

## Poultry Health and Disease Management in Pakistan: Implications for Food Security, Public Health, and Sustainable Livelihoods

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### Abstract

**Importance:** Poultry production is central to Pakistan's food security and rural economy, yet poultry health remains undermined by infectious diseases, poor management practices, antimicrobial misuse, and environmental stress.

**Objective:** To assess the prevalence of major poultry diseases, risk factors for flock mortality, antimicrobial resistance trends, and the economic implications of poultry health challenges in Pakistan.

**Design, Setting, and Participants:** A simulated cross-sectional study was conducted across 200 poultry farms (100 broiler, 60 layer, 40 backyard) in four provinces of Pakistan. Data were collected on disease prevalence, mortality, vaccination, antimicrobial use, and biosecurity practices. Laboratory analysis of samples from 20,000 birds assessed common pathogens and antimicrobial resistance.

**Main Outcomes and Measures:** Prevalence of Newcastle disease, avian influenza, infectious bursal disease, colibacillosis, and salmonellosis; antimicrobial resistance profiles of *E. coli* and *Salmonella* isolates; predictors of high flock mortality; and estimated annual economic losses.

**Results:** Newcastle disease (29.5%) and colibacillosis (37.5%) were the most prevalent diseases, with higher rates in backyard flocks. Antimicrobial use was reported in 71% of farms; multidrug-resistant *E. coli* was detected in 35% of farms, most commonly in broiler systems. Regression analysis identified low biosecurity (adjusted OR, 3.12; 95% CI, 1.85–5.27), inadequate vaccination (OR, 2.45; 95% CI, 1.42–4.20), and heat stress (OR, 2.33; 95% CI, 1.38–3.95) as significant predictors of high mortality. Access to veterinary support was protective (OR, 0.58; 95% CI, 0.33–0.99). Average annual farm-level losses were PKR 445,000, with broiler farms sustaining the highest absolute costs, while backyard flocks faced greater relative livelihood vulnerability.

**Conclusions and Relevance:** Poultry health in Pakistan is threatened by endemic diseases, antimicrobial misuse, and climate stress, imposing substantial economic losses and zoonotic risks. Strengthening biosecurity, regulating antimicrobial use, expanding vaccination, and building climate-resilient poultry systems are critical for safeguarding food security, public health, and rural livelihoods.

**Keywords:** Poultry Health; Infectious Diseases; Antimicrobial Resistance; Food Security; One health; Pakistan

### Introduction

The poultry sector is one of the fastest-growing components of livestock production in Pakistan, contributing significantly to national food security, rural incomes, and employment. Poultry provides over 35% of total meat production and is the most affordable

source of high-quality animal protein for millions of households.<sup>1</sup> Despite this central role, poultry health remains a persistent challenge due to infectious diseases, poor biosecurity practices, limited veterinary oversight, and environmental stressors such as climate change.

Infectious diseases, including Newcastle disease, avian influenza, infectious bursal disease, colibacillosis, and salmonellosis, cause substantial economic losses each year. Outbreaks disrupt production cycles, increase mortality rates, and reduce productivity through poor growth and reduced egg laying.<sup>4</sup> Moreover, unregulated use of antimicrobials in poultry farming exacerbates the problem by fueling antimicrobial resistance (AMR), which poses risks not only to poultry health but also to human health through zoonotic transmission.

Pakistan's poultry sector is dominated by small and medium-sized farms, many of which lack adequate infrastructure for disease prevention and control. Poor vaccination coverage, limited access to veterinary services, substandard housing, and inadequate biosecurity measures amplify vulnerability to disease outbreaks. Furthermore, environmental pressures such as heat stress and poor water quality negatively affect poultry health and productivity.<sup>7</sup> With climate change predicted to increase the frequency of extreme weather events, the poultry industry faces compounding threats to its resilience.

This paper explores the state of poultry health in Pakistan within a One Health framework, examining the interplay of infectious diseases, farm management practices, antimicrobial use, and environmental challenges. It seeks to

- (1) review the epidemiology of major poultry diseases in Pakistan,
- (2) analyze current disease prevention and treatment practices, and
- (3) propose policy interventions for sustainable poultry health management that balance food security, economic viability, and public health.

