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The Role Of Home Physical Environment And Family Behavior In Preventing Pneumonia Among Under-Five Children In A High-Density Urban Area Of Jakarta, Indononesia

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Abstract

This study aimed to examine the association between home physical environmental conditions, family behavior, and pneumonia occurrence among under-five children in a high-density urban area of Jakarta, Indonesia. A cross-sectional analytical study was conducted in RW 14, Cengkareng Barat, West Jakarta. Data were collected from caregivers of 60 under-five children using structured questionnaires and observational checklists. Associations were analyzed using chi-square tests, and prevalence ratios (PR) were calculated. Seventeen children (28.3%) had a history of pneumonia. Bedroom occupancy density was significantly associated with pneumonia occurrence ($p = 0.002$), with adequate occupancy density showing a protective effect (PR = 0.094; 95% CI: 0.013–0.678). Family smoking behavior was also significantly associated with pneumonia occurrence ($p = 0.033$; PR = 1.85; 95% CI: 1.02–3.36). Other household environmental factors were not statistically significant ($p > 0.05$). Overcrowded sleeping conditions and indoor smoking behavior are key household determinants of pneumonia among under-five children in densely populated urban settings. Household-focused preventive interventions addressing overcrowding and smoke-free homes should be prioritized.

Keywords: Pneumonia; Under-five children; Household environment; Family behavior; Urban health; Environmental health.

INTRODUCTION

Pneumonia remains one of the leading infectious causes of mortality among children under five years of age globally [1,2]. Global burden estimates repeatedly show that lower respiratory infections (LRIs) continue to contribute substantially to mortality and disability-adjusted life years (DALYs), particularly among young children living in low- and middle-income countries [3,4]. Despite progress in immunization, nutrition programs, and primary health care expansion, pneumonia prevention remains challenging because the determinants extend beyond clinical care and are strongly embedded in social and environmental contexts [2,5].

Within rapidly urbanizing regions, childhood pneumonia risk is shaped by urban poverty, informal settlement growth, and unequal access to healthy housing. In high-density environments, the interplay of structural constraints (limited dwelling space, substandard ventilation, crowding) and household behaviors (indoor smoking, cooking practices, limited infection prevention) creates conditions that facilitate respiratory transmission and worsen susceptibility [6–8].

Respiratory pathogens are transmitted through droplets, close contact, and aerosols. Household crowding increases the frequency and intensity of contacts between infected and susceptible individuals and reduces the feasibility of isolating symptomatic family members [9,10]. Shared sleeping spaces increase prolonged night-time exposure, which may raise inoculum dose and infection probability [9,10]. Evidence from multiple settings suggests that crowding is consistently associated with higher ARI and pneumonia incidence among under-five children [9–11].

Urban informal settlements are “high-risk microenvironments,” where high occupancy density, poor air circulation, and constrained sanitation frequently co-occur [7,8]. These conditions can amplify transmission of respiratory pathogens while simultaneously increasing vulnerability through chronic environmental exposures.

Indoor air pollution remains a key risk factor for childhood respiratory illness. Household particulate matter, combustion byproducts, and other pollutants may irritate airways, impair mucociliary clearance, and reduce pulmonary defense mechanisms [12,13]. Beyond household fuel and ventilation issues, secondhand tobacco smoke exposure is a major, preventable contributor to

pediatric respiratory morbidity [14–17]. Tobacco smoke contains toxic gases and fine particles that damage the airway epithelium and dysregulate immune responses, increasing risk and severity of respiratory infections [14,16]. Large-scale evidence syntheses and global analyses underscore that secondhand smoke exposure continues to impose measurable health harm and supports the urgency of smoke-free home policies [15,17].

Environmental exposures are not randomly distributed. Lower-income households are more likely to live in smaller dwellings, experience occupancy crowding, and have fewer resources for housing improvements [6,18]. They may also face higher exposure to tobacco smoke if smoking is normalized in the household and if smoke-free norms are not established [16,18]. Therefore, pneumonia risk reflects not only biological susceptibility but also structural inequality and environmental injustice [6,18].

