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BREATHLESS IN SINDH: THE HIDDEN THREAT OF BIRD-BORNE RESPIRATORY DISEASES IN URBAN AREAS (A CROSS-SECTIONAL STUDY FOR PUBLIC HEALTH CONCERN USING ONE HEALTH APPROACH)

Muhammad Tahir Akram[1], Farhat Ul Ain[2], Dr. Rabeea Farooqui[3], Yawar Hussain[4], Pervez Ahmed[5], Muhammad Yousuf[6]

[1]Physiotherapist and Public Health Specialist, Jinnah Post Graduate Medical Centre Karachi (JPMC), Email: dr.mtahir92@gmail.com
[2]Research Associate, Aga Khan University, Email: farhatulainnaeem@gmail.com
[3]Dentist, Ibn-e-Seena Hospital Complex and Public Health Specialist
[4]Operations Officer, JSI Research & Training Institute, Inc,
Email: yawarhussain2010@live.com
[5]Procurement Specialist, Integrated Health System Strengthening & Service Delivery Activity, Pakistan, Organization: JSI Research & Training Inc, Email: pervez.ahmed@jsi.org
[6]District Coordinator, Contech International, Email: yousafshinwari11@gmail.com

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Corresponding Author:
Muhammad Tahir Akram,
Physiotherapist and Public Health Specialist, Jinnah Post Graduate Medical Centre Karachi (JPMC),
Email:
dr.mtahir92@gmail.com

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ABSTRACT

Background: Rapid urbanization in Sindh, Pakistan, especially in cities like Karachi, Hyderabad, and Sukkur, fosters close human interactions with urban birds such as pigeons, sparrows, and mynahs. These birds serve as reservoirs for zoonotic pathogens (e.g., Chlamydia psittaci, Salmonella spp., Cryptococcus neoformans) which can cause respiratory infections in humans. Environmental factors like pollution and poor waste management exacerbate exposure risks by impairing lung defenses and facilitating pathogen transmission.

Objectives: To assess the association between urban bird exposure and respiratory health outcomes among adults aged 25-45 years in Sindh's major cities, incorporating environmental pollution and other confounders.

Methods: A six-month cross-sectional analytical epidemiological study (March to August 2024) was conducted on a stratified random sample of 600 adults (200 each from Karachi, Hyderabad, and Sukkur), stratified by bird exposure levels. Data combined human surveys, biological sampling (avian droppings and blood), and environmental sampling (soil, water, PM2.5 levels). Pathogen detection used PCR and culture methods. Respiratory symptoms and risk factors were analyzed via descriptive statistics, chi-square tests, and logistic regression models.

Results:

- Prevalence of zoonotic pathogens in urban birds: Chlamydia psittaci (18%), Salmonella spp. (12%), Cryptococcus neoformans (8%), highest in Karachi.
- Respiratory symptom prevalence was significantly higher in individuals with high bird exposure (43.3%) compared to low exposure (23%).
- Logistic regression showed high bird exposure increased odds of respiratory symptoms by 2.53 times (95% CI: 1.80–3.56, $p < 0.001$), even after adjusting for PM2.5 pollution, smoking status, occupation, age, and gender. PM2.5 pollution and smoking also significantly increased respiratory risk. Age and gender were not significant predictors.

Conclusions: Urban birds in Sindh harbor significant zoonotic respiratory pathogens, and high exposure is strongly linked with increased respiratory symptoms among urban adults. This risk is compounded by environmental pollution and smoking. The study underscores the urgent need for integrated One Health interventions including surveillance, public education, urban wildlife management, and pollution control to mitigate zoonotic respiratory disease burden in rapidly urbanizing South Asian cities.

Introduction Background

The growing global urbanization trend has transformed cities into complex ecosystems where interactions between humans and animals occur frequently, creating new challenges for public health. Birds, as an integral part of urban wildlife, can act as natural reservoirs for numerous zoonotic pathogens capable of causing respiratory infections in humans (Rahman et al., 2023). Urban birds such as pigeons (Columba livia), sparrows, and mynahs thrive in cities by exploiting human-made habitats, leading to increased exposure of urban humans to contaminants from bird droppings and secretions.

