlation and regression analysis.

Stocking density and disease prevalence

Table 1 shows the correlation between stocking density and the incidence of respiratory disease in poultry on ten farms (Zhao *et al*., 2014). All ten farms had an equal sample size of 50 birds, but stocking densities varied from 8 to 18 birds per square meter. Respiratory symptoms were expressed as a percentage of birds showing symptoms out of the number observed.

The findings in Table 1 indicate a trend where higher stocking density is linked with an increasing trend of respiratory disease prevalence. At the lowest density (8 birds/m^2), disease prevalence was only 4%, whereas at the highest density (18 birds/m^2), prevalence was 28%. This indicates that overcrowding plays a significant role in the development of respiratory health problems in poultry. The results highlight that keeping stocking density levels lower can assist in decreasing respiratory disease incidence, probably because of improved quality of air, diminished stress, and enhanced general welfare conditions.

Table 1: Stocking density and respiratory disease prevalence across farms.

Farm No.	Stocking density (birds/m^2)	Total birds Observed	Birds with respiratory symptoms	Prevalence (%)
1	8	50	2	4.00
2	9	50	3	6.00
3	10	50	4	8.00
4	12	50	6	12.00
5	13	50	8	16.00
6	14	50	9	18.00
7	15	50	11	22.00
8	16	50	12	24.00
9	17	50	13	26.00
10	18	50	14	28.00

Environmental factors affecting respiratory health

Table 2 displays the environmental conditions seen at the ten farms involved in the study. Measurements of ammonia concentration, temperature, and humidity were made, together with an evaluation of ventilation quality (classed as good, moderate, or poor). Increasing ammonia concentrations and temperature, combined with decreasing ventilation quality, with rising stocking density is indicated by the data.

Table 2: Environmental conditions observed across farms.

Farm No.	Ammonia (ppm)	Temperature (˚C)	Humidity (%)	Ventilation quality (good/moderate/poor)
1	9	25	58	Good
2	10	26	60	Good
3	12	26.5	61	Moderate
4	14	27	64	Moderate
5	17	28	66	Poor
6	18	28.5	67	Poor
7	20	29	69	Poor
8	21	29.5	70	Poor
9	23	30	72	Poor
10	24	30.5	73	Poor

The findings in Table 2 point out that more densely stocked farms are likely to experience higher ammonia concentrations, higher temperatures, and greater humidity, all of which are harmful to respiratory health. Low ventilation was seen mostly in farms with greater ammonia levels (above 17 ppm). Low ammonia levels (below 10 ppm) were seen with good ventilation, illustrating that proper airflow is important in keeping the air quality better. Poor environmental conditions in high-density farms probably cause respiratory stress and an elevated disease incidence among poultry.

Links Researchers

Pathogen detection in symptomatic birds

Table 3 indicates the prevalence of the major respiratory pathogens in symptomatic birds sampled from each farm. These pathogens were *Mycoplasma gallisepticum*, *Escherichia coli*, and infectious bronchitis virus (IBV). The prevalence of mixed infections, which refer to the prevalence of more than one pathogen in a single bird, was also noted.

Table 3: Respiratory pathogens detected in birds from each farm.

Farm No.	*Mycoplasma gallisepticum*	*Escherichia coli*	Infectious bronchitis virus (IBV)	Mixed infections found
1	1	1	0	No
2	1	1	0	No
3	2	2	0	Yes
4	3	2	1	Yes
5	3	3	1	Yes
6	4	3	1	Yes
7	4	4	2	Yes
8	5	4	2	Yes
9	5	4	2	Yes
10	6	4	2	Yes

The information presented in Table 3 indicates that when stocking density in farms and environmental stress increased, there was an increase in the pathogen load and mixed infections. Farms of lower stocking density (Farm 1 and 2) showed single-pathogen infections with minimal detection numbers. However, the higher-density farms (Farms 7–10) showed multiple pathogens per bird, including *Mycoplasma gallisepticum, E. coli*, and IBV. The high prevalence of mixed infections in denser farms indicates that crowded and poor environmental conditions weaken bird immunity, exposing them to more than one respiratory pathogen and deteriorating general flock health.

