UNIVERSITI PUTRA MALAYSIA

RETROSPECTIVE STUDY ON FELINE HIGH-RISE SYNDROME CASES IN UNIVERSITY VETERINARY HOSPITAL OF UNIVERSITI PUTRA MALAYSIA FROM 2020-2021

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LIST OF ABBREVIATIONS

HRS	High-rise Syndrome
SBT	Sindrom Bertingkat Tinggi
UPM	Universiti Putra Malaysia
UVH	University Veterinary Hospital
DSH	Domestic Shorthair
BSH	British Shorthair
%	Percentage
CRT	Capillary Refill Time
TMJ	Temporomandibular Joint

ABSTRAK

Abstrak dari kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 – Projek Ilmiah Tahun Akhir.

KAJIAN RETROSPEKTIF MENGENAI SINDROM BERTINGKAT TINGGI DALAM KUCING YANG DIBAWA KE HOSPITAL UNIVERSITI VETERINAR, UNIVERSITI PUTRA MALAYSIA, DARI TAHUN 2020 -2021

oleh

Ashwinie Selvaraj

2022

Penyelia: Dr Wan Mastura Shaik Mohamed Mossadeq

Penyelia Bersama: Dr Rozanaliza Radzi

Sindrom bertingkat tinggi (SBT) merujuk kepada kecederaan yang dialami oleh kucing ketika jatuh dari ketinggian dua atau lebih tingkat. Kecederaan biasa yang berkaitan dengan SBT adalah trauma toraks, perut, ortopedik, dan orofasial. Bangunan bertingkat tinggi adalah pilihan tempat tinggal yang popular di kalangan orang dari semua latar belakang kerana kemudahan, keselamatan, dan kosnya. Oleh kerana semakin banyak orang memilih untuk tinggal di bangunan tinggi, pentingnya menggabungkan reka bentuk mesra kucing ke unit kediaman semakin bertambah. Kajian ini bertujuan untuk meneroka faktor risiko yang mempengaruhi kes SBT di antara kes-kes kecederaan traumatik kucing yang ditunjukkan kepada Hospital Veterinar Universiti (UVH) Universiti Putra Malaysia (UPM). Buku log kes dari UVH-UPM dari tahun 2020 hingga 2021 telah dikaji semula untuk mengenal pasti kes-

kes kecederaan traumatik kucing. Rekod perubatan untuk kes-kes tersebut kemudian diperiksa secara manual untuk mencari kes SBT. Kriteria untuk kes terpilih ialah jatuh dari ketinggian 2 tingkat atau lebih. Dari jumlah 314 kes, 42 kes sesuai dengan kriteria. Ketinggiannya berkisar antara 2 tingkat hingga 8 tingkat tinggi dengan kekerapan jatuh tertinggi berlaku dari tingkat tiga. Kumpulan umur yang terjejas adalah antara 1-6 tahun. Tidak ada hubungan antara jantina dan kejadian HRS. Jenis kecederaan yang paling biasa dialami adalah kecederaan anggota badan berjumlah 85.7% daripada semua kecederaan diikuti oleh kecederaan orofasial (28.6%). Risiko kecederaan toraks meningkat apabila ketinggian kejatuhan meningkat. Hasil kajian menunjukkan bahawa sifat tertentu seperti usia dan ketinggian kejatuhan dapat mempengaruhi kemungkinan dan hasil SBT kucing.

Kata kunci: kucing; sindrom bertingkat tinggi; kecederaan traumatik; patah tulang

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfilment of the course VPD 4999 – Final Year Project.

RETROSPECTIVE STUDY ON FELINE HIGH-RISE SYNDROME CASES IN UNIVERSITY VETERINARY HOSPITAL OF UNIVERSITI PUTRA MALAYSIA FROM 2020-2021

by

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2022

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Co-Supervisor: Dr. Rozanaliza Radzi