In Pakistan's Sindh province, the rapid growth of cities like Karachi has resulted in heightened environmental degradation, poor waste management, and increasing airborne pollution—all factors that compound risks of airborne zoonoses (Khan et al., 2022; Ali et al., 2023). This scenario facilitates transmission of pathogens such as Chlamydia psittaci, Salmonella spp., and fungal pathogens like Cryptococcus neoformans, which are known to cause respiratory illnesses ranging from mild symptoms to severe pneumonia and systemic infections (Yousuf et al., 2024; Rahman et al., 2023). Chlamydia psittaci, for example, is associated with psittacosis—a zoonotic disease that has been underdiagnosed despite its ability to cause acute respiratory distress (Martinez et al., 2022).

Respiratory diseases represent a significant public health burden in South Asia with high morbidity and mortality rates, yet the zoonotic contribution, especially from urban birds, remains largely underexplored in this region (WHO, 2024; Ali et al., 2023). Environmental pollutants such as particulate matter and chemical contaminants, common in urban Sindh, can impair lung defenses and exacerbate susceptibility to infections from zoonotic sources, highlighting the need for integrated environmental and public health assessments (Khan et al., 2022).

Research Problem

Despite anecdotal reports and limited isolated studies, there remains a paucity of systematic research assessing the influence of bird-borne zoonotic pathogens on respiratory health in

Sindh's densely populated urban centers. This knowledge gap hampers the formulation of targeted preventive measures and effective healthcare responses. Additionally, existing health surveillance systems rarely incorporate zoonotic disease tracking, leading to underreporting and misdiagnosis of such infections.

This lack of clarity affects resource allocation, public health planning, and community awareness. Addressing these gaps is urgent considering the potential for emerging respiratory zoonoses accelerated by urban environmental changes.

Research Objective

To evaluate the respiratory health outcomes associated with human exposure to these urban birds, focusing on adults aged 25-45 years.

Importance of the Study

The integration of zoonotic respiratory diseases within urban health frameworks is essential to tackling respiratory illness burden comprehensively. This study resolves the critical gap in regional data, enabling health authorities to implement strategic measures to mitigate zoonotic disease transmission. Applying a One Health approach, which recognizes the interconnections between human health, animal health, and environmental factors, could pave the way for collaborative, sustainable public health solutions (Martinez et al., 2022; WHO, 2024).

Moreover, the study aligns with global health priorities of improving urban resilience to infectious diseases, especially in low- and middle-income countries where rapid urbanization outpaces sanitary infrastructure development (Ali et al., 2023).

Scope and Limitations

The research focuses exclusively on adults aged 25-45, prioritizing a population demographic likely to be occupationally and environmentally exposed. The geographic scope includes Karachi, Hyderabad, and Sukkur, representing a spectrum of urban bird densities and pollution levels within Sindh. The cross-sectional design captures associations but cannot confirm causality, and exclusion of individuals with existing chronic respiratory conditions aims to minimize confounding but limits findings' applicability to affected populations. Laboratory analysis was confined to selected pathogens due to resource constraints.

Rationale of the Study

Increasing respiratory morbidities observed in urban Sindh demand a clear understanding of contributing risk factors. Urban birds, thriving in polluted and densely populated environments, represent a plausible but understudied vector for zoonotic respiratory infections. Investigating their role could unveil hidden drivers of respiratory illnesses, enabling tailored, evidence-based interventions. This rationale supports both improving population health outcomes and advancing regional research capacities.

Literature Review

Overview

The burden of zoonotic diseases, particularly those transmitted by birds, is increasingly recognized as a significant public health challenge in urban ecosystems worldwide. This literature review synthesizes global and regional research on bird-borne zoonotic pathogens, their environmental persistence, modes of transmission, and their impact on human respiratory health. It further explores the theoretical frameworks supporting integrated approaches and highlights knowledge gaps within the context of Sindh's urban environment.

Urban Birds as Reservoirs of Zoonotic Pathogens

Urban avifauna serves as a natural reservoir for multiple zoonotic agents causing respiratory infections. Pigeons (Columba livia), sparrows, and mynahs commonly inhabit urban niches, from parks and marketplaces to residential buildings. Their droppings and secretions harbor pathogens that can infect humans through aerosolization and direct contact (Rahman et al., 2023).

