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Article

# Epizootological Monitoring and Age-Related Dynamics of Colibacteriosis and Pullorosis in Poultry

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**Abstract:** This study presents the results of an epizootological assessment of Pullorum dis-ease, Colibacillosis, and their mixed infections across different age groups of poul-try in two commercial farms of the Republic of Karakalpakstan. The investigation was conducted during the first quarter of 2026 at "Agro Biznes Qanliko'l" LLC (Qonliko'l district) and "Kungrad Golden Egg" LLC (Qo'ng'irot district). A total of 1,750 Lohmann Brown Classic layer chickens were included in epizootological monitoring: 1,000 birds from "Agro Biznes Qanliko'l" LLC and 750 birds from "Kungrad Golden Egg" LLC. The examined birds were distributed into four age groups: 1–9 weeks, 10–17 weeks, 18–25 weeks, and older than 26 weeks. For each age group, the overall morbidity rate and the individual occurrence of Pullorum disease, Colibacillosis, and mixed infections were evaluated separately. The overall morbidity rate was 10.7% at "Agro Biznes Qanliko'l" LLC and 8.9% at "Kungrad Golden Egg" LLC. In both farms, the highest morbidity was recorded in 1–9-week-old chicks, reaching 15.2% and 12.0%, respectively, with a progressive decline in older age groups, converging to 6.0% in birds older than 26 weeks. Mixed infec-tions constituted the dominant disease form in younger birds at "Agro Biznes Qanliko'l" LLC (4.8%), while Pullorum disease alone was more prevalent at "Kungrad Golden Egg" LLC (4.4%). Chi-square analysis confirmed a statistically significant association between age group and morbidity at "Agro Biznes Qanliko'l" LLC ($\chi^2$ = 13.47, df = 3, p = 0.004), while no statistically significant in-ter-farm difference was identified ($\chi^2$ = 1.494, p = 0.222). Binary logistic regression identified age as an independent predictor of morbidity: compared with 1–9-week-old chicks, birds older than 26 weeks demonstrated markedly reduced odds of dis-ease occurrence (OR = 0.395; 95% CI: 0.249–0.625; p < 0.001). The findings pro-vide a scientific basis for identifying age-related risk groups, improving epizooto-logical monitoring, and developing targeted veterinary-sanitary preventive measures based on age-related susceptibility in poultry farms of the Republic of Karakalpakstan.

**Keywords:** Pullorum disease, Colibacillosis, poultry, epizootological monitoring, age groups, Salmonella Pullorum, Escherichia coli, mixed infection, logistic regression.

**Introduction**

The poultry industry constitutes a strategically important sector of agricultural production, providing the population with essential protein-rich food products, par-ticularly eggs and poultry meat. However, infectious bacterial diseases in commer-cial poultry farms continue to cause substantial economic losses through reduced productivity, elevated treatment costs, and increased mortality rates, especially among young birds [1]. Among the most epidemiologically significant bacterial in-fections affecting poultry are Pullorum disease and Colibacillosis, both of which can occur independently or as concurrent mixed infections, thereby further compli-cating disease management and control [2].

Pullorum disease is a contagious bacterial infection of poultry caused by Sal-monella enterica serovar Gallinarum biovar Pullorum, a host-adapted pathogen of considerable veterinary importance. Despite advances in biosecurity and sanitary measures, the disease continues to be of significant economic relevance in many countries. In young chicks, the clinical course is particularly severe and is charac-terized by weakness, profuse diarrhea, stunted growth, and high mortality rates. A major epidemiological challenge associated with this disease is the persistence of infection through vertical transmission via contaminated eggs, as well as the pres-ence of asymptomatic carrier birds in affected flocks, which substantially compli-cates early detection and elimination efforts.

Colibacillosis is caused by pathogenic strains of Escherichia coli and repre-sents one of the most economically significant bacterial diseases in commercial poultry production worldwide. The pathogen affects multiple organ systems, pro-ducing inflammatory lesions in the respiratory tract, intestines, pericardium, peri-hepatitis tissues, and other visceral organs. Avian pathogenic E. coli is associated with increased mortality, reduced productivity, and elevated food safety risks, re-sulting in considerable financial losses for producers [3][4].