High-rise syndrome (HRS) refers to the injuries sustained by cats when they fall from a height of two or more storeys. The typical injuries associated with HRS are thoracic, abdominal, orthopaedic, and orofacial trauma. High-rise buildings are a popular choice of residence amongst people of all backgrounds due to their convenience, safety, and cost. As more people opt for living in high-rise buildings, the importance of incorporating cat-friendly designs to residential units grows. This study aimed to explore risk factors that influenced the cases of HRS amongst the cases of feline traumatic injury presented to the University Veterinary Hospital (UVH) of Universiti Putra Malaysia (UPM). Case logbooks from UVH-UPM from 2020 to 2021 were reviewed to identify cases of feline traumatic injury. The medical records for those cases were then manually examined to find cases of HRS. The criteria for selected cases were falling from a height of 2 storeys or more. From a

total of 314 cases, 42 cases fit the criteria. The height ranged from 2 storeys to 8 storeys high with the highest frequency of falls occurring from the third floor. The predominantly affected age group was between 1-6 years old. There was no association between sex and incidences of HRS. The most common type of injury sustained was limb injuries totalling at 85.7% of all injuries followed by orofacial injuries (28.6%). The risk of thoracic injury increased as the height of the fall increased. The results show that certain attributes such as age and height of fall can impact the likelihood and outcome of feline HRS.

Keywords: feline; high-rise syndrome; traumatic injury; fractures

1.0 INTRODUCTION

High-rise syndrome (HRS) refers to the injuries sustained by cats when they fall from a height of two or more storeys high. The typical injuries that are associated with HRS are thoracic, abdominal, orthopaedic, and orofacial trauma. HRS can occur due to a myriad of reasons mainly inexperience and species-typical behaviour such as hunting and playing but the primary risk factors are open windows, open balcony doors, and loose window screens (Lefman & Prittie, 2022).

Cats are naturally keen to sit near windows and on windowsills. It serves as a form of enrichment and provides sunlight exposure to these cats whose lives are mostly spent indoors (Todd, 2012; Ellis, 2009). High-rise buildings are becoming more popular amongst people of all backgrounds due to their convenience, safety, and cost (Chung, 2021). As more and more people opt for living in high-rise buildings, the importance of incorporating cat friendly designs to residential units grows.

This study will investigate the association of age and gender of cat with the occurrence of HRS, as well as the association between types of injuries sustained with the height of fall. It will also investigate whether the time of presentation has any effect on the healing period.

High-rise buildings are increasing in popularity among people of all ages due to their convenience, safety, and cost. This increases the risk of pets falling from open balconies and windows. Awareness can mitigate the occurrence of HRS by encouraging the application of cat-friendly architecture such as window and balcony screens, or installation of safe patios. This study will help us understand the current pervasiveness of HRS as well as the risk factors involved.

The aims of this study are:

a) To investigate the association of age, gender, and breed with the occurrence of HRS in the cases presented to UVH, UPM.

b) To investigate the association between type of injuries frequently sustained with the height of fall of the cats diagnosed with HRS in UVH, UPM.

The hypotheses for this study are:

a) Ho: The age, gender, and breed of the cat do not influence the occurrence of HRS presented to UVH, UPM.

Ha: The age, gender, and breed of the cat influence the occurrence of HRS presented to UVH, UPM.

b) Ho: The height of fall does not influence the type of injuries sustained by the cats with HRS in UVH, UPM.

Ha: The height of fall influences the type of injuries sustained by the cats with HRS in UVH, UPM.

2.0 LITERATURE REVIEW

2.1 High-rise Syndrome

High-rise Syndrome (HRS) refers to the injuries obtained when cats fall from a height of two or more stories high (Catalkaya et al., 2022; Zaghloul & Samy, 2018; Merbl et al., 2013). Most literature have a consensus that the minimum height to qualify for HRS is 2 storeys high but the height in metres ranges from 6-8 metres. The height of each floor in a typical Malaysian building ranges from 2.5-3.6 metres, with the ground floor requiring a minimum height of 3 metres (Rahman, 2021; Uniform Building By-Laws, 1984). Thus, the minimum height of fall for a cat with HRS in Malaysia is 5.5 metres.

In recent years, high-rise buildings have been sprouting like mushrooms in cities such as Kuala Lumpur, Shah Alam, and Johor Bahru to name a few. This can be attributed to limited land availability, increased emigration to urban centres, and affordability (Lim, 2022; Chung, 2021). Pet ownership is also seeing a steady increase every year amongst Malaysians. Cat ownership in Malaysia increased by 2% from 608.7 thousand to 658.5 thousand cat owners between 2016 to 2020 (Euromonitor, 2020). In addition to that, the recent Covid-19 pandemic has also encouraged the keeping of pets for companionship (Euromonitor, 2022).