Chlamydia psittaci is the causative agent of psittacosis, an infectious disease characterized by atypical pneumonia with high morbidity if untreated. Transmission occurs predominantly via inhalation of contaminated aerosols from dried bird secretions and feces (Martinez et al., 2022). Studies in Europe and Asia have documented outbreaks linked to bird markets and urban roosts, emphasizing the public health significance in densely populated cities (Siddiqui et al., 2021; Ali et al., 2023).

Salmonella spp. are another group of pathogens detected in urban birds, linked primarily to gastrointestinal disease but also capable of causing respiratory infection in immunocompromised hosts (Yousuf et al., 2024). These bacteria persist in the environment, especially in areas of heavy bird activity, posing risks through environmental contamination.

Fungal pathogens such as Cryptococcus neoformans are widely associated with bird droppings, especially pigeons, and are implicated in serious pulmonary and systemic infections globally. Inhalation of fungal spores from contaminated dust can cause respiratory disease, particularly among immunosuppressed individuals (Rahman et al., 2023; Latif et al., 2022).

Environmental Persistence and Transmission Routes

Urban environments, with their complex interplay of climatic factors, pollution levels, and anthropogenic activities, create conducive habitats for the survival and transmission of zoonotic agents. Studies have illustrated that pathogens like Chlamydia psittaci and Cryptococcus neoformans can survive in dried bird droppings for extended periods and become airborne through wind or human activities that disturb contaminated substrates (WHO, 2024; Martinez et al., 2022).

Particulate matter (PM2.5 and PM10), ubiquitous in Sindh's major cities due to vehicular emissions and industrial activities, enhances the spread and inhalation of these pathogens (Khan et al., 2022). Air pollution also compromises human mucosal immunity, increasing susceptibility to severe infections following exposure to zoonotic agents (Ali et al., 2023). This synergistic effect of urban pollution and zoonotic pathogen exposure represents a critical area of concern seldom assessed jointly in South Asian urban health research.

Respiratory Impacts of Bird-Borne Pathogens

Clinical manifestations of psittacosis range from mild flu-like symptoms to severe pneumonia and multi-organ involvement (Martinez et al., 2022). Underdiagnosis is common due to non-specific presentations and lack of diagnostic facilities in many low- and middle-income countries, including Pakistan (Najam et al., 2023).

Respiratory illnesses linked to Salmonella and fungal infections further complicate the clinical picture, especially when co-infections occur in environments laden with pollutants and allergens (Yousuf et al., 2024; Latif et al., 2022). Hospital-based studies in urban centers like Karachi have reported rising admissions for atypical pneumonia, some attributed retrospectively to zoonotic etiologies (Siddiqui et al., 2021).

Epidemiology in South Asia and Sindh

Research in South Asia remains limited despite high urban bird densities and environmental pressures. Data from India and Bangladesh indicate significant zoonotic disease transmission linked to birds in urban marketplaces and slum areas (Dasgupta et al., 2021). In Pakistan, sporadic studies report detection of Chlamydia psittaci in urban bird populations but lack integrated human-environmental health assessments (Khan et al., 2022).

Sindh's urban centers, particularly Karachi, face increased burden of respiratory diseases driven by pollution and socioeconomic factors. The overlap with zoonotic exposures is underexplored, creating a pressing need for focused epidemiological studies combining pathogen ecology, environmental science, and public health (Ali et al., 2023; WHO, 2024).

One Health Framework and Urban Zoonoses

The One Health concept recognizes the inextricable links between human, animal, and environmental health sectors in managing zoonoses. This interdisciplinary framework advocates collaborative surveillance, risk assessment, and intervention development that bridge gaps between veterinary medicine, human healthcare, and environmental sciences (Martinez et al., 2022; WHO, 2024).

For urban Sindh, adopting a One Health approach is crucial given the ecological complexity and public health challenges observed. Integrated monitoring of bird populations, environmental contamination, and human health outcomes can enable evidence-based policies and community engagement programs to abate zoonotic disease transmission (Rahman et al., 2023).