The disease may develop as a primary infection or as a secondary complica-tion following exposure to environmental stressors, including suboptimal housing conditions, inadequate ventilation, excessive dust concentrations, compromised feed and water quality, and concurrent infectious agents. A growing concern in con-temporary poultry production is the emergence and spread of antimicrobial re-sistance among bacterial pathogens. The extensive use of antimicrobial agents in poultry production systems has been recognized as a significant driver of resistance development, posing serious threats to animal health, food safety, and public health [5].

In particular, the acquisition of multidrug resistance by certain strains of Esch-erichia coli and Salmonella Pullorum substantially reduces therapeutic efficacy, complicates the implementation of preventive programs, and necessitates the rein-forcement of evidence-based veterinary management strategies [6]. Epidemiologi-cal surveillance data from European countries, including France and Russia, have documented varying levels of antimicrobial resistance in E. coli strains isolated from poultry and food-producing animals, emphasizing the need for continuous and systematic microbiological monitoring [7][8][9][10].

In the context of expanding poultry production in Uzbekistan, early detection of infectious diseases, assessment of their prevalence across specific age groups, and characterization of local epidemiological patterns are of increasing practical importance. The Republic of Karakalpakstan, as a region with specific ecological characteristics, warrants particular attention in this regard. According to Rakhmato-va et al. [11][12], the territory of Karakalpakstan was among the areas most fre-quently affected by dust and sand storms during the period 2010–2023. Such envi-ronmental conditions may negatively affect the immunobiological resistance of young poultry, promote the proliferation of opportunistic microorganisms, and in-crease the risk of horizontal disease transmission within flocks. These ecological factors may be considered as additional predisposing conditions for the develop-ment and spread of bacterial infections, particularly in younger age groups with in-complete immunological development [13][14].

Given the foregoing, the analysis of age-specific morbidity rates — separately for the 1–9-week, 10–17-week, 18–25-week, and older than 26-week age categories — is of considerable epidemiological value for the accurate identification of risk groups and the rational planning of preventive veterinary measures against Pullo-rum disease, Colibacillosis, and their mixed infections in poultry farms of the Re-public of Karakalpakstan.

The aim of the present study was to conduct an epizootological assessment of the prevalence of Pullorum disease, Colibacillosis, and their mixed infections across different age groups of poultry in selected commercial farms of the Republic of Karakalpakstan.

**Materials and Method**

The present study was conducted during the first quarter of 2026 at two selected commercial poultry farms of the Republic of Karakalpakstan: "Agro Biznes Qanliko'l" LLC, located in Qonliko'l district, and "Kungrad Golden Egg" LLC, located in Qo'ng'irot district. These farms were selected based on their representativeness of intensive layer poultry production under the ecological conditions of the region.

The study subjects were Lohmann Brown Classic layer hens and chicks maintained under commercial production conditions. "Agro Biznes Qanliko'l" LLC maintains a total of 30,000 laying hens; during the monitoring period, 1,000 birds representing different age categories were included in the epizootological assessment. "Kungrad Golden Egg" LLC maintains 28,000 laying hens, of which 750 birds were included in the monitoring survey. In total, 1,750 birds across two farms were examined.

For the purpose of epizootological analysis, the examined birds were categorized into four age groups: 1–9 weeks (young chicks), 10–17 weeks (growing birds), 18–25 weeks (pre-production pullets), and older than 26 weeks (adult laying hens). This classification was applied to identify age-specific risk periods and to assess the occurrence of Pullorum disease, Colibacillosis, and their mixed infections across distinct physiological stages of poultry development.[15]

During farm visits, comprehensive epizootological data were collected, including the overall veterinary and sanitary conditions of each farm, microclimatic parameters (temperature, humidity, ventilation), implementation of prophylactic vaccination programs, age-specific disease incidence, clinical signs, and mortality records. Farm records indicated that prophylactic vaccination against Infectious Bursal Disease and Avian Influenza had been administered at both farms.

