Safety investigation in students' residential buildings using Hazard Identification Risk Analysis and Risk Control

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ABSTRACT

Students' residential buildings in this study attracted a variety of bird species, especially the Barn Swallow or the scientific name Hirundo Rustica due to its rich food and water resources and the building structure that is suitable to habitat. However, the flock of Barn Swallow contributes to major issues in managing building maintenance such as their droppings inside and outside the buildings, structures, and vehicles rust due to exposure to pigeon droppings, roof materials, and structures becoming easily damaged because of the birds' activity. This study aims to assess the safety and health risks using Hazard Identification, Risk Assessment, and Risk Control (HIRARC) to suggest the intervention for the severe and most likelihood risks existing in the study. The HIRARC results show the highest scale point 15 in the residential building corridor compared to the other areas. To mitigate the risks in the future, a cover mechanism along the corridor pipeline will be designed. This study significantly highlights the main risks in residential building maintenance management related to biological hazards, and also contributes to valuable resources for building managers and policymakers in developing effective strategies to manage bird-related risks in residential environments.

Keywords: HIRARC, Barn Swallow, Residency Building

1. INTRODUCTION (First-level heading, Cambria 11pt, Uppercase, Bold)

Over the past decade, Malaysia has experienced a significant transformation in urban living patterns, characterized by a pronounced shift towards vertical residential developments. This trend is driven by rapid urbanization, population growth, and evolving socio-economic dynamics, which have collectively influenced housing preferences and urban infrastructure development. According to the Department of Statistics Malaysia, the urban population increased from 26,544,440 in 2022 to 27,006,299 in 2023 [1], underscoring the accelerating pace of urbanization. Concurrently, tall residential buildings, including condominiums, apartment complexes, serviced residences, and high-rise luxury towers, have become a dominant feature of urban housing markets. These structures vary in architectural design, height, and functionality, catering to diverse resident needs while reshaping urban skylines.

Despite their growing popularity, tall residential buildings present a range of challenges and risks that warrant careful consideration. Studies have highlighted several disadvantages associated with vertical living, including congestion, limited outdoor space, noise pollution, and reduced privacy [2]. Additionally, structural integrity, fire hazards, and environmental pollution have been identified as significant safety concerns [3]. Biological hazards, such as pest infestations (e.g., rodents and insects), mold growth due to poor ventilation, and the presence of avian species, further complicate the living environment in these buildings [4, 5]. Notably, the colonization of

tall buildings by birds, such as Barn Swallows (Hirundo rustica), has been linked to health and safety risks, including waste accumulation and potential disease transmission [6].

This study focuses on a specific case involving residential buildings housing 4,000 students affiliated with a local university. Among the examined blocks (A1, A3, and A4), Block A2 was identified as the primary site of Barn Swallow habitation, likely due to its central location within the residential complex and proximity to a pond. The U-shaped, six-floor structure, with 27 units per floor, features architectural elements that facilitate avian nesting and perching, particularly along pipelines and window ledges. The birds' presence has necessitated regular cleaning interventions to mitigate contamination risks, as illustrated in Figure 1. Research on Barn Swallow habitat preferences indicates their affinity for open areas, access to water sources, and specific architectural features conducive to nest construction [7].

Given the potential hazards associated with avian colonization and other risks inherent to tall residential buildings, this study employs a systematic approach to safety assessment using Hazard Identification, Risk Analysis, and Risk Control (HIRARC) methodologies. The findings aim to inform strategies for enhancing safety and well-being in residential accommodations, addressing both structural and biological risks. This research contributes to the broader discourse on urban living by providing insights into the challenges of vertical housing and proposing evidence-based solutions for sustainable and safe urban development.