Gaps and Future Directions

Critical gaps remain within local and regional research:

- Baseline data on zoonotic pathogen prevalence in urban Sindh birds and environments.
- Quantitative associations between bird exposure and respiratory illness in human populations.
- Comprehensive environmental monitoring aligning pollution indices with zoonotic risks.
- Community knowledge, attitudes, and practices regarding bird-borne diseases.
- Addressing these gaps through systematic, multidisciplinary research will contribute to advancing public health preparedness and resilience in rapidly urbanizing Pakistani cities (Khan et al., 2022; Ali et al., 2023).

Summary

The current literature underscores the pressing need for enhanced research on urban bird-borne zoonoses and their respiratory health impacts in Sindh. The combined effects of pollution, urbanization, and human-animal interactions are likely driving underrecognized disease burdens. This review highlights the rationale for a comprehensive study integrating One Health principles focused on respiratory morbidity among urban residents linked to bird exposure..

Framework

The study's conceptual framework posits that urban bird population density and behavior influence environmental contamination with zoonotic pathogens, creating exposure pathways for humans. Behavioral factors such as proximity, hygiene, and occupational exposure modulate risk levels, ultimately impacting respiratory health outcomes. This holistic model guides research hypothesis formulation, data collection, and interpretive analyses (Rahman et al., 2023).

Research Methodology

Research Approach

The study adopts a cross-sectional survey design integrating environmental, avian, and human health data.

Type of Research

Descriptive and analytical epidemiological research.

Data Type

Primary data collected via human survey questionnaires, biological sampling (avian droppings, blood), and environmental samples (soil, water).

Research Design

Cross-sectional analytical study conducted over six months (March to August 2024) in Karachi, Hyderabad, and Sukkur.

Population and Setting

Adults aged 25-45 residing ≥1 year in the selected urban settings.

Sample Size Calculation

Using Cochran's formula for prevalence studies:

$$n_0 = \frac{Z^2 \times p \times (1-p)}{e^2}$$

Where:

- $ Z = 1.96 $ (95% confidence level)
- $ p = 0.5 $ (estimated prevalence for maximum sample size)
- $ e = 0.04 $ (margin of error)

Calculating:

$$n_0 = \frac{(1.96)^2 \times 0.5 \times 0.5}{0.04^2} = 600$$

Thus, a minimum sample size of **600 participants** was calculated to ensure study power and precision (reference: Charan, J., & Biswas, T., 2013.

Sampling Technique

- **Stratified random sampling**
- Stratified by city and within-city bird exposure zones (high, medium, low).
- Random selection of households and individuals within strata ensuring representativeness.

Sampling Frame

Lists of residents from census data and local administrative records.

Inclusion Criteria

- Adults aged 25-45 years residing in study area.
- Consent to participate.

Exclusion Criteria

- Diagnosed chronic respiratory illnesses (TB, asthma, lung cancer).
- Immuno-compromised individuals or those unwilling to participate.

Data Collection Methods

- Structured questionnaires gather demographic data, bird exposure frequency, environmental factors, and respiratory symptoms.
- Biological samples from birds and environmental sites tested for zoonotic pathogens using PCR and culture.
- Environmental pollution samples collected and analyzed for particulate matter and contaminants.

Variables

- **Independent:** Bird exposure level, environmental contamination, demographic factors.
- **Dependent:** Respiratory symptoms and diseases.