The cause of HRS is usually related to species-typical behaviours such as during playing, hunting, or from accidentally slipping when walking along the balcony railing (Merbl et al., 2013; Vnuk et al., 2004). Cats are innately drawn towards elevated structures such as shelves, climbing posts, and windowsills as it provides them a vantage point. It also serves to make them feel less vulnerable and escape stressors such as other pets and unfamiliar people. Besides that, windows are a great source of enrichment for cats as it allows them to hear, smell, and see their

outside environments. Thus, access to windows enables them to exhibit their natural behaviour and prevents unwanted behaviours (London, 2022; Tan et al., 2020).

In most studies, cats affected by HRS are usually young, ranging from 1 to 3 years (Catalkaya et al., 2022; Zaghloul & Samy, 2018; Zimmerman et al., 2013; Merbl et al., 2013). Next, most studies have also found that there is no significant correlation between sex and cases of HRS (Zaghloul & Samy, 2018; Oxley & Montrose, 2016; Merbl et al., 2013).

2.2 Mechanics and physiology of a falling cat

Cats are able to rotate their bodies mid-air due to their righting reflex. Their flexible spine and absence of a functional clavicle aids this movement. The righting reflex is present in cats as young as 3 weeks and is perfected once they reach 6 to 9 weeks of age (Pilitowski, 2016). Aside from that, cats can reach terminal velocity at a lower rate compared to humans due to their smaller mass. After falling between 5 to 7 storeys, they reach a terminal velocity of 60 miles/h or 97 km/h as they freefall. Humans, in comparison, reach terminal velocity at 120 miles/h or 193 km/h. This lower velocity combined with their righting reflex contribute to the high survival rate of cats with HRS (Villazon, 2020; Bonner et al., 2012).

Before they reach freefall, they usually instinctively extend their limbs to land feet-first. The force is transferred throughout the skeleton. Thus, impact in falls from heights below 5 storeys are commonly said to be limb fractures, specifically long bone fractures. This reduces the incidences and severity of thoracic and abdominal injuries (Merbl et al., 2013). Papazoglou et al. (2001) suggests that increased cases of spinal trauma can be seen in falls from shorter heights as the cats may not have enough time to orient themselves.

During freefall, cats spread their bodies to increase drag and reduce fall speed. This distributes the impact more evenly throughout the body, minimizing the severity of injuries. The force is spread throughout the body which decreases the occurrence of fractures. But this can also increase the incidences of thoracic, abdominal, and head trauma (Merbl et al., 2013; Vnuk et al., 2004).

2.3 Injuries associated with High-rise Syndrome

Early literature suggests that HRS usually manifests in the form of a triad of injuries which include epistaxis, hard palate fractures, and pneumothorax (Robinson, 1976; Whitney & Mehlhaff, 1987). Whitney & Mehlhaff (1987) reported pulmonary contusions as the most common injury followed by pneumothorax, facial trauma, and limb fractures.

In newer studies, orthopaedic fractures, specifically limb fractures, are said to be the most encountered injury. Other common signs include mandibular symphysis fracture, temporomandibular joint (TMJ) luxation, and pulmonary contusion (Catalkaya et al., 2022; Merbl et al., 2013; Collard et al., 2005).

3.0 METHODOLOGY

3.1 Conduct of study

The study conducted was a retrospective study on all cases of feline HRS that were presented to the University Veterinary Hospital of Universiti Putra Malaysia. Case logbooks for the year 2020 to 2021 were first reviewed to shortlist cases of traumatic feline injuries. The patient medical records were then examined to obtain cases of HRS. The details from the medical records were reviewed to eliminate cases that did not fit the inclusion criteria. Cases

were included if the affected cat fell from a height of 2 or more storeys and the medical records were complete with radiographs that were consistent with the diagnosis.

