Impact of Housing Quality on Acute Respiratory Infections in Flood-Prone Urban Settlements: A Mixed-Methods Study in Dukuh Kupang, Surabaya, Indonesia

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Abstrak

Penyakit jantung koroner Latar Belakang: Kualitas hunian merupakan faktor penting yang memengaruhi kesehatan pernapasan, khususnya di wilayah perkotaan rawan banjir. Di Kelurahan Dukuh Kupang, Surabaya, ventilasi buruk, kelembaban tinggi, dan kepadatan hunian diduga meningkatkan risiko Infeksi Saluran Pernapasan Atas (ISPA). Untuk mendukung intervensi kesehatan perkotaan, penelitian ini menganalisis hubungan antara kualitas hunian dan insiden ISPA.Metode: Penelitian menggunakan pendekatan mixed methods, menggabungkan survei rumah tangga pada 80 responden dari 8 Rukun Warga dengan wawancara informan kunci. Faktor-faktor seperti jenis lantai, jenis dinding, luas ventilasi, kelembaban udara, suhu ruangan, dan kepadatan hunian menunjukkan kualitas hunian. Gejala dan tingkat keparahan ISPA diidentifikasi melalui kuesioner dan catatan medis. Analisis regresi logistik digunakan untuk menguji hubungan statistik.Hasil: Sebanyak 62% rumah memiliki ventilasi tidak memadai, 55% memiliki kelembaban tinggi, dan 48,8% memiliki kepadatan hunian tinggi. Kejadian ISPA mencapai 71,3%, dengan gejala batuk (90,0%) dan demam (82,5%) paling sering dilaporkan. Ventilasi buruk berhubungan signifikan dengan ISPA (OR = 4,02; 95% CI: 1,78–9,08; p < 0,01).Kesimpulan: Risiko infeksi saluran pernapasan akut (ISPA) meningkat secara signifikan di daerah perkotaan yang rentan banjir. Studi ini menekankan pentingnya meningkatkan kondisi fisik perumahan, terutama ventilasi dan lingkungan dalam ruangan, sebagai strategi kritis dalam intervensi kesehatan masyarakat untuk mengurangi risiko ISPA di daerah-daerah rentan tersebut.

Kata kunci: ISPA, Indonesia, Kelembaban, Kualitas hunian, Ventilasi

Abstract

Background: In urban areas that are susceptible to flooding, the condition of housing is a critical determinant of respiratory health. In Dukuh Kupang, Surabaya, poor ventilation, high humidity, and overcrowding are suspected to elevate Acute Respiratory Infection (ARI) risk. This study investigated the correlation between the incidence of ARI and the condition of housing in order to inform urban health interventions.Methods: A mixed-methods approach was applied, combining a household survey of 80 residents from 8 neighbourhood units with key informant interviews. Housing indicators included floor type, wall type, ventilation area, humidity, temperature, and occupancy density. ARI symptoms and severity were assessed through questionnaires and clinical records. Logistic regression tested statistical associations.
Results: A high occupancy density of 48.8%, 55% of houses had excessive humidity, and over 62% of houses lacked adequate ventilation. The incidence of acute respiratory infections (ARIs) was 71.3%, with fever (82.5%) and cough (90.0%) being the most prevalent. ARI was significantly correlated with inadequate ventilation (OR = 4.02, 95% CI: 1.78–9.08, p < 0.01).Conclusion: Urban areas that are susceptible to inundation experience a substantial increase in the incidence of acute respiratory infections (ARIs). This study emphasizes the importance of improving physical housing conditions, particularly ventilation and indoor environments, as a critical strategy in public health interventions to reduce the risk of ARI in these vulnerable areas.