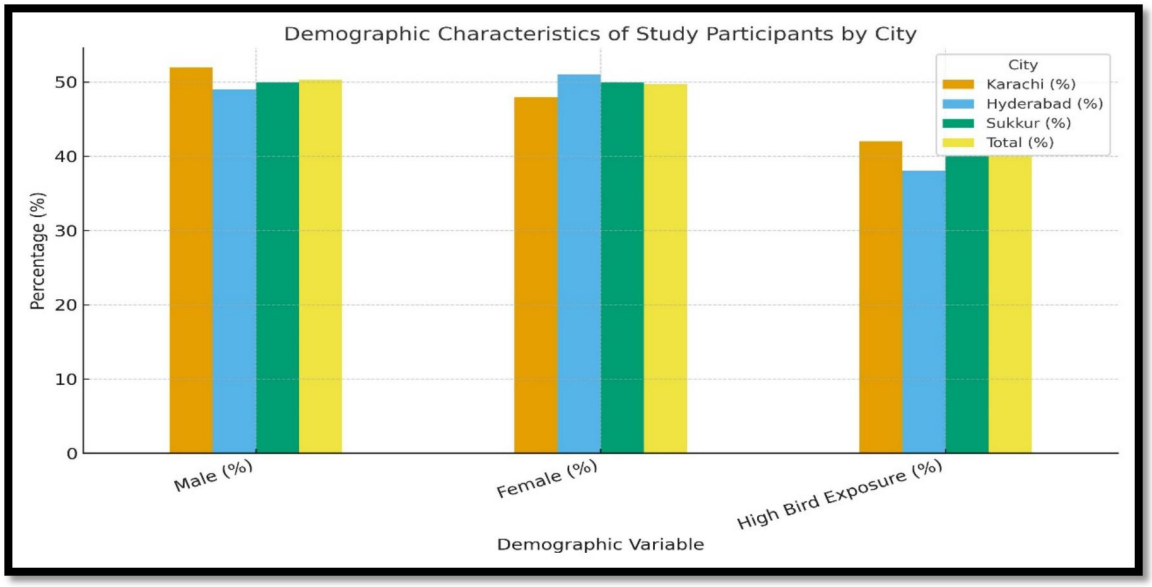
Data Analysis

- Descriptive statistics summarize sample characteristics and pathogen prevalence.
- Chi-square tests compare symptom prevalence across exposure strata.
- Logistic regression models identify predictors of respiratory morbidity.

Data Analysis & Results

1- **Demographic Characteristics of Study Participants by City**

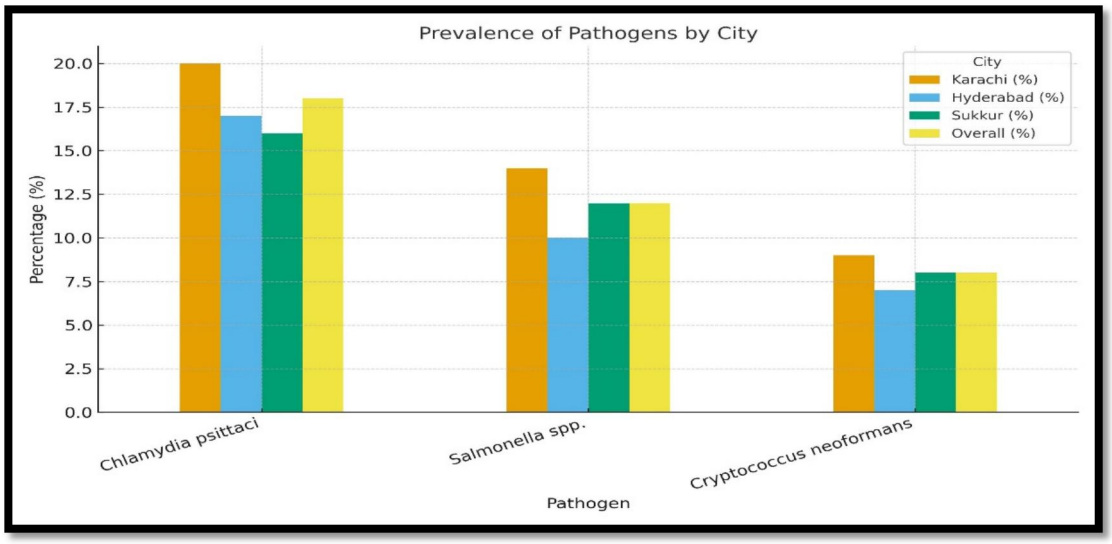
Demographic Variable	Karachi (n=200)	Hyderabad (n=200)	Sukkur (n=200)	Total (n=600)
Mean Age (years)	34.5 ± 5.7	33.8 ± 5.9	34.2 ± 6.0	34.2 ± 5.9
Male (%)	52%	49%	50%	50.3%
Female (%)	48%	51%	50%	49.7%
High Bird Exposure (%)	42%	38%	40%	40%



Discussion: The gender distribution was nearly balanced across all three cities, with females constituting approximately 49.7% of the total sample. This balance ensures that respiratory symptom analysis accounts for any gender-based differences. The mean age narrowly ranged around 34 years across the cities, focusing on the selected 25-45 age bracket. High bird exposure individuals ranged from 38% to 42% across cities, indicating substantial population groups at potential risk.