Figure 1. Students' Residency Buildings Complex

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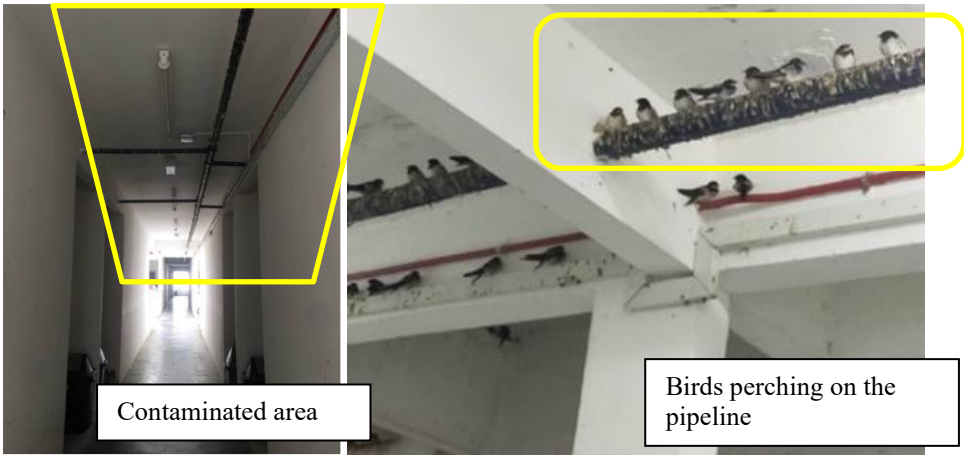

Figure 2. Barn Swallow inhabit the pipelines

2. METHODS

This study employed a structured methodology to systematically evaluate and mitigate hazards associated with avian activity, particularly barn swallows (Hirundo rustica), in residential buildings housing 4,000 students affiliated with a local university. The study focused on four residential blocks (A1, A2, A3, and A4), with Block A2 identified as the primary site of barn swallow habitation due to its high avian occupancy. The U-shaped, six-floor buildings, as depicted in Figure 1, served as the study site, with each floor comprising 27 units designed to accommodate student residents.

2.1 Data Collection and Observation

A multi-phase observational approach was implemented to assess bird behaviour, habitat preferences, and associated hazards. Initial observations were conducted to document the behavioral patterns of barn swallows, including their nesting and perching activities. Subsequent observations aimed to identify preferred nesting sites and areas frequently inhabited by the birds. Finally, the study focused on documenting avian activities contributing to potential hazards, such as waste accumulation and structural interference. These observations were conducted systematically across all four residential blocks to ensure comprehensive data collection.

2.2 Hazard Identification and Risk Assessment

Hazard identification was conducted using the Hazard Identification, Risk Analysis, and Risk Control (HIRARC) methodology [8]. This involved meticulous documentation of areas prone to bird nesting, perching sites, and associated risks, such as droppings accumulation and structural damage. The geographical positioning of the buildings, including proximity to water sources and open areas, was analysed to understand environmental factors influencing bird attraction.

Risk assessment was performed through a two-step process. First, risks were qualitatively categorized based on severity and likelihood, as outlined in Table 1 and Table 2. This was followed by a semi-quantitative analysis, where numerical values were assigned to each risk to derive a comprehensive risk rating, as presented in Table 3 [8]. The risk matrix method, illustrated in Table 4, was utilized to prioritize hazards and inform the allocation of resources for risk mitigation strategies [8]. The risk was calculated by multiplying likelihood with severity as shown below. The measurement is made by identification on how severe and when likely of the hazard. In other words, the risk assessment is an in-depth look to specify situations, process and other harmful activities or hazard at residential buildings [8].