3.2 Type of data retrieved

Data that was obtained from the medical records were date of presentation, date of fall, visits to other veterinary clinics if any, case number, identification, age, sex, body weight, breed, management, brief history, radiological findings, final diagnosis, and treatment (general overview whether medically or surgically managed). Information regarding the injuries that were sustained was also recorded. The injuries were further categorised according to body systems. Radiographs of each case were retrieved from the archives of the Diagnostic Imaging Unit of UVH. The complete blood count and serum biochemistry results were also obtained and evaluated if available. This project was approved by the Final Year Project Committee of the Faculty of Veterinary Medicine as well as the University Veterinary Hospital of UPM.

3.3 Data analysis

The data obtained were tabulated in Microsoft Excel spreadsheets for ease of handling. Descriptive analysis was performed using SPSS and were presented in the form of percentages or frequencies. Measures of association was performed using the Pearson Chi-Square Test of Independence and Fisher's Exact Test where a p value <0.05 was considered significant with a 95% confidence interval.

4.0 RESULTS

4.1 Analysis of the number of cases and visits to UVH

A total of 5441 feline cases were presented to the Small Animal Clinic of University Veterinary Hospital between July 2020 to December 2021. Out of all those cases, 315 cases were identified as cases of feline traumatic injury. Twenty- two percent of cases (n=70) of feline traumatic injury were confirmed to be HRS. Multiple visits were counted as one entry.

Amongst these cases, 9% (n=6) were disregarded because the cats fell from the first floor which did not fit the criteria. Another 31% (n=22) were omitted because of incomplete data or there were no available radiographs to support the diagnosis. This leaves a total of 60% (n=42) cases for the final analysis. The prevalence of eligible cases of HRS amongst all traumatic cases presented to UVH in 2020-2021 was 13.3% (42/315). Twenty-nine percent of the cats presented (n=12) were brought to UVH after having visited a different veterinary clinic. Only 9.5% (4/42) of cases underwent surgical treatment.

4.2 Age, sex, and breed predilection towards HRS

Majority of the cats presented were young adults aged between 1 to 6 years old (n=22, 53%) (Figure 1). A good number of the cases presented were kittens less than 1 year old (n=16, 38%). Only 7% of the cases (n=3) consisted of mature adults aged between 7 to 10 years old. There was only 1 case that had a senior cat more than 10 years old (n=1, 2%). The mean age of the cats was 2.3 years old (range, 5 months to 13 years).

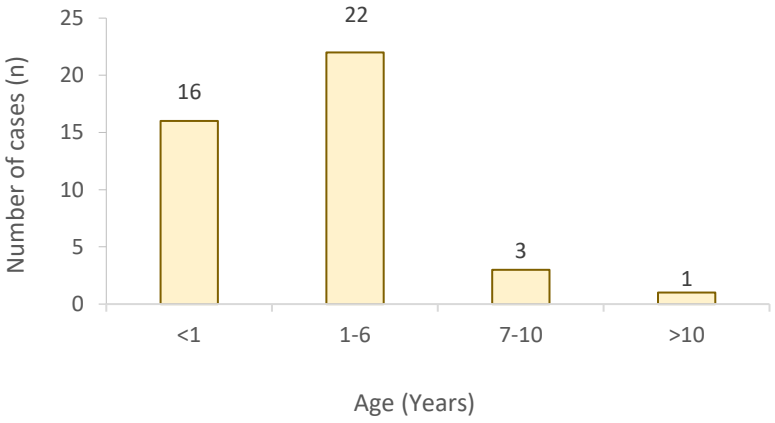
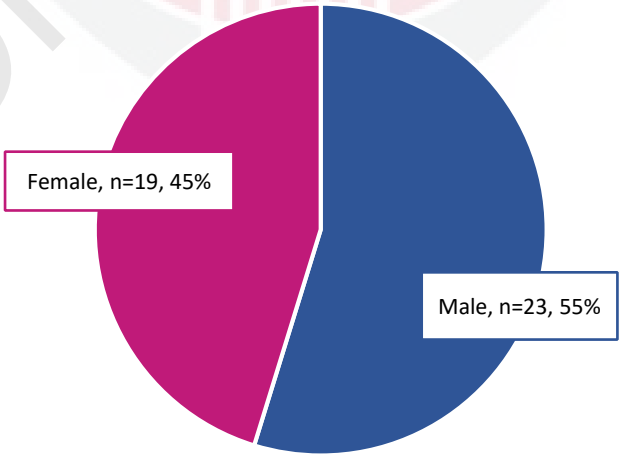


Figure 1: Age groups of cats presented to UVH with HRS (n=42)

There were slightly more males (n=23, 55%) than females (n=19, 45%) brought to the clinic (Figure 2 A). Amongst all the presented cats, 60% of them were not neutered (n=25). Sixty-three percent of the female cats were intact (12/19) (Figure 2 B) while 57% of the male cats were intact (13/23) (Figure 2 C). Based on the Fisher's Exact Test, there was no association (*P*=0.757) between the neuter status of the cats and cases of HRS.