Correlation analysis

Table 4 presents the correlation analysis between stocking density, ammonia concentration, and respiratory disease prevalence in poultry farms. Pearson's correlation coefficients (r) and p-values indicate the strength and statistical significance of each relationship.

The correlation analysis results in Table 4 indicate very strong and statistically significant positive relationships between stocking density, ammonia levels, and disease prevalence. The correlation between stocking density and disease prevalence ($r = 0.943$, $p < 0.001$) suggests that higher stocking density directly contributes to an increase in respiratory disease cases. Similarly, a strong positive correlation ($r = 0.908$) between stocking density and ammonia levels confirms that overcrowding leads to deteriorating air quality. Furthermore, ammonia levels themselves are strongly correlated ($r = 0.891$) with disease prevalence, demonstrating that poor environmental air quality exacerbates respiratory problems in poultry (Kühnisch *et al*., 2014). These findings reinforce the need for proper space allocation and air management to reduce disease risks.

Table 4: Correlation between stocking density, ammonia levels, and disease prevalence.

Parameters compared	Pearson's correlation (r)	Significance (p-value)
Stocking density and disease prevalence	0.943	<0.001
Stocking density and ammonia levels	0.908	<0.001
Ammonia levels and disease prevalence	0.891	<0.001

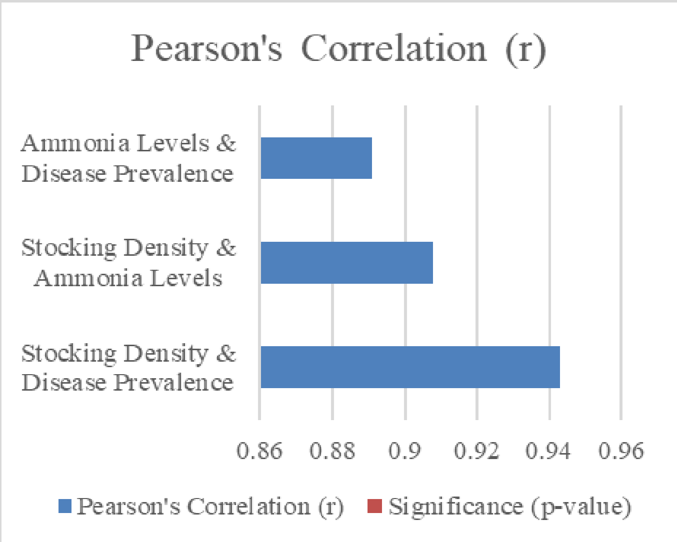

Figure 1: Graphical representation on correlation between stocking density, ammonia levels, and disease prevalence.

Regression analysis to predict disease prevalence

Table 5 displays the results of a linear regression analysis conducted to predict respiratory disease prevalence based on stocking density. The model includes the constant term, the regression coefficient for stocking density, standard error, t-values, and significance levels. The R-squared value indicates the overall explanatory power of the model.

Table 5: Linear regression model for predicting respiratory disease prevalence.

Regression parameter	Coefficient (B)	Standard error	t value	p value
Constant	2.34	0.95	2.46	0.039
Stocking density	1.42	0.10	14.10	<0.001
R-squared	0.89	—	—	—