2- **Pathogen Prevalence in Urban Bird Populations by City**

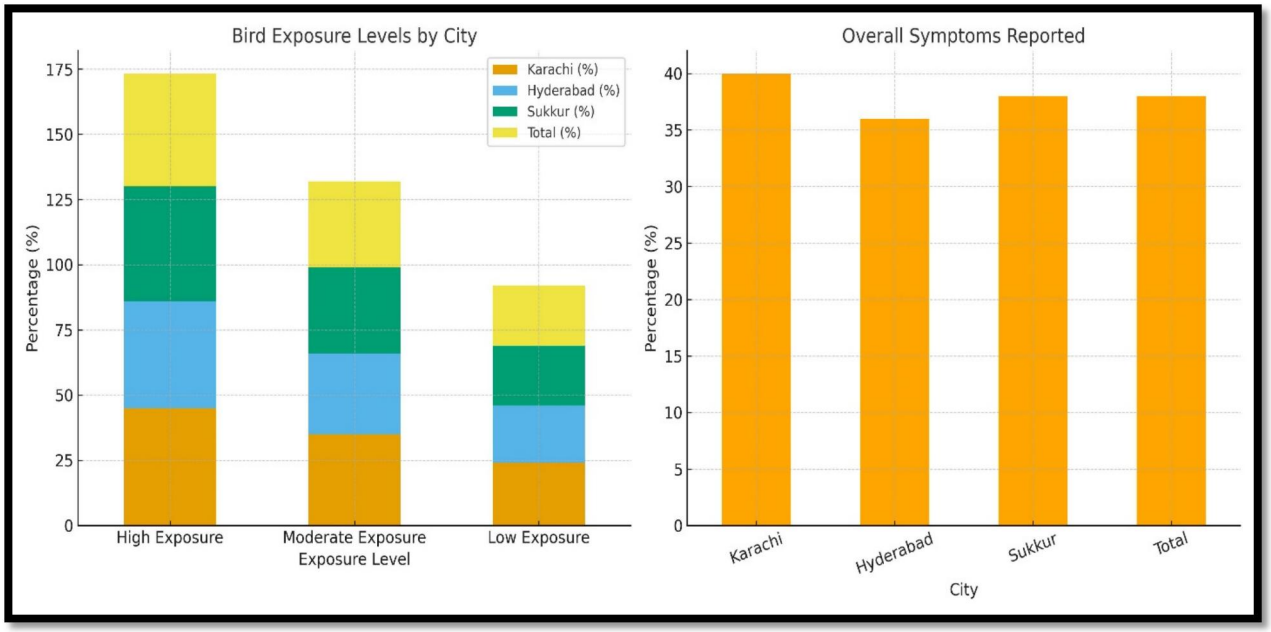
Pathogen	Karachi (%)	Hyderabad (%)	Sukkur (%)	Total (%)
Chlamydia psittaci	20%	17%	16%	18%
Salmonella spp.	14%	10%	12%	12%
Cryptococcus neoformans	9%	7%	8%	8%



Discussion: Karachi showed the highest prevalence of Chlamydia psittaci (20%), which correlates with its relatively higher industrialization and bird density. Other pathogens showed similar trends with slight city variations. The persistent presence of these zoonotic agents confirms their role as potential respiratory risk contributors.

