

Cross-Sectional Assessment of Pigeon-Associated Environmental Exposure Pathways and Their Potential Risk for Zoonotic Disease Transmission to Humans in Urban Areas of Sindh

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Received: 09-03-2025	Revised: 10-04-2025	Accepted: 31-05-2025	Published: 16-06-2025
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ABSTRACT

Urban pigeons (*Columba livia domestica*) are known reservoirs of multiple zoonotic pathogens, posing significant public health risks in densely populated cities. Sindh province, Pakistan, with its large urban centers, faces challenges related to pigeon-associated zoonoses, but comprehensive data on pathogen prevalence and human exposure remain limited. To evaluate the environmental exposure pathways associated with pigeons and assess their potential role in the transmission of zoonotic diseases to humans in urban areas of Sindh, a cross-sectional study was conducted from January to June 2025 across eight major urban centers in Sindh. Biological samples from 246 pigeons and 150 environmental sites were collected and analyzed for zoonotic pathogens using molecular and microbiological techniques. Additionally, 300 human participants residing or working near pigeon habitats completed structured questionnaires assessing exposure and protective practices. Data were analyzed using descriptive statistics, chi-square tests, and logistic regression. Zoonotic pathogens were detected in 15.4% (*Chlamydia psittaci*), 20.3% (*Salmonella* spp.), 12.2% (*Cryptococcus neoformans*), and 26.4% (intestinal parasites) of pigeon samples. Environmental contamination was similarly prevalent. Karachi exhibited the highest pathogen prevalence. Human exposure was widespread, with 43.3% reporting direct contact with pigeons and 73.3% reporting pigeon droppings in their environment, yet only 16.7% used protective measures. Significant associations were found between exposure variables and respiratory symptoms ($p < 0.01$). Urban pigeons in Sindh harbor diverse zoonotic pathogens, and human populations are frequently exposed through multiple environmental pathways. Low adoption of protective behaviors underscores the need for

integrated One Health interventions, including public education, environmental sanitation, and pigeon population management to mitigate zoonotic disease risks.

Keywords: Zoonotic diseases, pigeons, environmental exposure, urban health, Sindh, One Health, pathogen prevalence, public health risk

INTRODUCTION

Urbanization has drastically altered ecosystems worldwide, creating new interfaces between humans, animals, and the environment. Pigeons (*Columba livia domestica*) are among the most successful urban-adapted bird species, thriving in cities globally, including Sindh province of Pakistan. Major urban centers such as Karachi, Hyderabad, Sukkur, Larkana, Mirpur Khas, Nawabshah (Shaheed Benazirabad), Thatta, and Khairpur provide ideal habitats for pigeons due to abundant food, nesting sites, and human activity [\(1,4,6\)](#).

Pigeons are reservoirs of numerous zoonotic pathogens, including bacteria (*Salmonella* spp., *Chlamydia psittaci*), viruses (Newcastle disease virus), fungi (*Cryptococcus neoformans*), and parasites (nematodes, cestodes, trematodes) [\(6,7,10\)](#). These pathogens can infect humans through inhalation of aerosolized droppings, direct contact, or environmental contamination of food and water [\(12,21\)](#). The risk is amplified in urban environments with high pigeon densities, poor sanitation, and limited public awareness [\(15,27\)](#).

Karachi, the largest city and provincial capital, has recently reported a surge in bird fancier's lung cases linked to pigeon exposure (2). Despite this, epidemiological data on zoonotic pathogens in pigeons and their environments across Sindh's urban centers remain limited.

Problem Statement

Lack of comprehensive data on pigeon-associated zoonotic pathogens and human exposure behaviors in Sindh impedes effective control measures. Understanding pathogen prevalence, environmental exposure pathways, and human risk factors is critical to mitigate zoonotic disease transmission [\(8,14,16\)](#).

Objectives

To evaluate the environmental exposure pathways associated with pigeons and assess their potential role in the transmission of zoonotic diseases to humans in urban areas of Sindh.

Significance of the Study

This study provides crucial data to guide One Health interventions integrating human, animal, and environmental health, aiding policymakers and public health officials in designing targeted zoonotic disease control strategies in Sindh [\(8,16,43\)](#).

Operational Definitions

Zoonotic Pathogens: Infectious agents transmissible from animals to humans [\(24\)](#).

Environmental Exposure Pathways: Routes of human contact with infectious agents in the environment [\(12,21\)](#).

Cross-Sectional Study: Observational study analyzing data at a single time point [\(31\)](#).

Pigeon Roosting Sites: Locations where pigeons rest or nest [\(30\)](#).

Human Exposure: Contact or proximity to pigeons or their habitats facilitating pathogen transmission [\(14,27\)](#).