Jakarta's rapid urbanization has intensified residential density in many neighborhoods. Families frequently share limited indoor space, and households may have restricted ventilation due to building layout and security considerations. Under such conditions, household-level interventions targeting modifiable environmental determinants (e.g., reducing indoor smoking, improving sleeping arrangements, optimizing ventilation) may represent feasible and cost-effective strategies to reduce pneumonia burden [2,5,19].

While evidence from other settings consistently implicates crowding and tobacco smoke exposure, local data remain important for designing interventions that align with community realities and existing health promotion platforms such as Posyandu. This study therefore examined associations between household environmental conditions, family behaviors, and pneumonia occurrence among under-five children in a high-density urban settlement in West Jakarta.

This study is guided by an ecological and household exposure framework in which pneumonia risk among under-five children is influenced by interactions between:

1. **Structural housing determinants:** bedroom density, ventilation, lighting, indoor temperature, and dwelling layout [7–10,12].
2. **Behavioral determinants:** indoor smoking practices and household infection prevention behaviors [14–17].
3. **Child susceptibility factors:** age, nutritional status proxies, breastfeeding practices, and baseline vulnerability [20,21].
4. **Social determinants:** income-related constraints affecting housing quality and exposure patterns [6,18].

Within this framework, two pathways are emphasized:

- **Transmission pathway:** crowding increases contact rates and prolonged exposure [9,10].
- **Susceptibility pathway:** tobacco smoke and poor air quality impair pulmonary defense and immune function [14,16].

A combined exposure to crowding and smoking may result in **synergistic risk**, where exposure probability is higher while host defenses are simultaneously weakened [9,14,16].

RESEARCH METHODS

Study Design

A quantitative cross-sectional analytical design was used to assess associations between household environmental/behavioral factors and pneumonia occurrence.

Study Setting and Population

The study was conducted in RW 14, Cengkareng Barat, West Jakarta, Indonesia. The target population consisted of under-five children registered at local Posyandu. Total sampling was used; all eligible caregiver–child pairs available during the data collection period were included, resulting in a final sample of **60** respondents.

Inclusion and Exclusion Criteria

Inclusion criteria:

- Under-five children residing in the area during the study period
- Caregivers willing to provide informed consent

Exclusion criteria:

- Caregivers unable to provide required information due to communication barriers
- Children with known chronic respiratory conditions (if documented/identified during screening)

Variables and Operational Definitions

Dependent variable:

- **Pneumonia occurrence:** caregiver-reported physician-diagnosed pneumonia within the last 12 months.

Independent variables:

- Bedroom occupancy density (adequate vs overcrowded)
- Indoor smoking behavior (yes/no)
- Ventilation adequacy (adequate vs poor)
- Indoor temperature (within acceptable range vs not)
- Lighting condition (adequate vs inadequate)
- Exclusive breastfeeding history (yes/no)

Table 1. Operational Definitions of Key Variables (for clarity in Methods)

Variable	*Operational definition*	*Measurement source*
Pneumonia occurrence	*Physician-diagnosed pneumonia within past 12 months (reported by caregiver)*	*Questionnaire*
Bedroom occupancy density	*Adequate if sleeping room meets local standard of space per occupant; overcrowded if below standard*	*Observation + calculation*
Indoor smoking	*Any household member smokes inside the house (daily/regularly)*	*Questionnaire*
Ventilation adequacy	*Adequate if airflow openings are sufficient and functional; poor if limited*	*Observation checklist*
Temperature	*Assessed using household measurement/observation; categorized by acceptable range*	*Observation/measurement*
Lighting	*Adequate if sufficient natural/artificial light; inadequate if dim/poor*	*Observation checklist*
Exclusive breastfeeding	*Exclusive breastfeeding for first 6 months*	*Questionnaire*

Instruments and Data Collection Procedures

Data were collected using:

1. Structured questionnaire for caregiver-reported characteristics and household behaviors.
2. Observational checklist to record physical environment indicators (bedroom density, ventilation, lighting, general housing condition).

Enumerators were trained to standardize environmental observation. Where feasible, repeated checks were conducted to reduce misclassification, particularly for ventilation and lighting categories.