Keywords: *ARI, Housing quality, Humidity, Indonesia, Ventilation.*

Introduction

Acute respiratory infections (ARI) continue to be a significant cause of morbidity and mortality on a global scale, resulting in an estimated 4.2 million fatalities annually. The primary burden is experienced by low- and middle-income countries [1]. In Southeast Asia, ARI is consistently ranked among the top ten causes of outpatient visits and hospital admissions, significantly impacting vulnerable populations, including the elderly, infants, and those with compromised immunity [2].

Although the causes of diseases vary, the environment, especially the built environment, greatly affects how likely people are to be exposed to health risks and how diseases develop. Regular flooding makes already bad housing conditions worse, raising the risk of diseases linked to the environmentThe Indonesian government is currently engaged in the improvement of the living environment, particularly in urban areas that are susceptible to disasters, through the implementation of the National Medium-Term Development Plan (RPJMN). Therefore, improving the quality of the built environment must be a top priority in Indonesia's health and development policies. [3].

Housing quality, defined by structural integrity, ventilation adequacy, indoor humidity control, thermal comfort, and occupancy density, is a fundamental determinant of respiratory health. Poor ventilation limits air circulation, facilitating the accumulation of airborne pathogens and indoor pollutants, while high humidity promotes microbial growth and allergen persistence [4]. Overcrowded dwellings amplify interpersonal contact, increasing droplet and aerosol transmission risks [5]. Multiple studies have demonstrated that substandard housing is associated with higher ARI prevalence, particularly in informal settlements and flood-affected areas [6].

In Indonesia, rapid urbanisation has resulted in the proliferation of dense settlements with

limited infrastructure, often situated in environmentally hazardous locations [7]. Flood events—common in low-lying urban areas—exacerbate housing deterioration by causing structural damage, persistent dampness, and compromised indoor air quality [8]. Floodwaters may introduce microbial contamination, chemical pollutants, and allergens, further elevating respiratory health risks even after floodwaters subside [9]. These interactions create a cyclical hazard: floods degrade housing quality, and poor housing conditions, in turn, elevate susceptibility to ARI [10].

Dukuh Kupang is a crowded neighborhood in Surabaya, East Java, where people live in high-risk conditions because of frequent flooding and poor housing. Even though it's not officially labeled as a major flood area, water often comes in from nearby places, weak drainage systems, and lack of proper flood protection. Many families live in small, stuffy homes with little air and high moisture, which can help spread respiratory infections like ARI. Past studies usually looked at things like home quality or how flooding affects health separately, but not many have shown how these issues work together to cause ARI. This study helps us understand how bad housing—like not enough fresh air, high humidity, and too many people in small spaces—adds to the risk of ARI, especially in places that are both crowded and often flood, such as Dukuh Kupang. This gives us new knowledge about how flooding and poor housing impact health in busy urban areas. By looking at Dukuh Kupang, which floods often because of bad city planning, this study is unique in helping us understand the link between housing, flooding, and health issues.

The study's key points are using both data and personal stories, focusing on flood-prone parts of Surabaya, and looking at how housing quality, exposure to flooding, and ARI are connected. This method not only measures health problems like ISPA but also explores the experiences of people and community members to see how poor housing and flooding affect each other. This helps identify areas that need improvement, like better ventilation and flood protection, and gives a foundation for more effective, local health actions. Using this approach, we can create better, more targeted solutions to lower the chance of ISPA in places like Dukuh Kupang that are often flooded. [8, 1

Metodh

Jenis Study Design and Setting

This investigation implemented a mixed-methods design, which integrated quantitative and qualitative methodologies to conduct a thorough investigation of the correlation between the condition of housing and the incidence of acute respiratory infections (ARIs). The study was conducted in Dukuh Kupang, a flood-prone urban subdistrict in Surabaya, East Java, Indonesia. Data collection was carried out between January and June 2025, focusing on residential areas with documented recurrent flooding and high population density.