## Literature Review

### Global Context of Poultry Health

Globally, poultry health is shaped by complex interactions between pathogens, husbandry practices, and environmental factors. Infectious diseases are responsible for major losses in both industrial and backyard poultry systems. Avian influenza and Newcastle disease, in particular, are transboundary infections with zoonotic potential, requiring strict surveillance and biosecurity. The Food and Agriculture Organization (FAO) emphasizes integrated disease management strategies, including vaccination, genetic resistance, improved nutrition, and farm-level biosecurity.

### Epidemiology of Poultry Diseases in Pakistan

Poultry farming in Pakistan has expanded rapidly, but disease outbreaks remain frequent. Newcastle disease is endemic and remains the leading cause of mortality in commercial and backyard flocks. Highly pathogenic avian influenza has been reported sporadically, raising concerns about zoonotic spillover. Other common diseases include Gumboro (infectious bursal disease), fowl cholera, colibacillosis, and salmonellosis, which contribute to production losses and food safety risks.

Studies show that mortality rates in small-scale poultry farms can reach 20–30% during severe outbreaks, with significant financial repercussions for smallholder farmers. The absence of comprehensive national surveillance systems for poultry diseases limits the ability to predict and control outbreaks effectively.

### **Farm Management and Biosecurity Practices**

The majority of poultry farms in Pakistan operate with inadequate biosecurity. Entry of unauthorized persons, poor sanitation, contaminated feed, and use of untreated water are common risk factors. Backyard poultry, which serves as an income and nutrition source for rural households, is particularly vulnerable because of free-ranging birds and lack of vaccination. Vaccination coverage is often inconsistent due to logistical constraints and farmer awareness gaps.

### **Antimicrobial Use and Resistance**

Antimicrobials are widely used in poultry farming in Pakistan for both therapeutic and growth-promoting purposes. Overuse and misuse contribute to the emergence of resistant bacterial strains such as multidrug-resistant *E. coli* and *Salmonella*. Resistant organisms may spread to humans through direct contact, contaminated poultry products, and the environment. This links poultry health directly to public health, underscoring the need for a One Health perspective.

### **Environmental and Climate Challenges**

Heat stress is increasingly recognized as a major threat to poultry health in Pakistan, where rising temperatures exceed optimal thresholds for broiler and layer performance. Heat stress reduces feed intake, compromises immunity, and increases mortality. Water scarcity and poor quality also impair poultry health by predisposing birds to infections. Climate change, coupled with rapid intensification of poultry farming, amplifies the risks of disease outbreaks and productivity losses.

### **Policy and Institutional Gaps**

Despite the significance of poultry in national food security, Pakistan lacks a comprehensive poultry health policy. Veterinary services remain underfunded, disease surveillance systems are weak, and small-scale farmers lack access to technical support. The poultry industry has developed private-sector initiatives for disease management, but coverage is uneven and often inaccessible to rural producers. Bridging this gap requires integrated government-industry collaboration supported by scientific evidence and international best practices.

### **Theoretical Framework**

This study is underpinned by two complementary frameworks:

#### **Eco-Epidemiological Model**

The eco-epidemiological model views poultry health outcomes as the result of complex interactions among host (bird), pathogen, environment, and management systems.<sup>1</sup> In this context:

- **Host factors** include genetic resistance, immune status, age, and nutrition of birds.

- **Pathogen factors** cover the virulence of agents such as Newcastle disease virus, avian influenza virus, and *Salmonella*.
- **Environmental factors** include climate conditions (temperature, humidity), housing systems, water quality, and biosecurity.
- **Management practices** such as vaccination, antimicrobial use, and hygiene modulate disease risk.

This model provides a layered understanding of disease ecology, recognizing that poultry health cannot be addressed solely at the biological level but requires a systems approach that incorporates farm management and environmental pressures.

### One Health Approach

The **One Health framework** emphasizes the interconnectedness of human, animal, and environmental health. Applied to poultry health in Pakistan, it highlights:

- The **public health dimension**: zoonotic diseases (avian influenza, salmonellosis) and antimicrobial resistance risks.
- The **animal health dimension**: productivity losses and animal welfare from endemic poultry diseases.
- The **environmental dimension**: waste disposal, water contamination, and climate stress.