Clinical evaluation focused on the following signs: lethargy and weakness, reduced feed and water intake, ruffled feathers, profuse diarrhea, stunted growth, respiratory distress, behavioral changes including huddling, decreased productivity, and increased mortality. In cases of suspected Colibacillosis, particular attention was paid to signs of respiratory distress, systemic toxicity, and perihepatitis. In cases of suspected Pullorum disease, weakness, whitish diarrhea, and age-related developmental delay were assessed as primary indicators.[16]

Disease cases were recorded in three categories: birds exhibiting clinical and epizootological signs characteristic of Pullorum disease; birds exhibiting clinical and epizootological signs characteristic of Colibacillosis; and cases of mixed infection, in which both diseases were identified concurrently based on combined clinical and epizootological evaluation.

Laboratory analyses were performed at the Nukus Branch of the Samarkand State University of Veterinary Medicine, Animal Husbandry and Biotechnology. Pathological material collected from clinically affected birds under aseptic conditions was subjected to bacteriological and microbiological examination. Samples were inoculated onto appropriate differential and selective culture media. Primary identification of isolated microorganisms was based on colony morphology, cultural characteristics, microscopic appearance, Gram staining results, and key biochemical and biological properties. Isolates suspected of being *Salmonella* Pullorum were identified based on characteristic morphological, cultural, and serological properties, while isolates suspected of being avian pathogenic *Escherichia coli* were confirmed through morphological, cultural, and biochemical characterization.

The morbidity rate for each farm and age group was calculated as the proportion of clinically affected birds relative to the total number of examined birds, expressed as a percentage, using the following formula:

.

$$P = \left(\frac{n}{N}\right) \times 100\%$$

**where:**

**P –** morbidity rate (%),

**n –** number of diseased poultry,
**N –** total number of examined poultry.

**Statistical analysis**

The obtained data were subjected to comparative analysis across age groups and farms. To assess the statistical significance of the association between poultry age and morbidity, Pearson's chi-square test was applied, with effect size estimated using Cramer's V. To evaluate the independent contribution of age group and farm to the probability of disease occurrence, binary logistic regression analysis was performed, with morbidity status (sick/healthy) as the dependent variable. Results are reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value of less than 0.05 was considered statistically significant. The results are presented in tabular and graphical form.[17]

**Result and Discussion**

During the epizootological monitoring conducted in the first quarter of 2026, a total of 1,750 Lohmann Brown Classic layer chickens were examined across two poultry farms of the Republic of Karakalpakstan: 1,000 birds at "Agro Biznes Qanliko'l" LLC (Qonliko'l district) and 750 birds at "Kungrad Golden Egg" LLC (Qo'ng'irot district). The examined birds were distributed into four age groups: 1–9 weeks, 10–17 weeks, 18–25 weeks, and older than 26 weeks. For each age group, the overall morbidity rate and the individual occurrence of Pullorum disease, Colibacillosis, and mixed infections were as-sessed separately.

**Epizootological situation at "Agro Biznes Qanliko'l" LLC**

At "Agro Biznes Qanliko'l" LLC, 107 out of 1,000 examined birds exhibited clinical and epizooto-logical signs consistent with Pullorum disease, Colibacillosis, or their mixed infection, corresponding to an overall morbidity rate of 10.7%. The highest morbidity was recorded in 1–9-week-old chicks (15.2%), with a progressive decline in subsequent age groups: 13.0% in birds aged 10–17 weeks, 10.0% in those aged 18–25 weeks, and 6.0% in birds older than 26 weeks. In the youngest age group, mixed infection represented the predominant disease form (7.6%), followed by Pullorum disease alone (4.8%) and Coli-bacillosis alone (2.8%).