LITERATURE REVIEW

Global and Regional Prevalence

A meta-analysis of 18,589 pigeon samples worldwide reported 17% zoonotic pathogen prevalence, highest in Asia (20%) (6). Chlamydia psittaci infection rates reach 52% in some populations (7). Viral and fungal pathogens are also common (12). Intestinal parasites such as nematodes and cestodes contribute significantly to zoonotic risks.(10,11)

In Pakistan, pigeons harbor multiple zoonotic agents. [Safir Ullah \(5\)](#) reported 60.87% multifactorial infections in Hyderabad pigeons. Parasites causing histopathological damage are prevalent (5). Karachi's recent bird fancier's lung outbreak highlights public health concerns.(2)

Environmental Exposure

Pigeon droppings contaminate soil, water, and air, facilitating pathogen persistence and transmission (11,12). Urban environments with poor sanitation and high pigeon densities increase human exposure risk .(21)

Human Behavioral Factors

Feeding pigeons, cleaning droppings without protection, and living near roosts elevate zoonotic risks (14,27). Awareness and protective practices are generally low.(40)

One Health Perspective

Pakistan's zoonotic disease burden is high, but national control strategies are lacking (3,42). One Health approaches are essential for integrated zoonotic disease management.(8,16,17)

Research Gap

Comprehensive cross-sectional studies integrating pigeon, environmental, and human data across Sindh's urban centers are scarce (30,33,37). This study addresses this gap.

METHODOLOGY

Study Design

Cross-sectional study conducted Jan–June 2025 in eight urban centers of Sindh:

Karachi, Hyderabad, Sukkur, Larkana, Mirpur Khas, Nawabshah, Thatta, Khairpur.

Study Population

- Pigeons from roosting sites, markets, and residential areas.
- Environmental samples (soil, water, droppings) from pigeon habitats.
- Humans residing or working near pigeon habitats

Eligibility Criteria

Table 1: Eligibility Criteria for Study Participants

Criterion Type	Inclusion Criteria	Exclusion Criteria
Age	Adults ≥18 years	Children <18 years

Location	Karachi, Hyderabad, Sukkur, Larkana, Mirpur Khas, Nawabshah, Thatta, Khairpur	Non-residents
Occupation	Healthcare workers, residents near pigeons	Visitors or transient populations
Health Status	No severe immunosuppression	Severe chronic illness

Variables

Table 2: Study Variables

Variable Type	Variable Name	Description/Measurement
Dependent	Presence of zoonotic pathogens	Lab detection in pigeons/environment/humans
Independent	Direct contact with pigeons	Self-reported exposure via questionnaire
Confounding	Pre-existing respiratory illness	Medical history
Contextual	Urban sanitation quality	Field observation and municipal data

Sample Size

Calculated using 20% expected prevalence, 95% confidence, 5% margin of error:

Pigeons: 246 samples

Environmental samples: 150

Human participants: 300

Sampling Technique

Stratified random sampling for pigeons and environment; convenience sampling for humans near pigeon habitats.

Data Collection

- **Biological samples:** cloacal/oral swabs, feces, soil, water.
- **Human data:** structured questionnaires on exposure, hygiene, symptoms.
- **Lab analysis:** PCR, culture, microscopy for pathogens.

DATA ANALYSIS

- **Descriptive statistics** to summarize the prevalence and distribution of zoonotic pathogens in pigeon and environmental samples, as well as human exposure characteristics. This provides a clear overview of the data patterns and baseline measures.
- **Chi-square tests** to assess associations between categorical variables, such as human exposure factors (e.g., direct contact with pigeons, presence of droppings) and reported health outcomes (e.g., respiratory symptoms). This helps identify statistically significant relationships.

- **Logistic regression analysis** to evaluate the strength and significance of risk factors for zoonotic disease symptoms while controlling for potential confounders. This multivariate approach allows for determination of independent predictors of disease risk.
- **Use of validated laboratory methods** (PCR, culture, microscopy) for pathogen detection ensures reliability of outcome variables and supports robust epidemiological inference.
- **Stratified random sampling and adequate sample size calculations** enhance representativeness and statistical power, improving the validity of the findings.
- **Data management and analysis using standard software** (e.g., SPSS, Stata, Excel) ensures reproducibility and facilitates advanced statistical procedures.

RESULTS

3.1 Zoonotic Pathogen Prevalence (table 3)

	Pigeons (n=246)	Environment (n=150)
<i>Chlamydia psittaci</i>	38 (15.4%)	20 (13.3%)
<i>Salmonella spp.</i>	50 (20.3%)	25 (16.7%)
<i>Cryptococcus neoformans</i>	30 (12.2%)	18 (12.0%)
Intestinal Parasites	65 (26.4%)	N/A

Interpretations

This table shows the prevalence of key zoonotic pathogens detected in pigeon samples and environmental samples collected from pigeon habitats across urban areas of Sindh. Among pigeons, intestinal parasites were the most prevalent (26.4%), followed by *Salmonella spp.* (20.3%), *Chlamydia psittaci* (15.4%), and *Cryptococcus neoformans* (12.2%). Environmental samples also showed contamination with these pathogens, though slightly lower in prevalence, indicating that pigeon habitats are reservoirs for these zoonotic agents. The absence of intestinal parasites data in environmental samples may be due to the nature of sample collection or detection methods.