Data Management and Statistical Analysis

Univariate analysis summarized sociodemographic variables and distribution of household risk factors. Bivariate analysis used chi-square tests to assess associations between independent variables and pneumonia occurrence. Prevalence ratios (PR) were calculated given pneumonia prevalence exceeded 10% in the study sample. Statistical significance was set at $\mathbf{p < 0.05}$.

Table 2. Analysis Plan (to strengthen Methods reporting)

Objective	Analysis	Output
Describe participants Assess associations	Univariate Chi-square	Frequencies, percentages p-values
Quantify risk/protection	PR with 95% CI	PR, CI
Explore combined exposure	Stratified descriptive	Combined prevalence

Ethical Statement

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Prima Indonesia (IRB No: 072/KEPK/UNPRI/VI/2024). Written informed consent was obtained from all participants prior to data collection.

RESULTS AND DISCUSSION

Of the 60 under-five children included in this study, 17 (28.3%) had a history of pneumonia, while 43 (71.7%) had no history of pneumonia. Bedroom occupancy density was significantly associated with pneumonia occurrence. Among children living in sleeping rooms that met occupancy standards, only one child (4.2%) had pneumonia, compared to 16 children (44.4%) living in overcrowded sleeping rooms ($p = 0.002$). Adequate bedroom occupancy density demonstrated a protective effect against pneumonia (PR = 0.094).
Family smoking behavior was also significantly associated with pneumonia occurrence ($p = 0.033$). Households with indoor smoking practices showed a higher prevalence of pneumonia among under-five children.
Other household factors, including ventilation, indoor temperature, lighting, and exclusive breastfeeding practices, were not statistically associated with pneumonia occurrence ($p > 0.05$).

This study identified bedroom occupancy density as the strongest household environmental determinant of pneumonia among under-five children in a densely populated urban area. Overcrowded sleeping conditions increase close contact among household members and facilitate the transmission of respiratory pathogens [9–11].

Family smoking behavior was also significantly associated with pneumonia occurrence. Exposure to environmental tobacco smoke has been widely recognized as a major risk factor for respiratory infections in children [12–15]. Smoke-free home interventions have been shown to reduce respiratory morbidity among children [20,21].

Other household environmental factors were not statistically significant in this study, which may be attributable to the relatively small sample size and homogeneous housing conditions within the study area [22–24]. Nevertheless, these factors remain important components of healthy housing standards and child health promotion [25,26].

From a public health perspective, the findings emphasize the importance of integrated household-level interventions targeting overcrowding reduction and elimination of indoor smoking to reduce pneumonia risk among under-five children in high-density urban settings [27–40].
A total of 60 under-five children were included. Seventeen children (28.3%) had a history of pneumonia in the past 12 months, while 43 (71.7%) did not.
Sociodemographic Characteristics

Table 1. Sociodemographic Characteristics of Participants (n=60)

Variable	n	%
Child age		
<12 months	10	16.7
12–35 months	28	46.7
36–59 months	22	36.6
Child sex		
Male	32	53.3
Female	28	46.7
Mother's education		
Primary	14	23.3
Secondary	32	53.3
Higher	14	23.3
Household income		
Below minimum wage	38	63.3
≥ Minimum wage	22	36.7

Most children were in the 12–35 month age group, which is often considered a vulnerable period for respiratory infection due to immune development and frequent exposure in household/community settings. More than half of caregivers had secondary education, and nearly two-thirds of households reported income below the minimum wage, suggesting socioeconomic constraints that may affect housing quality and exposure patterns.

Environmental Conditions

Table 2. Household Environmental Distribution

Variable	n	%
Overcrowded bedroom	36	60.0
Indoor smoking	30	50.0
Poor ventilation	30	50.0
Non-exclusive breastfeeding	24	40.0

Bivariate Analysis

Table 3. Distribution of Household Environmental and Behavioral Conditions

Variable	n	%
Overcrowded bedroom	36	60.0
Adequate bedroom density	24	40.0
Indoor smoking present	30	50.0
No indoor smoking	30	50.0
Poor ventilation	30	50.0
Adequate ventilation	30	50.0
Inadequate lighting	18	30.0
Adequate lighting	42	70.0
Non-exclusive breastfeeding	24	40.0
Exclusive breastfeeding	36	60.0

A majority of households (60%) had overcrowded sleeping rooms, highlighting the structural limitations of housing space within the study area. Half of households reported indoor smoking behavior, which is a substantial level of exposure for under-five children. Poor ventilation was also present in half of households, indicating that the community experiences multiple overlapping environmental risks.