*Table 1. Prevalence of Pullorum disease, Colibacillosis and mixed infections among different age groups of poultry at "Agro Biznes Qanliko'l" LLC poultry farm*

| Age of poultry | Number of examined birds | Total number of diseased birds | Overall morbidity, % | Number of birds diagnosed with Pullorum disease only | % | Number of birds diagnosed with Colibacillosis only | % | Number of birds with mixed infection of Pullorum disease and Colibacillosis | % |
|---|---|---|---|---|---|---|---|---|---|
| 1–9 weeks of age | 250 | 38 | 15,2 | 12 | 4,8 | 7 | 2,8 | 19 | 7,6 |
| 10–17 weeks of age | 200 | 26 | 13,0 | 10 | 5,0 | 6 | 3,0 | 10 | 5,0 |
| 18–25 weeks of age | 250 | 25 | 10,0 | 9 | 3,6 | 6 | 2,4 | 10 | 4,0 |
| >26 weeks of age | 300 | 18 | 6,0 | 6 | 2,0 | 3 | 1,0 | 9 | 3,0 |
| **Total** | **1000** | **107** | **10,7** | **37** | **3,7** | **22** | **2,2** | **48** | **4,8** |

The findings presented in Table 1 confirm that morbidity declined consistently with increasing age across all disease categories, with mixed infections constituting the dominant pathological pattern in younger birds.

**Epizootological situation at "Kungrad Golden Egg" LLC**

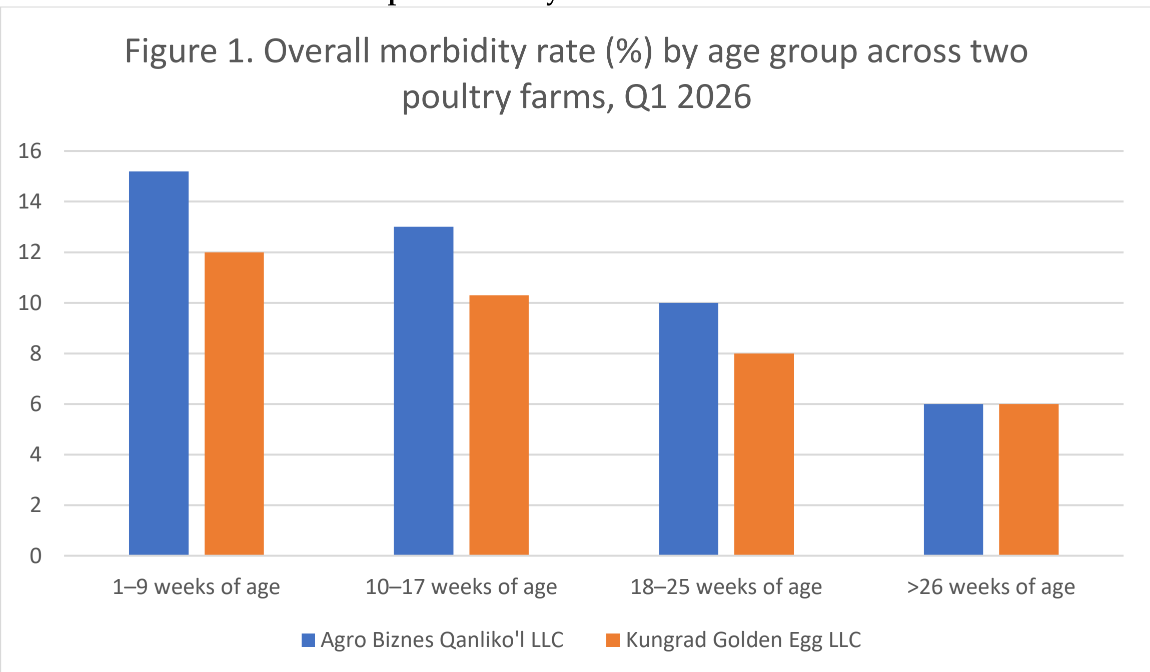
At "Kungrad Golden Egg" LLC, 67 out of 750 examined birds were classi-fied as diseased, yielding an overall morbidity rate of 8.9%. The highest morbidity was again observed in 1–9-week-old chicks (21 out of 175 birds; 12.0%), followed by a consistent age-related decline: 10.3% in birds aged 10–17 weeks, 8.0% in those aged 18–25 weeks, and 6.0% in birds older than 26 weeks. In contrast to "Agro Biznes Qanliko'l" LLC, Pullorum disease alone was the most prevalent dis-ease form at this farm (4.4%), while mixed infections accounted for 2.1% of total examined birds.