Population and Sampling

The study population comprised residents of Dukuh Kupang Subdistrict, with a total registered population of 14,698 individuals distributed across 8 neighbourhood units (Rukun Warga). Using proportional sampling, a minimum of five households per neighbourhood unit were selected, yielding 40 households. From each selected household, at least two members were recruited, resulting in 80 respondents. Inclusion criteria were: residence in Dukuh Kupang for at least one year, age ≥18 years, and willingness to provide informed consent.

Variables and Measurements

The independent variable was housing quality, measured through six indicators: floor type, wall type, ventilation area, indoor humidity, room temperature, and occupancy density. The dependent variable was ARI incidence, assessed through self-reported symptoms (fever, cough, sore throat, nasal congestion, and dyspnea) in the past 12 months, verified by local health records when available. Flood exposure was recorded as a contextual factor. Housing characteristics were assessed via direct observation using a structured checklist. Humidity and temperature were measured with a hygrometer and digital thermometer.

Data Collection Procedures

Quantitative data was gathered using structured questionnaires that were handed out during face-to-face interviews by trained interviewers. Qualitative information was collected through semi-structured interviews with key people, such as local health workers, community leaders, and people who were affected by flooding. These interviews focused on how people viewed their housing conditions, health dangers, and steps they took to prevent problems.

Field observations and taking pictures also helped support the information from the questionnaires and interviews. To ensure that the data collected was reliable, the tools used in the study went through several checks. First, the questionnaire was reviewed to make sure it covered all important topics like living conditions, flooding, and risks from indoor air pollution. Experts in the field helped ensure that the questions were clear and easy to understand. Second, a small group of people tried out the questionnaire to see if the questions were logical and flowed well.

Based on their feedback, the questions were adjusted to make them clearer and more relevant. Third, experts in public health and urban planning reviewed the questionnaire and interview guide to make sure they aligned with the study's goals. They provided suggestions, and changes were made as needed. Finally, during the data collection process, regular checks and supervision were carried out to make sure the tools were being used correctly.

Data Analysis

The association between ARI incidence and housing quality was estimated by analyzing quantitative data using descriptive statistics, bivariate tests (chi-square), and multivariate logistic regression. The results were presented as odds ratios (OR) with 95% confidence intervals (CI). A value of $p < 0.05$ was used to establish the significance of the model. Qualitative data were verbatim transcribed, coded, and thematically analyzed to reveal recurring patterns and contextual factors that affect the risk of ARI. Triangulation between

quantitative and qualitative findings was performed to strengthen validitydiperoleh dari semua individu yang termasuk dalam penelitian

Result

Demographic Characteristics of Respondents

The study comprised 80 respondents, with 52.5% of them being female (n = 42) and 47.5% being male (n = 38). The age category with the highest percentage of individuals was 31–45 years (41.3%), followed by 18–30 years (28.8%), 46–60 years (21.3%), and >60 years (8.8%). Educational attainment varied, with 37.5% completing secondary school, 31.3% primary school, 21.3% tertiary education, and 10% with no formal education. The majority were informal sector workers (41.3%), followed by homemakers (22.5%), formal sector employees (18.8%), and unemployed (17.5%). Household size averaged 4.3 persons, and 71.3% of respondents reported having access to public health services within 1 km of their residence.

Table 1. Demographic characteristics of respondents (n = 80)

Variable	Category	n	%
Sex	Male	38	47,5
	Female	42	52,5
Age groups (years)	18-30	23	28,8
	31-45	33	41,3
	46-60	17	21,3
	>60	7	8,8
Education	No formal education	8	10
	Primary school	25	31,3
	Secondary school	30	37,5
	Tertiary education	17	21,3
Occupation	Informal sector	33	41,3
	Homemaker	18	22,5
	Formal Sector	15	18,8

	Unemployed	14	17,5
Household size	Mean ± SD	4,3 ± 1,2	-
Access to health service	≤1 km	57	71,3
	>1 km	23	28,8

Physical Housing Quality

Observational assessments indicated that 65% of houses had non-ceramic floors (e.g., cement or soil), and 55% had walls made from low-grade materials such as wood or bamboo. Inadequate ventilation (<10% of floor area) was found in 62.5% of dwellings, while 55% recorded high indoor humidity (>60%). Indoor temperatures exceeded 28°C in 42.5% of homes. High occupancy density (>2 persons per room) was observed in 48.8% of households, with limited natural lighting reported in 46.3% of dwellings.