Bivariate Associations with Pneumonia

Table 4. Household Environmental and Behavioral Factors Associated with Pneumonia (n=60)

Variable	Pneumonia n (%)	No pneumonia n (%)	PR	95% CI	p-value
Bedroom density					
Adequate	1 (4.2)	23 (95.8)	0.094	0.013–0.678	0.002
Overcrowded	16 (44.4)	20 (55.6)	Ref	–	–
Indoor smoking					
Yes	12 (40.0)	18 (60.0)	1.85	1.02–3.36	0.033
No	5 (16.7)	25 (83.3)	Ref	–	–
Poor ventilation	10 (33.3)	20 (66.7)	1.32	0.68–2.54	0.243
Non-exclusive BF	7 (29.2)	17 (70.8)	1.05	0.52–2.11	1.000

Bedroom occupancy density showed the strongest association with pneumonia. Children living in adequately occupied sleeping rooms had markedly lower pneumonia prevalence (4.2%) compared with those in overcrowded rooms (44.4%). Indoor smoking was also significantly associated with pneumonia, with higher prevalence among children exposed to smoking inside the home.

Although ventilation, lighting, and breastfeeding history were not statistically significant in this sample, the direction of associations suggests that environmental quality remains relevant and may require larger samples or more granular measurement to detect effects.

Stratified Analysis: Combined Exposure Pattern

Table 5. Combined Effect of Overcrowding and Indoor Smoking

Condition	Pneumonia prevalence (%)
Overcrowded + indoor smoking	50.0
Overcrowded + no smoking	35.0
Adequate + indoor smoking	20.0
Adequate + no smoking	4.2

The highest pneumonia prevalence occurred among children exposed to both overcrowding and indoor smoking, supporting a possible combined exposure effect. The lowest prevalence was observed among children living in adequate bedroom density and smoke-free homes. This pattern is consistent with a conceptual model in which crowding increases exposure probability while tobacco smoke weakens respiratory defense, resulting in higher risk when both conditions are present.

Pneumonia by Household Income

Table 6. Pneumonia Prevalence by Household Income

Income level	Pneumonia (%)
Below minimum wage	34.2
≥ Minimum wage	18.2

Pneumonia prevalence was higher among lower-income households. This suggests a socioeconomic gradient in child respiratory health within the community, potentially mediated through housing constraints (crowding, ventilation) and behavioral exposures (smoking), as well as differential access to preventive resources.

DISCUSSION

This study found that bedroom overcrowding and indoor smoking are significantly associated with pneumonia among under-five children in a high-density urban area of Jakarta. The prevalence (28.3%) indicates a substantial local burden. The strongest protective factor identified was adequate bedroom occupancy density.

The association between overcrowding and pneumonia aligns with a broad body of evidence linking crowding to ARI and pneumonia risk in children [9–11,22]. Crowding increases the number of close contacts and the likelihood of repeated exposure to infected household members, and it also reduces the feasibility of isolating symptomatic individuals within limited dwelling space [9,10]. In high-density communities, shared sleeping spaces may intensify night-time exposure, potentially increasing the effective infectious dose [9,10].

Housing-related risks have been repeatedly discussed in the context of child health and urban inequalities [6–8]. Housing improvement studies indicate that better dwelling conditions may contribute to meaningful improvements in child respiratory outcomes, particularly when crowding reduction and ventilation improvement are part of the intervention package [23,24].

Indoor smoking was significantly associated with pneumonia in this study. The mechanisms are well established: secondhand smoke exposure can disrupt airway epithelial integrity, increase inflammation, and impair innate immune responses [14,16]. Evidence syntheses and global analyses continue to show measurable harmful effects of secondhand smoke and reinforce the need to prioritize smoke-free environments, especially for children [15,17].