Together, these frameworks allow us to assess poultry health not only as a veterinary concern but as a **cross-sectoral issue** that directly influences food security, rural livelihoods, and human health in Pakistan.

### Methodology

#### Study Design

A cross-sectional, mixed-methods study design was employed. Quantitative data were generated through simulated poultry health surveys and laboratory diagnostics, while qualitative data came from farmer interviews and policy document review.

#### Study Sites and Sampling

- **Regions**: Four provinces of Pakistan (Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan).
- **Farms**: 200 poultry farms sampled (50 per province), stratified into:
  - **Commercial broiler farms** (n = 100)
  - **Commercial layer farms** (n = 60)
  - **Backyard smallholder flocks** (n = 40)
- **Sample size**: ~20,000 birds represented, with subsamples for diagnostic testing.

#### Data Collection Tools

1. **Clinical examination and farm records**
  - Mortality rate, morbidity patterns, vaccination records, antimicrobial use logs.
2. **Laboratory diagnostics**



- Serology and PCR for Newcastle disease, avian influenza, infectious bursal disease.
- Bacterial cultures for *Salmonella* and *E. coli* (with antimicrobial susceptibility testing).
- 3. **Environmental sampling**
  - Water quality testing (coliform counts, pH, salinity).
  - Litter and waste samples for pathogen detection.
- 4. **Farmer questionnaire (structured)**
  - Farm management practices, biosecurity measures, climate-related stressors, awareness of zoonotic risks.
- 5. **Policy and institutional review**
  - Analysis of veterinary service coverage, national poultry health guidelines, and AMR policy frameworks.

## Variables

- **Dependent variables:** poultry mortality rate (%), disease incidence (per 1,000 birds), productivity outcomes (feed conversion ratio, egg production rate).
- **Independent variables:** vaccination coverage, antimicrobial use (yes/no, type, frequency), biosecurity score (composite index), climate stress indicators (temperature, humidity, ventilation), water quality indicators.
- **Intermediate variables:** detection of pathogens (positive/negative), antimicrobial resistance profile (sensitive vs multidrug-resistant).

## Analytical Approach

- **Descriptive statistics:** prevalence of major poultry diseases, average mortality rates, antimicrobial use frequency.
- **Comparative analysis:** differences in disease prevalence between commercial and backyard flocks.
- **Regression models:** predictors of high mortality and disease outbreaks (biosecurity score, vaccination coverage, antimicrobial use).
- **One Health mapping:** integration of poultry health findings with potential zoonotic spillovers (e.g., salmonellosis, avian influenza).
- **Cost estimation:** simulated economic losses due to mortality and reduced productivity.

## Ethical Considerations

- Farmer consent obtained before surveys and sample collection.
- All biological sampling simulated under animal welfare protocols.
- Confidentiality of farm-level data ensured.

## Results (Simulated)

**Table 1.** Sample characteristics of poultry farms (n = 200)

| Farm Type          | Farms (n) | Mean Flock Size (birds) | Mean Age of Flock (weeks) | Mean Mortality (%) |
|--------------------|-----------|-------------------------|---------------------------|--------------------|
| Commercial broiler | 100       | 10,000 ± 2,300          | 5.5 ± 0.8                 | 7.8 ± 3.5          |
| Commercial layer   | 60        | 5,500 ± 1,200           | 25.3 ± 3.1                | 5.2 ± 2.1          |

|                      |            |                      |                   |                  |
|----------------------|------------|----------------------|-------------------|------------------|
| Backyard smallholder | 40         | 120 ± 45             | 16.7 ± 2.5        | 14.5 ± 5.8       |
| <b>Overall</b>       | <b>200</b> | <b>7,120 ± 4,200</b> | <b>15.8 ± 8.4</b> | <b>8.7 ± 5.4</b> |

*Note: Backyard flocks had higher average mortality compared to commercial farms.*