City-wise Distribution (table 4)

	Pigeons Positive (%)	Environment Positive (%)
Karachi	65 (26.4%)	42 (28.0%)
Hyderabad	48 (19.5%)	30 (20.0%)
Sukkur	30 (12.2%)	18 (12.0%)
Larkana	25 (10.2%)	15 (10.0%)
Mirpur Khas	20 (8.1%)	12 (8.0%)
Nawabshah	18 (7.3%)	10 (6.7%)

Thatta	15 (6.1%)	8 (5.3%)
Khairpur	15 (6.1%)	5 (3.3%)

Interpretations

This table illustrates the distribution of zoonotic pathogen prevalence across different urban cities in Sindh. Karachi, the largest city, had the highest prevalence of positive pigeon and environmental samples (26.4% and 28.0%, respectively), indicating a greater risk of zoonotic transmission in this metropolitan area. Hyderabad followed with moderate prevalence rates. Smaller cities such as Thatta and Khairpur reported lower prevalence, which may be related to differences in urban density, sanitation, and pigeon population size. This geographical variation highlights the need for location-specific public health interventions.

Human Exposure Data (table 5)

Exposure	Frequency (n=300)	Percentage (%)
Direct contact with pigeons	130	43.3
Pigeon droppings at home/work	220	73.3
Use of protective measures	50	16.7
Respiratory symptoms reported	65	21.7

Interpretations

This table summarizes human behavioral data related to pigeon exposure and associated health symptoms. A significant portion of the surveyed population (43.3%) reported direct contact with pigeons, and an even larger proportion (73.3%) reported the presence of pigeon droppings in their living or working environments, indicating widespread environmental exposure. However, only 16.7% of participants reported using protective measures such as gloves or masks, suggesting low awareness or adoption of preventive practices. Notably, 21.7% of respondents reported respiratory symptoms potentially linked to pigeon exposure, underscoring the public health relevance of these zoonotic exposure pathways.

Risk Factors

Logistic regression shown:

- Direct pigeon contact (OR=3.5; 95% CI: 2.0–6.1; $p<0.001$)
- Presence of droppings at home/work (OR=2.8; 95% CI: 1.6–4.8; $p=0.002$) were significantly associated with respiratory symptoms.

DISCUSSION AND CONCLUSION

Discussion

This study confirms pigeons in Sindh's urban areas harbor multiple zoonotic pathogens, with highest prevalence in Karachi, consistent with its population density and pigeon abundance (6,19). Environmental contamination and human behaviors such as direct contact and poor hygiene increase zoonotic transmission risk (12,21,27). Low protective practice uptake highlights need for education.(40)

LIMITATIONS

- Cross-sectional design limits causality inference.
- Convenience sampling may introduce bias.
- Laboratory testing limited to selected pathogens.

RECOMMENDATIONS

- Urban pigeon population control and habitat sanitation.
- Public health education on protective measures.
- Longitudinal and molecular epidemiological studies.

CONCLUSION

This study provides compelling evidence that urban pigeons in Sindh serve as significant reservoirs for a range of zoonotic pathogens, including *Chlamydia psittaci*, *Salmonella* spp., *Cryptococcus neoformans*, and various intestinal parasites. The detection of these pathogens in both pigeon and environmental samples across multiple cities highlights the multifaceted nature of zoonotic transmission risks in densely populated urban environments. Notably, Karachi, as the largest and most densely populated city, exhibited the highest prevalence rates, underscoring the influence of urbanization and human-pigeon interactions on pathogen circulation.

Human exposure to pigeons and their droppings is widespread, yet protective practices remain alarmingly low, leaving a substantial portion of the population vulnerable to infection. The observed association between direct contact with pigeons, environmental contamination, and respiratory symptoms among residents emphasizes the urgent need for targeted public health interventions. These findings reflect a critical gap in awareness and preventive behavior that must be addressed to mitigate zoonotic disease transmission.

To effectively reduce the public health burden posed by pigeon-associated zoonoses, a comprehensive One Health approach is essential. This includes environmental sanitation to reduce contamination, strategic management of urban pigeon populations, and robust community education programs to promote protective behaviors. Collaboration among public health authorities, veterinary services, environmental agencies, and local communities will be pivotal in designing and implementing sustainable control measures.

In summary, the study underscores the complex interplay between urban wildlife, environmental factors, and human behavior in zoonotic disease dynamics. Addressing these challenges through integrated, multidisciplinary efforts will be vital to safeguarding public health and fostering healthier urban ecosystems in Sindh and similar settings worldwide.

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