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$$\text{risk } (\mathbf{R}) = \text{likelihood } (\mathbf{L}) \times \text{severity } (\mathbf{S}) \quad (1)$$

Table 1 Likelihood table

LIKELIHOOD (L)	EXAMPLE	RATING
Most likely	The most possible outcome of understanding the threat / occurrence.	5
Possible	It has a fair probability of happening and is not uncommon.	4
Conceivable	It could happen at some stage in the future.	3
Remote	It was not understood that it would occur after several years.	2
Inconceivable	It is almost unlikely and has never happened.	1

Table 2 Severity table

SEVERITY (S)	EXAMPLE	RATING
Catastrophic	Numerous deaths, irrecoverable damage to property and productivity.	5
Fatal	Approximately one single fatality causes substantial harm to property if danger is detected.	4
Serious	Non-fatal accident, lifelong handicap.	3
Minor	Disabling injury, but not lasting.	2
Negligible	Minor abrasions, fractures, cuts, damage to the first aid kind.	1

Table 3 Risk assessment matrix level

LIKELIHOOD	SEVERITY				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Table 4 Indication of risk level

RISK LEVEL	
1 to 4	LOW
5 to 12	MEDIUM
13 to 20	HIGH

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2.3 Ethical Considerations and Limitations

Ethical approval was obtained prior to the study to ensure compliance with established ethical guidelines. Potential limitations, including sample size constraints and environmental variability, were acknowledged and accounted for during data analysis and interpretation to maintain the robustness of the findings.

3. RESULTS AND DISCUSSION

3.1 Observation findings

Figure 3 illustrates the temporal patterns of avian activity within the residential buildings. The data reveal that barn swallows (Hirundo rustica) exhibited peak activity during the early morning and dusk periods. During these times, the birds were observed engaging in foraging behaviour, departing from their nests in search of food, and subsequently returning to rest. This cyclical activity pattern coincided with increased noise levels, which were reported to cause disturbances among the student residents. The noise generated by the birds during their return to nesting sites was identified as a significant source of annoyance, impacting the living conditions of the occupants. These observations highlight the temporal correlation between avian activity and resident discomfort, underscoring the need for targeted mitigation strategies to address noise-related issues.

Figure 3. Barn Swallow reside the buildings at night time

From the observation, it was found that barn swallows frequently perched on the edges of the building, leaving their waste along the corridors, as depicted in Figure 4 (a-f). The accumulation of avian waste in these areas resulted in unpleasant odours, contributing to discomfort among residents. Although daily cleaning routines were implemented to maintain hygiene and a healthy environment, certain areas, such as the pipelines, were not regularly cleaned due to logistical challenges, including the need for specialized equipment (e.g., ladders) and increased resource consumption (e.g., water and cleaning agents). This limitation in cleaning practices allowed waste to persist in less accessible areas, exacerbating hygiene concerns.

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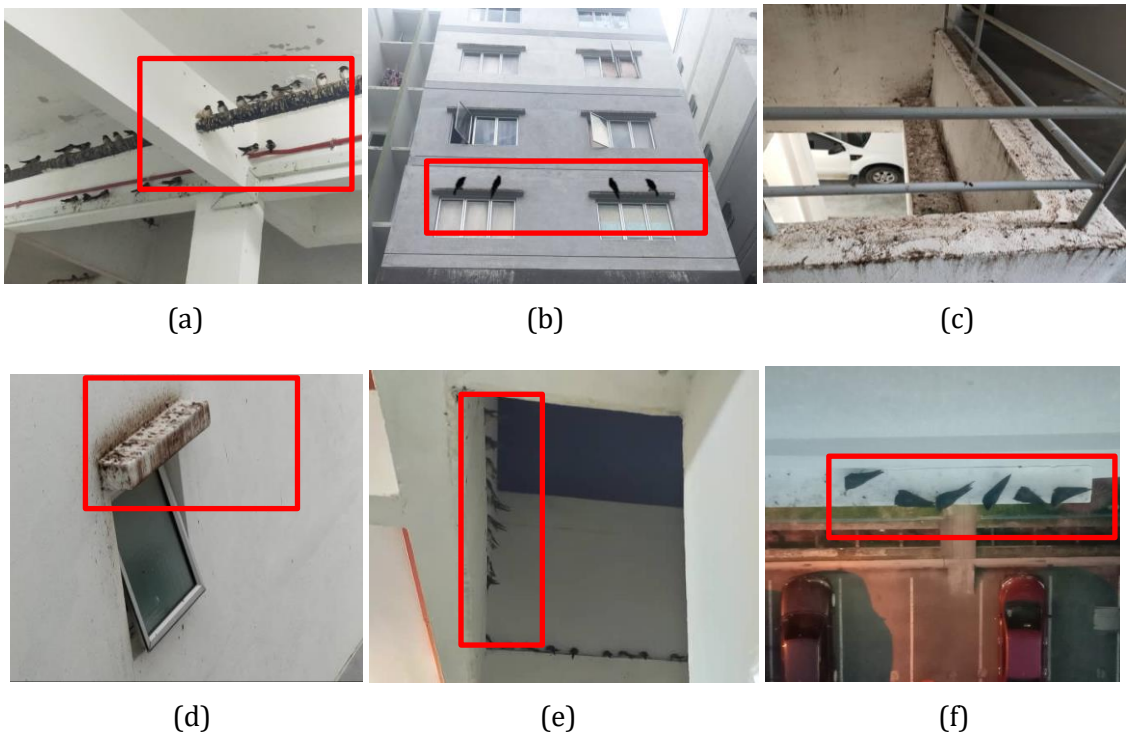