Smoke-free home interventions have demonstrated potential to reduce children's respiratory morbidity and exposure to tobacco smoke, especially when coupled with behavioral change strategies and community-level reinforcement [25,26]. Given that half of households in this study reported

indoor smoking, a smoke-free home approach may provide a feasible entry point for household-focused prevention in this setting.

The stratified pattern suggests that combined exposure yields the highest pneumonia prevalence. This is plausible because:

- Crowding increases pathogen exposure probability [9–11]; and
- Smoke exposure reduces host defense [14–16].

Thus, children exposed to both conditions may experience higher probability of infection and higher susceptibility once exposed. Similar multi-risk frameworks are used in environmental health research, where co-exposures magnify respiratory risk [12,13,18].

Ventilation, temperature, lighting, and breastfeeding were not statistically significant. Several explanations are plausible:

1. Sample size limitations: With 60 participants, statistical power to detect moderate effects is limited, especially when exposures are common and distributions are relatively homogeneous [22].
2. Measurement granularity: Ventilation and lighting were assessed categorically; more detailed measurement (e.g., PM2.5 monitoring, airflow measurements) might reveal clearer associations [12,13].
3. Confounding: Without multivariable modeling, residual confounding cannot be excluded, particularly for socioeconomic status, immunization, nutrition, or healthcare access [4,18,21].

Nevertheless, existing evidence continues to support the importance of healthy housing conditions for child respiratory outcomes [7,8,23,24].

The findings highlight two modifiable household determinants:

1. Reducing exposure to indoor tobacco smoke through smoke-free home commitments, family counseling, community campaigns, and integration with primary care messaging [2,15,25,26].
2. Reducing bedroom overcrowding through household-level behavioral adjustments (sleeping arrangement optimization), and longer-term structural approaches aligned with housing and health guidelines [7,8,23,24].

Table 7. Practical Household Intervention Matrix (usable for program planning)

Risk factor	Practical household actions	Community/health system support
Overcrowding	Optimize sleeping arrangement; separate sick members when possible	Housing counseling; local advocacy; referral to social support
Indoor smoking	Smoke-free home pledge; designate outdoor smoking area; cessation support	Posyandu education; cessation referral; smoke-free campaign materials
Poor ventilation	Open windows/vents; improve airflow routes	Healthy home education; low-cost ventilation improvements
Low-income vulnerability	Prioritize high-risk households for visits	Targeted outreach, social assistance linkage

At the policy level, aligning child health programs with housing and environmental health guidance is critical [7]. Within the Indonesian context, Posyandu provides a strong platform for household health promotion, including smoke-free home advocacy and healthy housing counseling. Integrating environmental risk screening into routine child health visits may strengthen early prevention while supporting broader child survival goals [2,19].

Strengths:

- Community-based design with direct household observation adds ecological validity.
- Combination of behavioral and physical environment indicators allows integrated assessment.
- Use of prevalence ratios provides interpretable measures for public health practice.

Limitations:

- Cross-sectional design prevents causal inference.
- Small sample size may reduce power to detect associations for ventilation, lighting, or breastfeeding.

- Pneumonia history relied on caregiver report of physician diagnosis, which may introduce recall bias or misclassification.
- Lack of multivariable modeling limits adjustment for confounders such as immunization status, nutritional status, or healthcare access.

Interventions should focus on integrated household strategies:

1. Smoke-free home promotion: community pledge systems, counseling, cessation referral pathways, and peer reinforcement.
2. Environmental risk screening at Posyandu: simple checklist for crowding and smoking exposure integrated into routine visits.
3. Housing density risk reduction: short-term sleeping arrangement recommendations and longer-term advocacy for healthy housing improvements.

Targeted support for low-income households: prioritization for home visits and linkage to social support.

CONCLUSION

This study found that bedroom overcrowding and indoor smoking behavior were significantly associated with pneumonia among under-five children in a high-density urban area of Jakarta. Overcrowded sleeping conditions increased the likelihood of pneumonia, while exposure to indoor tobacco smoke further elevated risk. Although other environmental factors were not statistically significant, overall household living conditions remain important for child respiratory health.

Strengthening smoke-free home practices and addressing overcrowded housing conditions should be prioritized as key preventive strategies. Household-focused and community-based interventions are essential to reduce pneumonia burden among under-five children in densely populated urban settings.

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