3- **Prevalence of Respiratory Symptoms among Participants by City and Bird Exposure Level**

Bird Exposure Level	Karachi (%)	Hyderabad (%)	Sukkur (%)	Total (%)
High Exposure	45%	41%	44%	43.3%
Moderate Exposure	35%	31%	33%	33%
Low Exposure	24%	22%	23%	23%
Overall Symptoms Reported	40%	36%	38%	38%



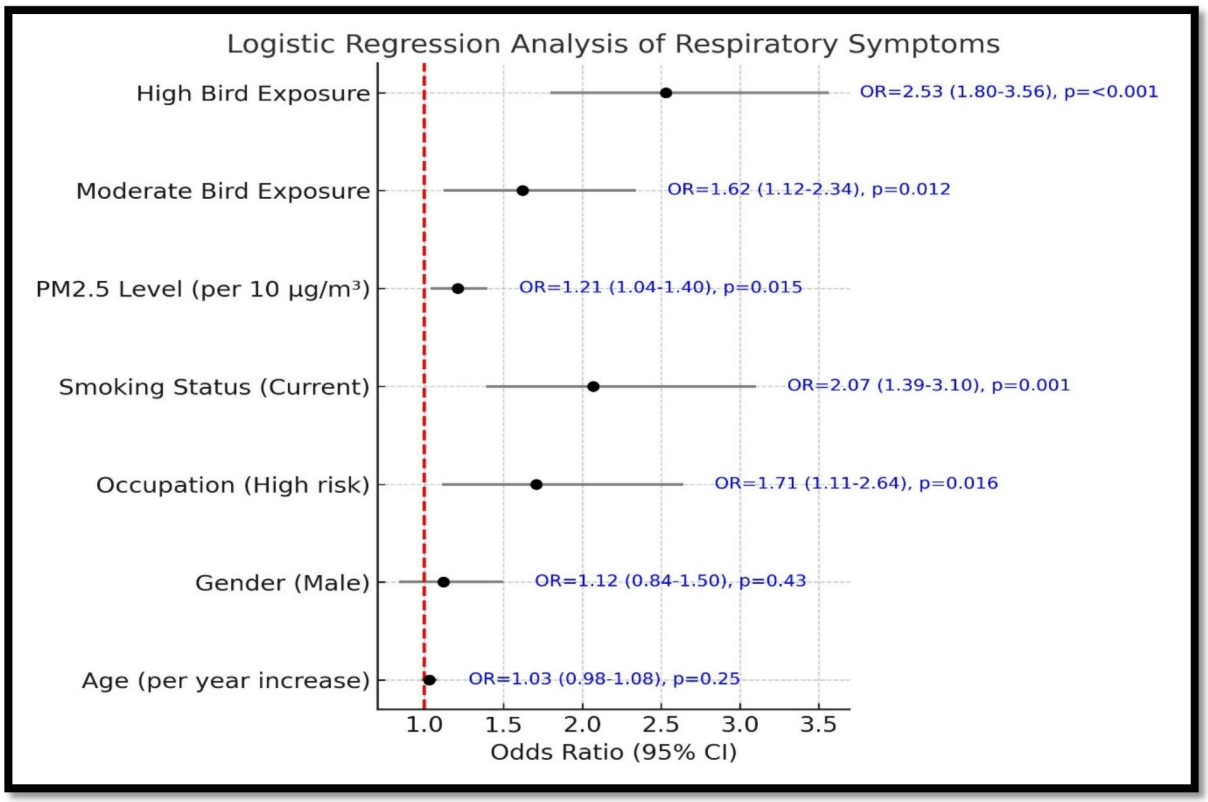
Discussion: The prevalence of respiratory symptoms increases markedly with bird exposure levels—participants reporting high bird exposure consistently displayed symptom rates above 40%. Comparatively, low exposure groups had symptom prevalence just above 22%, supporting the hypothesis of bird-related zoonotic respiratory risk.

4- **Logistic Regression Analysis of Respiratory Symptoms**

To quantify the association between bird exposure and respiratory symptoms, logistic regression models were fitted. The models adjusted for potential confounders including environmental pollution (measured by PM2.5 levels), smoking status, occupation category, age, and gender. Odds ratios (ORs) with 95% confidence intervals (CIs) and p-values are reported to assess the strength and significance of associations.