*Table 2. Prevalence of Pullorum disease, Colibacillosis and mixed infections among different age groups of poultry at "Kungrad Golden Egg" LLC poultry farm*

| Age of poultry | Number of examined birds | Total number of diseased birds | Overall morbidity, % | Number of birds diagnosed with Pullorum disease only | % | Number of birds diagnosed with Colibacillosis only | % | Number of birds with mixed infection of Pullorum disease and Colibacillosis | % |
|---|---|---|---|---|---|---|---|---|---|
| 1–9 weeks of age | 175 | 21 | 12,0 | 10 | 5,7 | 6 | 3,4 | 5 | 2,9 |
| 10–17 weeks of age | 175 | 18 | 10,3 | 9 | 5,1 | 5 | 2,9 | 4 | 2,3 |
| 18–25 weeks of age | 200 | 16 | 8,0 | 8 | 4,0 | 4 | 2,0 | 4 | 2,0 |
| >26 weeks of age | 200 | 12 | 6,0 | 6 | 3,0 | 3 | 1,5 | 3 | 1,5 |
| **Total** | **750** | **67** | **8,9** | **33** | **4,4** | **18** | **2,4** | **16** | **2,1** |

As presented in Table 2, the age-related pattern of morbidity at "Kungrad Golden Egg" LLC was consistent with that observed at the first farm, further supporting the inverse relationship between poultry age and susceptibility to bacterial infection.

**Comparative analysis between farms**




The overall morbidity rate was numerically higher at "Agro Biznes Qanliko'l" LLC (10.7%) than at "Kungrad Golden Egg" LLC (8.9%). In both farms, the highest age-specific morbidity was consistently recorded in 1–9-week-old chicks (15.2% and 12.0%, respectively), converging to an identical level of 6.0% in birds older than 26 weeks. A notable inter-farm difference was observed in the predominant disease form: mixed infections were more prevalent at "Agro Biznes Qanliko'l" LLC (4.8%), whereas Pullorum disease alone was the dominant form at "Kungrad Golden Egg" LLC (4.4%).

**Statistical analysis**

Chi-square analysis revealed a statistically significant association between poultry age group and morbidity at "Agro Biznes Qanliko'l" LLC ($\chi^2$ = 13.47, df = 3, p = 0.004, Cramer's V = 0.116), confirming that younger birds were significantly more susceptible to disease. At "Kungrad Golden Egg" LLC, the association did not reach statistical significance ($\chi^2$ = 4.746, df = 3, p = 0.191, Cramer's V = 0.080), although the descriptive trend was consistent in direction with the first farm. Comparative chi-square analysis between the two farms demonstrated no statistically significant difference in overall morbidity rates ($\chi^2$ = 1.494, df = 1, p = 0.222, Cramer's V = 0.029). All expected cell counts exceeded 5 in each analysis, confirming the validity of the applied chi-square tests.[18]

**Binary logistic regression analysis**

Binary logistic regression was performed to evaluate the independent effects of age group and farm on the probability of disease occurrence. The full model ($M_1$) demonstrated statistically significant improvement over the null model ($M_0$), with $\Delta X^2$ = 19.972, df = 4, p < 0.001 (McFadden $R^2$ = 0.018; Nagelkerke $R^2$ = 0.024), indicating that age group meaningfully contributed to predicting morbidity status.