A



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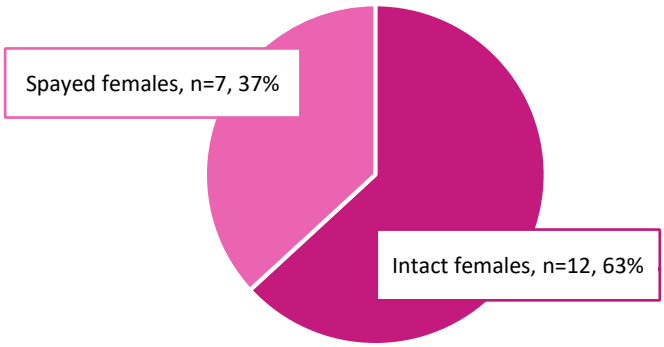

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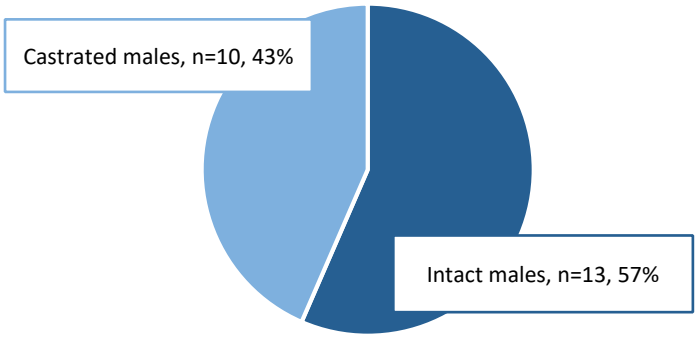

Figure 2: (A) Male and female cats presented to UVH for HRS (n=42). (B) Neuter status of female cats presented to UVH to HRS (n=19). (C) Neuter status of male cats presented to UVH for HRS (n=23)

Of all the cats presented to the clinic, the majority were Domestic Shorthair (DSH) cats (n=18, 43%). This was followed by mixed breed cats (n=8, 19%), Persian cats (n=5, 12%), Domestic Longhair (DLH) cats (n=4, 10%), British Shorthair (BSH) cats (n=3, 7%), and Bengal cats (n=2, 5%). The least presented cat breed were Maine Coons and Scottish Folds with each having

only one representative and contributing only two percent each. The breed and frequency are listed in Table 1 below.

Table 1: Breeds of cats presented to UVH for HRS (n=42)

Breed	**Frequency (cases)**	**Percentage (%)**
Domestic Shorthair (DSH)	18	43
Mixed breed	8	19
Persian	5	12
Domestic Longhair (DLH)	4	10
British Shorthair (BSH)	3	7
Bengal	2	5
Maine Coon	1	2
Scottish Fold	1	2

4.3 Distribution of HRS in relation to the height of fall

The mean height of fall was 4.5 storeys where the range was between the 2nd storey to the 8th storey. The mode and median of the level of fall was 3 storeys. As shown in Figure 3, 31.1% (13/42) of the falls were 3 storeys high, followed by 19.0% (8/42) of the cases having fallen 4 storeys. The least number of cases fell from the height of 2 storeys with only 3 cases.