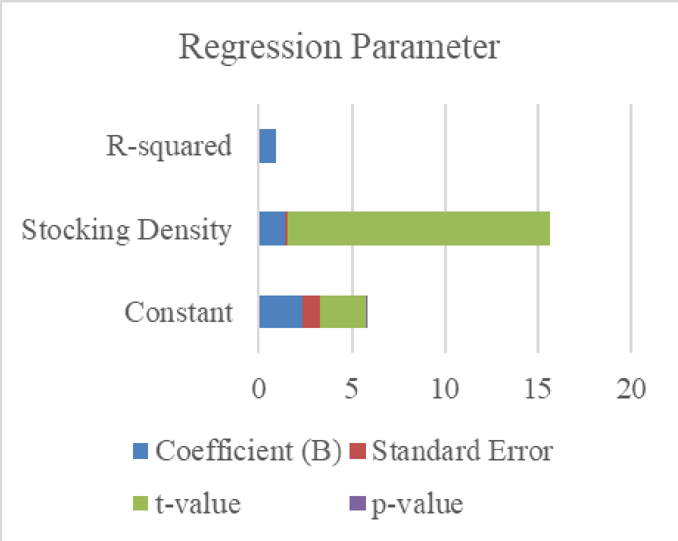

Figure 2: Graphical representation on linear regression model for predicting respiratory disease prevalence.

The analysis in Table 5 proves that poultry stocking density creates a clear and statistically significant association with respiratory illness prevalence ($p < 0.001$). Every unit increase in stocking density (birds/m^2) causes a 1.42% rise in prevalent respiratory diseases according to the coefficient value (B= 1.42). When stocking density equals zero the expected prevalence of diseases amounts to 2.34. The constructed model provides excellent results as the R-squared value reaches 0.89 so stocking density explains 89% of disease prevalence variations. Research results demonstrate how maximum poultry respiratory health depends strongly on proper cage space which remains essential for preventing diseases.

The study results strongly prove that increased poultry stocking density leads to higher levels of respiratory diseases in poultry flock populations. The increasing number of diseases shows that crowding conditions serve as a primary cause for respiratory illness. Environmental analysis demonstrates that the combination of contaminated air quality with elevated ammonia levels and insufficient ventilation stands as the fundamental causes of this issue.

Laboratory findings of simultaneous pathogens in symptomatic birds prove that high population density both boosts disease spread and damages immunity thus enabling simultaneous infections. The combined correlation and regression statistical findings validate the hypothesis showing high stocking density acts as a strong indicator of respiratory disease occurrence.

The recommended limit for poultry stocking density should not exceed 12 birds per square meter and farmers need to check air quality measurements frequently. Farm managers need to establish improved biosecurity measures and better ventilation plans as well as reduce stress elements to prevent respiratory infections. The research results serve to assist policymakers together with extension workers in providing training to small-scale poultry farm operators about disease prevention strategies along with animal welfare concepts.

CONCLUSIONS AND RECOMMENDATIONS

The research study shows that excessive stocking density within poultry operations leads to elevated respiratory disease occurrence because of unhealthful atmospheric conditions and mounting ammonia concentrations together with ventilation limitations (Akter *et al*., 2016). Birds living in crowded conditions became more susceptible to *Mycoplasma gallisepticum, Escherichia coli*, and IBV infections which led to intricate infections that harmed flock health status. The analysis of stock density relationships using regression shows high positive correlations that reveal density counts as the main trigger for respiratory problems. The recommended management practice for farmers includes stocking their facilities with no more than 12 birds per square meter while maintaining proper ventilation and conducting regular environmental checks and practicing enhanced biosecurity standards alongside adopting effective vaccination methods to secure poultry health and welfare.

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NOVELTY STATEMENT

This study stands out because it performs extensive research which directly links poultry stocking density to respiratory diseases while using field observations and environmental monitoring and laboratory pathogen identification and statistical modeling. Studies of past generalizations are outdone by this innovative research which shows that raising stocking density level leads to increased disease prevalence while statistical testing ($r = 0.943$) confirms this trend. The inclusion of environmental data about ammonia concentration and ventilation quality expands understanding of overcrowding effects because it shows how density both increases pathogen numbers and degrades air quality which leads to serious respiratory health problems for poultry.

AUTHOR'S CONTRIBUTION

All of the trials were designed by NQA, RAD and AMSA-M. STJ, AA and AMA conducted all of the tests, gathered the data, and composed the manuscript draft. FJH helped with the data analysis that was done to prepare the work for submission to the journal. The final draft of the work was reviewed and approved by all authors for publication in the Journal of Animal and Health Production.

Ethical consideration

Not applicable.

Conflict of interest

The authors state that there is not conflict of notice.

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