*Table 3. Binary logistic regression model fit and coefficient estimates*

*Model Summary - status*

| Model | Deviance | AIC | BIC | df | $\Delta X^2$ | p | McFadden $R^2$ | Nagelkerke $R^2$ | Tjur $R^2$ | Cox & Snell $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $M_0$ | 1133 | 1135.390 | 1140.857 | 1749 | | | 0.000 | | 0.000 | |
| $M_1$ | 1113 | 1123.417 | 1150.754 | 1745 | 19.972 | $5.057\times10^{-4}$ | 0.018 | 0.024 | 0.011 | 0.011 |

*Note.* $M_1$ includes farm, age_group

*Coefficients*

| Model | | Estimate | Standard Error | Odds Ratio | z | Wald Test: Wald Statistic | df | p | 95% Confidence interval (odds ratio scale): Lower bound | Upper bound |
|---|---|---|---|---|---|---|---|---|---|---|
| $M_0$ | (Intercept) | -2.204 | 0.080 | 0.110 | -27.59 | 761.0 | 1 | $1.599\times10^{-167}$ | 0.094 | 0.129 |
| $M_1$ | (Intercept) | -1.741 | 0.153 | 0.175 | -11.35 | 128.8 | 1 | $7.493\times10^{-30}$ | 0.130 | 0.237 |
| | farm (Kungrad Golden Egg) | -0.215 | 0.165 | 0.806 | -1.305 | 1.703 | 1 | $1.919\times10^{-1}$ | 0.584 | 1.114 |
| | age_group (10-17) | -0.181 | 0.213 | 0.834 | -0.850 | 0.722 | 1 | $3.954\times10^{-1}$ | 0.549 | 1.267 |
| | age_group (18-25) | -0.469 | 0.216 | 0.626 | -2.171 | 4.714 | 1 | $2.992\times10^{-2}$ | 0.410 | 0.955 |

*Model Summary - status*

| Model | Deviance | AIC | BIC | df | $\Delta X^2$ | p | McFadden $R^2$ | Nagelkerke $R^2$ | Tjur $R^2$ | Cox & Snell $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | age_group (26+) | -0.930 | 0.235 | 0.395 | -3.957 | 15.66 | 1 | $7.576\times10^{-5}$ | 0.249 | 0.625 |

*Note.* status level 'sick' coded as class 1.

Using the 1–9-week age group as the reference category, birds aged 18–25 weeks demonstrated significantly lower odds of disease occurrence (OR = 0.626; 95% CI: 0.410–0.955; p = 0.029), while birds older than 26 weeks exhibited markedly reduced odds of morbidity (OR = 0.395; 95% CI: 0.249–0.625; p < 0.001). Birds aged 10–17 weeks showed a non-significant reduction in odds compared to the reference group (OR = 0.834; 95% CI: 0.549–1.267; p = 0.395). Farm of origin was not a statistically significant predictor of morbidity (OR = 0.806; 95% CI: 0.584–1.114; p = 0.192), indicating comparable epizootological conditions across both farms after controlling for age.

Overall, the results consistently demonstrated that poultry age is the primary determinant of susceptibility to Pullorum disease and Colibacillosis under the studied conditions. In both farms, 1–9-week-old chicks represented the highest-risk group, and a statistically supported progressive decline in morbidity was observed with increasing age. Farm-related differences, while numerically present, were not statistically significant, suggesting that age-associated physiological and immunological maturation exerts a greater influence on disease occurrence than farm-specific management factors under the conditions of the Republic of Karakalpakstan.

**Discussion**

The present study demonstrated that the prevalence of Pullorum disease, Colibacillosis, and their mixed infections varied significantly according to poultry age groups in the examined farms of the Republic of Karakalpakstan. In both farms, the highest morbidity rates were consistently recorded among 1–9-week-old chicks, while a gradual decrease in disease occurrence was observed with increasing age. These findings confirm that poultry age is an important epidemiological determinant of susceptibility to bacterial infections under local production conditions, which is consistent with data reported in previous studies on avian bacterial diseases.