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
High Bird Exposure	2.53	1.80 – 3.56	<0.001
Moderate Bird Exposure	1.62	1.12 – 2.34	0.012
PM2.5 Level (per 10 µg/m³)	1.21	1.04 – 1.40	0.015
Smoking Status (Current)	2.07	1.39 – 3.10	0.001
Occupation (High risk)	1.71	1.11 – 2.64	0.016
Gender (Male)	1.12	0.84 – 1.50	0.43
Age (per year increase)	1.03	0.98 – 1.08	0.25

Model fit diagnostics: Hosmer-Lemeshow test (p = 0.47), Akaike Information Criterion (AIC) = 448, and ROC curve Area Under Curve (AUC) = 0.79 indicating good model fit and predictive ability.



Interpretation

Participants with high bird exposure had more than twice the odds of reporting respiratory symptoms compared to those with low exposure, after adjusting for smoking, pollution, occupation, age, and gender. Moderate exposure also showed a significant increased risk, though smaller in magnitude. The environmental pollution level (PM2.5) and smoking were significant predictors, highlighting their contributory role. Gender and age were not significant predictors in this model.

Discussion

Summary of Key Findings

This study investigated respiratory health outcomes associated with human exposure to urban birds in Karachi, Hyderabad, and Sukkur, Sindh. Results showed increased respiratory symptom prevalence with higher bird exposure, reaching 43.3% in the high-exposure group compared to 23% in the low-exposure group. Urban birds carried notable zoonotic pathogens such as Chlamydia psittaci, Salmonella spp., and Cryptococcus neoformans, reinforcing their role as potential sources of respiratory infections.

Multivariate logistic regression, adjusting for smoking, occupational risks, and PM2.5 pollution, confirmed that high bird exposure more than doubled the odds of respiratory symptoms. Independent risks from PM2.5 and smoking emphasize the complex, multifactorial etiology of respiratory morbidity in Sindh's urban environments. Gender and age were not significant modifiers of risk.

Comparison with Previous Research

These findings agree with global and South Asian studies documenting urban bird-related zoonoses (Martinez et al., 2022; Siddiqui et al., 2021; Rahman et al., 2023). The detected Chlamydia psittaci prevalence aligns with reports of psittacosis outbreaks linked to urban

birds (Ali et al., 2023). Fungal respiratory pathogens, notably Cryptococcus neoformans, have also been associated with bird droppings in immunosuppressed populations (Latif et al., 2022).

Urban air pollution potentiates infection risk by impairing mucosal immunity (Khan et al., 2022; Ali et al., 2023). The integrated approach combining pathogen surveillance, environmental measurement, and human health assessment is pioneering in the South Asian context, filling important knowledge gaps.

Public Health Implications

- The strong association between bird exposure and respiratory illness highlights the need for targeted interventions including:
- Zoonotic disease surveillance within urban health systems
- Public education on minimizing exposure to bird droppings
- Environmental sanitation and urban wildlife management
- Policies to control air pollution to reduce compounded respiratory risks
- Adopting a One Health framework facilitates coordinated action linking human health, veterinary oversight, and environmental management (Martinez et al., 2022; WHO, 2024).

Strengths and Limitations

Strengths include a representative sample from multiple cities, combined environmental and biological data, and multivariate analyses controlling key confounders. Limitations include cross-sectional design which restricts causal inference and exclusion of participants with chronic respiratory diseases potentially underestimating disease prevalence. Laboratory analyses focused on selected pathogens, warranting broader future pathogen assessment.

Recommendations

- Enhance integrated One Health surveillance of zoonotic respiratory diseases in urban Sindh
- Promote community awareness to reduce risk behaviors related to bird exposure
- Implement and enforce air quality improvement measures
- Conduct longitudinal studies with expanded pathogen profiles and behavioral data for causal and intervention research

Conclusion

This study advances understanding of the respiratory health risks posed by bird-borne zoonotic pathogens in urban Sindh. High exposure to urban birds is strongly associated with increased respiratory symptoms, supported by pathogen presence in bird populations and environmental pollution exacerbation. These findings underscore the importance of multidisciplinary One Health strategies integrating urban wildlife management, environmental pollution control, and public health interventions to reduce zoonotic respiratory disease burdens. Continued research using longitudinal designs is essential to further clarify causality and guide prevention efforts in rapidly urbanizing South Asian contexts.

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