**Table 2.** Prevalence of major poultry diseases by production system (% of farms reporting laboratory-confirmed cases)

| Disease                         | Broiler<br>(n=100) | (%) | Layer<br>(n=60) | (%) | Backyard<br>(n=40) | (%) | Overall<br>(n=200) | (%) |
|---------------------------------|--------------------|-----|-----------------|-----|--------------------|-----|--------------------|-----|
| Newcastle Disease (ND)          | 28.0               |     | 20.0            |     | 45.0               |     | 29.5               |     |
| Avian Influenza (AI)            | 6.0                |     | 8.0             |     | 12.0               |     | 8.0                |     |
| Infectious Bursal Disease (IBD) | 34.0               |     | 12.0            |     | 18.0               |     | 24.0               |     |
| Colibacillosis                  | 42.0               |     | 30.0            |     | 38.0               |     | 37.5               |     |
| Salmonellosis                   | 24.0               |     | 18.0            |     | 22.0               |     | 21.0               |     |

*Note: Newcastle disease was most prevalent in backyard flocks, while colibacillosis was most frequent in broilers.*

**Table 3.** Antimicrobial usage and resistance patterns

| Indicator                                          | Broiler<br>(%) | Layer<br>(%) | Backyard<br>(%) | Overall<br>(%) |
|----------------------------------------------------|----------------|--------------|-----------------|----------------|
| Any antimicrobial use in last cycle                | 85.0           | 70.0         | 40.0            | 71.0           |
| Use of antibiotics as growth promoters             | 32.0           | 20.0         | 10.0            | 22.0           |
| Detection of multidrug-resistant <i>E. coli</i>    | 44.0           | 28.0         | 25.0            | 35.0           |
| Detection of multidrug-resistant <i>Salmonella</i> | 21.0           | 15.0         | 18.0            | 18.0           |

*Note: Broiler farms reported highest antimicrobial use and highest MDR detection.*

**Table 4.** Predictors of high flock mortality (>10%) — Logistic regression (n = 200 farms)

| Predictor                                     | Adjusted OR | 95% CI    | p-value |
|-----------------------------------------------|-------------|-----------|---------|
| Low biosecurity score (lowest tertile)        | 3.12        | 1.85–5.27 | <0.001  |
| Inadequate vaccination (below 70% coverage)   | 2.45        | 1.42–4.20 | 0.001   |
| Backyard vs commercial farm                   | 1.96        | 1.10–3.48 | 0.021   |
| High ambient temperature (>35°C sustained)    | 2.33        | 1.38–3.95 | 0.002   |
| Access to veterinary support (regular visits) | 0.58        | 0.33–0.99 | 0.047   |

*Interpretation: Poor biosecurity, inadequate vaccination, and heat stress significantly increase mortality, while access to veterinary support is protective.*

**Table 5.** Economic losses due to poultry diseases (per farm, annualized, PKR)

| Farm Type | Mortality Loss (mean PKR) | Reduced Productivity (mean PKR) | Treatment/Medication Loss Cost (mean PKR) | Total Estimated Loss (mean PKR) |
|-----------|---------------------------|---------------------------------|-------------------------------------------|---------------------------------|
| Broiler   | 285,000                   | 180,000                         | 65,000                                    | 530,000                         |
| Layer     | 160,000                   | 210,000                         | 55,000                                    | 425,000                         |
| Backyard  | 25,000                    | 12,000                          | 4,500                                     | 41,500                          |

|                      |         |         |        |         |
|----------------------|---------|---------|--------|---------|
| Overall<br>(average) | 223,000 | 167,000 | 55,000 | 445,000 |
|----------------------|---------|---------|--------|---------|

*Note: Commercial farms incur higher absolute losses, but backyard flocks face proportionally greater economic vulnerability due to reliance on poultry as a household livelihood.*

## Key Findings (Narrative)

- **Disease burden is high:** Newcastle disease (29.5%) and colibacillosis (37.5%) dominate, with backyard flocks disproportionately affected.
- **Antimicrobial dependence:** 71% of farms used antimicrobials; MDR *E. coli* was detected in 35% of farms, with broilers at highest risk.
- **Drivers of mortality:** Poor biosecurity, inadequate vaccination, and climate stress significantly increased mortality; veterinary access reduced risk.
- **Economic impact:** Average farm losses were PKR 445,000 annually, with highest losses among broiler farms.
- **One Health implications:** Zoonotic pathogens (*Salmonella*, MDR *E. coli*) and unregulated antibiotic use pose risks to both food safety and human health.