(a) (b) (c)

(d) (e) (f)

Figure 4. (a-f) Biological hazard existence in the buildings

Figure 5 (a-c) highlights the extent of biological hazards posed by bird droppings within the residential complex. Parked vehicles in the area were frequently covered with droppings, leading to paint damage and rust due to the acidic nature of the waste as shown in Figure 5 (a). Additionally, the building exteriors and ground floors were often contaminated with droppings, as illustrated in Figure 5(b) and (c). The presence of these biological hazards not only compromised the aesthetic appeal of the area but also created an unclean and unwelcoming environment.

(a) (b) (c)

Figure 5. (a) Corrosion car, (b) Bird waste on car park, (c) Bird waste stain the building

3.1 HIRARC results

The study identified the hostel corridor area as a critical site for case analysis due to its high exposure to biological hazards. Potential risks were categorized into three levels: high, medium, and low, based on their severity and likelihood. Table 5 presents the outcomes of the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis. Three primary activities were documented in the HIRARC form, as illustrated in Table 5, providing a structured

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assessment of the risks associated with avian activity and guiding the development of targeted mitigation strategies. These findings underscore the need for comprehensive risk management approaches to address the health, safety, and aesthetic challenges posed by bird infestations in residential buildings. The Hazard Identification, Risk Assessment, and Risk Control (HIRARC) analysis identified three primary activities associated with hazards posed by barn swallow (Hirundo rustica) activity in the residential buildings. Each activity was evaluated based on likelihood, severity, and risk level, with corresponding recommendations for risk mitigation.

3.1.1 Activity 1: Students Passing Through the Corridor

The first activity involved students passing through corridors exposed to unsanitary conditions caused by bird droppings. The hazard identification revealed that students faced respiratory difficulties and increased susceptibility to illness due to the unsanitary environment. Existing risk control measures included regular housekeeping to ensure the corridors remained clean. Using the likelihood and severity rating metrics outlined in sub-chapter 2.6.1.3, the risk (R) was calculated as:

$$\text{Risk (R)} = \text{Likelihood (L)} \times \text{Severity (S)} = 5 \times 3 = 15 (\text{High})$$

As this activity fell into the high-risk category, immediate action was deemed necessary. The HIRARC form recommended covering the pipeline areas along the corridor to minimize bird perching and subsequent waste accumulation.