The elevated morbidity observed in younger birds is likely associated with the incomplete development of humoral and cellular immune responses during the early post-hatching period. Young chicks are highly sensitive to environmental stressors, including fluctuations in temperature and humidity, inadequate ventilation, and sanitary-hygienic deficiencies. Furthermore, the intestinal microbiota and nonspecific immune defense mechanisms are not fully stabilized during the first weeks of life, which increases susceptibility to opportunistic and pathogenic bacterial agents such as *Salmonella* Pullorum and *Escherichia coli*. The predominance of mixed infections in the 1–9-week age group at "Agro Biznes Qanliko'l" LLC (7.6%) further supports the notion that immunologically immature birds are simultaneously vulnerable to multiple bacterial pathogens, a pattern that has been documented in commercial poultry production systems.

The results obtained at "Agro Biznes Qanliko'l" LLC revealed a statistically significant association between poultry age and morbidity ($\chi^2 = 13.47$, df = 3, p = 0.004, Cramer's V = 0.116). In contrast, although a consistent decreasing trend was observed at "Kungrad Golden Egg" LLC, the association did not reach statistical significance ($\chi^2 = 4.746$, df = 3, p = 0.191, Cramer's V = 0.080). The absence of statistical significance at the second farm, despite a similar directional pattern, may reflect farm-specific differences in stocking density, ventilation capacity, feeding regimens, sanitary protocols, or microclimatic conditions. However, these farm management variables were not independently quantified in the present study and therefore warrant separate investigation in future research.

Comparative analysis between the two farms demonstrated that the overall morbidity rate was numerically higher at "Agro Biznes Qanliko'l" LLC (10.7%) than at "Kungrad Golden Egg" LLC (8.9%); however, this difference was not statistically significant ($\chi^2 = 1.494$, df = 1, p = 0.222, Cramer's V = 0.029). This finding indicates that the overall epizootological situation across the two farms was broadly comparable during the monitoring period, despite the observed numerical differences in age-specific morbidity and disease type distribution.

A notable finding of the present study was the relatively high occurrence of mixed infections in younger age groups, particularly at "Agro Biznes Qanliko'l" LLC, where mixed infections accounted for 4.8% of all examined birds. Mixed bacterial infections may aggravate clinical manifestations, elevate mortality risk, complicate differential diagnosis, and reduce the effectiveness of targeted preventive measures. The higher proportion of mixed infections at this farm may reflect differences in biosecurity implementation, environmental microbial load, or the concurrent circulation of multiple bacterial pathogens within the flock. Concurrent bacterial infections in commercial poultry production have been recognized as a significant challenge with substantial implications for flock productivity and health management.

Logistic regression analysis further confirmed that poultry age was an independent predictor of morbidity after controlling for farm-related effects. Compared with 1–9-week-old chicks, birds aged

18–25 weeks demonstrated significantly lower odds of disease occurrence (OR = 0.626; 95% CI: 0.410–0.955; p = 0.029), while birds older than 26 weeks exhibited markedly reduced morbidity odds (OR = 0.395; 95% CI: 0.249–0.625; p < 0.001). Farm of origin was not a statistically significant predictor (OR = 0.806; p = 0.192), indicating that age-associated physiological and immunological maturation exerts a greater influence on disease susceptibility than farm-specific management factors under the studied conditions.

The progressive reduction in morbidity with increasing age may be attributed to the maturation of immune competence, stabilization of intestinal microbiota, and increased physiological resistance to environmental stressors . Older birds generally demonstrate improved adaptation to farm microclimatic conditions and may acquire partial natural resistance through repeated exposure to environmental bacterial flora. These findings are consistent with previously published data indicating that younger poultry represent the most epidemiologically vulnerable group in commercial laying hen production .

From a veterinary and epizootological perspective, the findings of the present study indicate that preventive measures against Pullorum disease and Colibacillosis should be prioritized during the early rearing period, particularly the first nine weeks of life. Targeted interventions should include strict adherence to sanitary and hygienic requirements, maintenance of optimal microclimatic parameters, systematic monitoring of feed and water quality, and early identification and isolation of clinically affected birds. The importance of robust biosecurity during the brooding phase is well established in the context of avian bacterial disease prevention.