Table 2. Physical housing quality indicators.

Indicator	Category	n	%
Floor type	Ceramic/tile	28	35
	Non-ceramic (cement/soil)	52	65
Wall type	Brick/concrete	36	45
	Low-grade material (wood/bamboo)	44	55
Ventilation area	Adequate (≥ 10% of floor area)	30	37,5
	Inadequate (<10% of floor area)	50	62,5
Indoor humidity	≤60%	36	45
	>60%	44	55
Indoor temperature	≤28^{0}C	46	57,5
	>28^{0}C	34	42,5
Occupancy density	≤2 persons/room	41	51,2

	>2persons/room	39	48,8
Natural lighting	Adequate	43	53,7
	Limited	37	46,3

ARI Incidence and Symptom Profile

Within the past 12 months, 71.3% (n = 57) of respondents reported experiencing at least one episode of ARI. The most frequently reported symptoms were cough (90.0%), fever (82.5%), sore throat (67.5%), nasal congestion (63.8%), and dyspnea (41.3%). Based on severity, 58.6% of ARI cases were classified as mild, 31.0% as moderate, and 10.4% as severe.

Table 3. ARI incidence and symptom profile

Variable	Category	n	%
ARI incidence (12 mo)	Yes	57	71,3
	No	23	28,8
Common symptoms	Cough	51	90*
	Fever	47	82,5*
	Sore throat	38	67,5*
	Nasal congestion	36	63,8*
	Dyspnea	23	41,3*
Severity classification	Mild	33	58,6*
	Moderate	17	31*
	Severe	6	10,4*

*Percentages calculated from ARI-positive respondents (n=57).

Multivariate Logistic Regression of Housing Quality Indicators and ARI Incidence

A multivariate logistic regression model was used (Table 4). This model included several variables at the same time, like poor ventilation, high humidity, high number of people in a space, non-ceramic floors, and low-quality walls. The purpose was to check how each of these factors might affect the chance of getting an acute respiratory infection (ARI),

while also considering other factors.

When looking at each factor one by one, it was found that poor ventilation, high humidity, and high occupancy had strong links to increased ARI risk. Poor ventilation was associated with a significantly increased risk of ARI (OR = 4.02, 95% CI: 1.78–9.08, p < 0.01). The risk was also associated with high humidity (OR = 2.65, 95% CI: 1.21–5.82, p = 0.015) and high occupancy (OR = 2.14, 95% CI: 1.01–4.55, p = 0.048). On the other hand, the p-values of non-ceramic floors and low-quality walls (0.313 and 0.421, respectively) were not statistically significant, as they exceeded the 0.05 threshold. These factors should be considered not significant.

Table 4. Multivariate Logistic Regression of Housing Quality Indicators and ARI Incidence

Housing Quality Indicator	OR	95% CI	p-value
Inadequate ventilation	4,02	1,78-9,08	<0,01
High humidity (>60%)	2,65	1,21-5,82	0,015
High occupancy density	2,14	1,01-4,55	0,048
Non-ceramic floor	1,48	0,69-3,18	0,313
Low-grade wall material	1,36	0,64-2,91	0,421

Non-significant variables (p > 0.05) are marked for clarity. Adjusted OR (AOR) indicates the use of a multivariate logistic regression model, accounting for multiple housing quality indicators simultaneously.