## Discussion

This study highlights the considerable burden of poultry diseases in Pakistan, revealing both their direct economic impacts and wider implications for food security and public health. The simulated findings show that Newcastle disease, colibacillosis, and infectious bursal disease are among the most common infections affecting poultry flocks, with disproportionately higher prevalence in backyard systems. These results are consistent with prior epidemiological surveys reporting endemic circulation of Newcastle disease and bacterial infections in smallholder poultry across South Asia.

Antimicrobial use was widespread, with 71% of farms reporting routine administration, and multidrug-resistant (MDR) *E. coli* and *Salmonella* detected in a significant proportion of isolates. This reflects trends reported in other LMICs, where over-reliance on antimicrobials for growth promotion and preventive therapy contributes to resistance reservoirs.<sup>4,5</sup> The higher prevalence of MDR organisms in broiler farms suggests that intensive production systems face greater selective pressure, raising concerns for zoonotic transmission of resistant pathogens. This finding underscores the need to align poultry health management with global One Health priorities on antimicrobial resistance.

Regression analysis demonstrated that poor biosecurity, inadequate vaccination coverage, and high ambient temperatures significantly increased the risk of high flock mortality. These factors point to systemic weaknesses in poultry health infrastructure. Smallholder and backyard flocks were particularly vulnerable, not only due to limited veterinary oversight but also because free-ranging birds increase exposure to pathogens. Similar patterns have been observed in Africa and Southeast Asia, where backyard poultry systems remain vital to household nutrition but are disease-prone.

The economic analysis suggests that average annual farm-level losses exceed PKR 445,000, with mortality, reduced productivity, and treatment costs as primary drivers. While

commercial farms bear higher absolute losses, smallholders experience disproportionately greater livelihood shocks because poultry represents a major household asset. This dual burden of economic vulnerability and disease exposure highlights the importance of targeted interventions for both industrial and smallholder systems.

The results also draw attention to climate stress as an emerging determinant of poultry health. High temperatures significantly increased mortality, a finding that aligns with studies linking heat stress to compromised immunity, poor feed conversion, and increased susceptibility to infectious diseases.<sup>8</sup> In Pakistan, climate change is expected to intensify extreme weather events, compounding existing health risks in poultry systems.

### Conclusion

Poultry health in Pakistan faces multifaceted threats from endemic infectious diseases, poor farm management, antimicrobial misuse, and climate stress. The persistence of zoonotic pathogens and multidrug-resistant bacteria highlights the interdependence of poultry, human, and environmental health. Disease-related economic losses threaten the viability of both commercial and smallholder poultry production, with direct consequences for national food security and rural livelihoods.

A holistic response grounded in One Health and eco-epidemiological principles is urgently required. Strengthening surveillance, improving biosecurity, rationalizing antimicrobial use, and adapting poultry production to climate realities are critical to building resilience in this sector. Without these reforms, poultry production risks becoming both a health hazard and a fragile pillar of Pakistan's food system.

### Policy Implications

#### 1. Strengthen Poultry Disease Surveillance

- Establish a national poultry disease monitoring system with regular reporting on Newcastle disease, avian influenza, and bacterial infections.
- Integrate poultry health data into veterinary and public health information systems.

#### 2. Promote Biosecurity and Vaccination

- Develop subsidy programs or extension services to ensure universal vaccination coverage.
- Provide farmer training on low-cost biosecurity practices, especially for backyard producers.

#### 3. Regulate Antimicrobial Use

- Enforce restrictions on antibiotics as growth promoters.
- Promote veterinary oversight of antimicrobial prescribing and encourage alternatives (probiotics, vaccines).

#### 4. Support Smallholder Poultry Producers

- Provide microcredit and technical support to backyard and small-scale farmers.
- Develop community-based veterinary outreach programs to extend services to rural areas.



## 5. Climate-Resilient Poultry Systems

- Encourage investment in climate-smart housing designs (ventilation, cooling, insulation).
- Integrate poultry health into broader climate adaptation strategies for agriculture.

## 6. Public Health Integration

- Link poultry health programs with food safety initiatives to reduce zoonotic risks.
- Foster collaboration between livestock, public health, and environmental authorities under a One Health governance model.

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