The ecological characteristics of the Republic of Karakalpakstan may represent an additional predisposing factor for poultry disease susceptibility. As documented by Rakhmatova et al, the region experiences frequent dust and sand storms, which may compromise respiratory defense mechanisms, increase mucosal irritation, and promote the establishment of opportunistic bacterial pathogens in the upper respiratory and gastrointestinal tracts. These environmental conditions underscore the importance of continuous epizootological monitoring and the development of age-oriented preventive strategies adapted to local ecological conditions [19][20].

Despite the practical significance of the present findings, several limitations should be acknowledged. The study was primarily based on epizootological monitoring and clinical-bacteriological assessment, without molecular characterization of the isolated pathogens. Specifically, antimicrobial resistance profiling, virulence gene analysis, and serotyping of *Salmonella* Pullorum and *E. coli* isolates were not performed. Given the documented prevalence of multidrug-resistant strains of both pathogens in poultry farms across Europe and Central Asia , future studies should incorporate molecular epidemiological methods and antimicrobial susceptibility testing to provide a more comprehensive characterization of the infectious agents circulating in poultry farms of the Republic of Karakalpakstan.

## Conclusion

The present study provided an epizootological characterization of Pullorum disease, Colibacillosis, and their mixed infections across four age groups of Lohmann Brown Classic layer chickens in two commercial poultry farms of the Republic of Karakalpakstan. The findings consistently demonstrated that poultry age is a primary determinant of susceptibility to bacterial infections under local production conditions.

In both farms, the highest morbidity rates were recorded in 1–9-week-old chicks, with an overall morbidity of 15.2% at "Agro Biznes Qanliko'l" LLC and 12.0% at "Kungrad Golden Egg" LLC, followed by a progressive and uniform decline across older age categories, converging to 6.0% in birds older than 26 weeks. Mixed infections constituted the dominant disease form in younger birds at "Agro Biznes Qanliko'l" LLC (4.8%), whereas Pullorum disease alone was the most prevalent form at "Kungrad Golden Egg" LLC (4.4%).

Statistical analysis confirmed the epidemiological significance of age as a risk factor. A statistically significant association between age group and morbidity was established at "Agro Biznes Qanliko'l" LLC ($\chi^2$ = 13.47, p = 0.004), and binary logistic regression identified age group as an independent predictor of disease occurrence. Compared with 1–9-week-old chicks, birds older than 26 weeks exhibited markedly lower odds of morbidity (OR = 0.395; 95% CI: 0.249–0.625; $p < 0.001$). Farm of origin was not a statistically significant predictor (OR = 0.806; p = 0.192), indicating that age-associated physiological and immunological maturation exerts a greater influence on disease susceptibility than farm-specific management differences.

Based on the obtained results, 1–9-week-old chicks were identified as the highest-risk group for both Pullorum disease and Colibacillosis. The elevated morbidity in this age category reflects the incomplete development of the immunobiological system, heightened sensitivity to environmental stressors, and dependence on sanitary-hygienic and microclimatic conditions during the early rearing period. The progressive decline in morbidity with increasing age is associated with physiological maturation and the gradual development of natural resistance.

These findings demonstrate that preventive and veterinary-sanitary measures in poultry farms of the Republic of Karakalpakstan should not be applied uniformly across all age groups, but should instead be organized in a staged and risk-stratified manner. Priority interventions during the 1–9-week rearing period should include strict adherence to sanitary and hygienic standards, maintenance of optimal microclimatic conditions, systematic monitoring of feed and water quality, early clinical detection and isolation of affected birds, and a comprehensive approach to the prevention of mixed bacterial infections.

The results of this study provide a scientific and practical basis for identifying age-related risk groups, improving epizootological monitoring systems, and developing targeted preventive measures adapted to the ecological and production conditions of the Republic of Karakalpakstan. Future studies incorporating molecular characterization of isolated pathogens, antimicrobial resistance profiling, and virulence gene analysis are warranted to further advance the understanding of bacterial disease epidemiology in the region's poultry sector.

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