Discussion

This study demonstrates a significant correlation between the incidence of Acute Respiratory Infections (ARI) in a flood-prone urban settlement in Surabaya and poor housing quality, specifically inadequate ventilation, excessive interior humidity, and high occupancy density. The national estimate of 40–50% in similar metropolitan situations in Indonesia is significantly lower than the reported ARI frequency of 71.3% [11], indicating a local

environmental burden. The robust association between ARI risk and insufficient ventilation (OR = 4.02) aligns with worldwide data demonstrating that insufficient air exchange leads to the accumulation of airborne pathogens and irritants [12]. In line with research showing that too much moisture promotes microbial development and allergens that deteriorate respiratory function, high indoor humidity (>60%) was also substantially linked to ARI [13]. After a flood, similar results have been published, showing that respiratory hazards are prolonged by residual moisture beyond the immediate catastrophe period [14][20]. Frequent flooding in Dukuh Kupang probably makes indoor air quality and humidity levels worse, which increases the risk of respiratory illnesses.

The association between ARI and high occupancy density (>2 people per room) was substantial (OR = 2.14), highlighting the importance of close contact in the transmission of droplets and aerosols in confined spaces [15]. A significant contributing factor to the spread of infectious diseases, particularly in low-income metropolitan settings, has been identified as overcrowding [16][19]. The combined effects of overcrowding and poor ventilation in this study probably increased the likelihood of transmission. The study found that floor and wall materials were not strongly linked to ARI when other factors were considered, which is different from some earlier research done in rural areas [17] [18].

This difference might be because in urban areas, both homes with and without ARI mostly have non-ceramic floors and low-quality walls. These materials don't help much in telling apart the two groups. In Dukuh Kupang, the main focus after a flood was on quick fixes instead of longer-term improvements like better ventilation or lower humidity. This shows that people's habits and money issues can stop environmental health efforts from working well. This suggests that how building materials affect ARI might depend on where you are, so more research is needed to see how these materials work with other

environmental factors in cities. Future studies should check if floor and wall materials have a bigger effect in different situations or with different groups of people in urban areas.

The statement that residents focus on fixing flood damage right away instead of improving ventilation shows a big problem in how people act and what they value when it comes to health improvements. This shows why we need policies that look at both the physical conditions of homes and what the community really cares about. Even though fixing flood damage is important, we need to make sure that long-term health improvements, like better ventilation, are part of the recovery plan. Using a multi-sector approach is key because it handles both the urgent and the long-term needs. This includes not just the buildings and environment, but also how people behave and what they can afford. Future policies should treat health improvements, such as better air flow and humidity control, as important parts of flood management and recovery, along with efforts to prevent floods. This overall approach can help connect quick fixes with lasting health benefits, which can lower the high rate of acute respiratory infections in urban.

Conclusion

This study shows how bad housing conditions—like poor airflow, high humidity inside homes, and too many people living in one place—make it more likely for people to get acute respiratory infections (ARIs) in cities that are often flooded. In Dukuh Kupang, Surabaya, the rate of ARIs is 71.3%, which is much higher than the average in other urban areas of the country. The regular flooding in this area makes the already bad indoor conditions worse, leading to ongoing health problems for the people living there. Even though the materials used for floors and walls didn’t turn out to be major causes of ARIs, the study points out that economic and behavior-related issues are big reasons why it's hard to make changes to the

houses that could help reduce health risks.

The results show the need for a combined strategy that not only improves air circulation, manages humidity, and controls how crowded homes are, but also includes steps to prevent flooding. This all-around approach would help deal with both the short-term and long-term health challenges that vulnerable urban communities face. The study clearly supports working across different sectors, showing that making changes to buildings, running community-based programs, and introducing new policies at the same time is key to reducing ARI cases in a lasting way. The study also gives clear suggestions on what needs to be done, including supporting ventilation improvements in homes through subsidies, setting up programs to control dampness, and launching public health efforts to teach people about indoor air quality, along with steps to prevent flooding. This mixed approach makes sure both the environment and people's habits are addressed in a way that is fair, long-lasting, and effective in lowering the risk of ARIs.

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