3.1.2 Activity 2: Cleaning and Washing Bird Droppings

The second activity involved cleaners tasked with removing and washing bird droppings from the corridors. The hazard identified was exposure to bacteria and microorganisms, which posed health risks to the cleaners. Symptoms such as skin irritation were reported following cleaning activities. The existing risk control measure included cleaning and washing the affected areas. The risk was calculated as:

$$\text{Risk (R)} = \text{Likelihood (L)} \times \text{Severity (S)} = 4 \times 2 = 8 (\text{Medium})$$

To mitigate this medium-risk activity, it was recommended that cleaners wear a full set of personal protective equipment (PPE) to prevent direct exposure to harmful microorganisms.

3.1.3 Activity 3: Parked Cars Covered in Bird Droppings

The third activity focused on cars parked near the building, which were frequently covered in bird droppings. The hazard identified was the high acidity of the droppings, which caused paint damage and corrosion if not promptly removed. The risk level for this activity was calculated as moderate as calculated below. The existing risk control measures advised residents to park away from the building area.

$$\text{Risk (R)} = \text{Likelihood (L)} \times \text{Severity (S)} = 5 \times 2 = 10 \text{ (Medium)}$$

To mitigate this medium-risk activity, it is recommended that management provide covered parking facilities to protect vehicles from bird droppings.

3.1.4 Summary of Findings

The HIRARC analysis revealed three significant problems associated with barn swallow activity, with the first activity (students passing through the corridor) posing the highest risk. Addressing this primary hazard was prioritized to ensure a safer and healthier environment for students.

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Mitigation of the second and third activities was expected to follow as secondary outcomes once the primary hazard was controlled. The proposed solution involved implementing a barn swallow control device to reduce bird activity in the residential area. These findings demonstrate the successful application of the HIRARC methodology to identify and investigate hazards associated with barn swallow activity, achieving the study objective of employs a systematic approach to safety assessment at students' residential buildings.

Table 5 Summary of HIRARC results

	Activity: Controlling the waste of barn swallow at the hostel building.			Conducted by: Nurani binti Mohammad				
	Hazard identification			Risk analysis				
	Work activity	Hazard	Effect	Existing risk control	Likelihood	Severity	Risk	Recommendation
1.	Student passing by at corridor.	Living in unsanitary and unpleasant surrounding.	Sick and difficult for breathing.	Housekeeping.	5	3	15 (high)	Covered the pipeline area along the corridor.
2.	The workers are cleaning and washing the birds dropping at the corridor.	The area exposed to bacteria and may threaten human health.	The workers skin is itching after clean the area.	Cleaning and washing the bird dropping.	4	2	8 (medium)	The workers clean the hostel building with using full set of personal protective equipment (PPE).
3.	The car that park at the hostel building area is always covered to the birds dropping.	Bird droppings have a relatively high acid can cause damage to the equipment.	It causes the car paint to fall off or fade if these bird droppings are not washed immediately.	Park the car away from the hostel building.	5	2	10 (medium)	The management can provide the covered parking to the students and workers.

4. CONCLUSION

This study systematically evaluated the hazards associated with barn swallow (Hirundo rustica) activity in student residential buildings using the Hazard Identification, Risk Analysis, and Risk Control (HIRARC) methodology. The findings revealed significant risks, including unsanitary conditions, health hazards, and property damage, stemming from bird droppings and nesting behaviors. Three primary activities—students passing through contaminated corridors, cleaners exposed to biological hazards, and parked vehicles damaged by acidic droppings—were identified and assessed, with risk levels categorized as high, medium, and moderate, respectively.

The implementation of targeted mitigation strategies, such as covering pipeline areas, providing personal protective equipment (PPE) for cleaners, and establishing covered parking facilities, was recommended to address these risks. By prioritizing the highest-risk activity and proposing a barn swallow control device, this study provides a framework for enhancing safety, hygiene, and overall living conditions in residential buildings. These outcomes underscore the importance of proactive risk management in urban housing environments and contribute to the broader discourse on sustainable and safe urban development. Future research should explore long-term solutions for avian control and their effectiveness in similar settings.

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