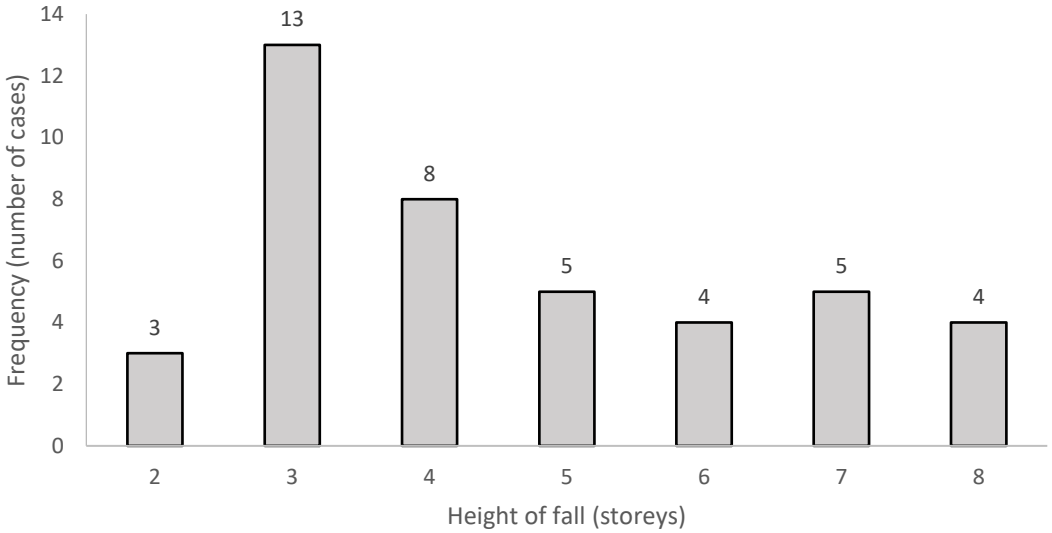

Figure 3: Frequency of HRS cases in relation to height of fall

4.4 Types of injuries sustained by cats affected with HRS

The common injuries found upon presentation to the clinic are as shown in Appendix I. Cases were often presented with multiple injuries. The injuries sustained affected most body systems. The most presented injuries and clinical signs which included pelvic fractures, hindlimb fractures, epistaxis, cleft palate, haematuria, pale mucous membranes, and hypothermia. Table 2 shows the frequency of injuries associated with each body system. Limb injuries were the most prevalent where 85.7% (36/42) of the cases were affected. This was followed by orofacial injuries at 28.6% (12/42). Shock and abdominal injuries both were 21.4% (9/42) each. Only 14.3% (6/42) of the cats were presented with thoracic injuries. Spinal injuries were presented in 9.5% (4/42) of the cats making it the least common injury.

Table 2: Frequency of injuries in HRS according to body system

Type of injury	Frequency (cases)	Percentage (amongst injuries, n=76)	Percentage (amongst cases, n=42)
Limb	36	47.4%	85.7%
Orofacial	12	15.8%	28.6%
Abdominal	9	11.8%	21.4%
Shock	9	11.8%	21.4%
Thoracic	6	7.9%	14.3%
Spinal	4	5.3%	9.5%
Total	76	100%	-

*Each case may be affected by single or multiple injuries

The frequency of limb injuries according to anatomical location can be seen in Appendix I. Pelvic fractures were a quarter (11/44) of all limb injuries and was seen in 26.2% (11/42) cats. This was followed by tibial fractures which was present in 19.1% (8/42) of all cases and was 18.2% of limb injuries. Hindlimb injuries were a majority of limb injuries (21/44, 47.7%). Forelimb injuries were mostly presented as humeral fractures which were in 9.1% (4/44) of all limb injuries. The ratio between forelimb and hindlimb injuries was 4:7. Excluding the pelvis, 54% (15/28) of the limb injuries occurred on the left side while 32% (9/28) occurred on the right side. Only 14% (4/28) affected both the left and right sides.

Amongst thoracic injuries, the commonly presented injuries were lung contusions, haemoptysis, and pneumothorax which were each equally represented at 28.6% (2/7) of all thoracic injuries and 4.8% (2/42) of all cases. There was also one case of luxation at the 6^{th}-7^{th} sternebrae.

Cats with signs of shock were mostly presented with pale mucous membranes which occurred in 11.9% (5/42) of all cases and 45.4% (5/11) of all shock related clinical signs. This was followed by hypothermia which was seen in 9.5% (4/42) of all cases and 36.4% (4/11) of shock injuries. There was one case of tachycardia and one case with prolonged capillary refill time.

Haematuria was the most observed clinical sign under abdominal injuries with 3 cases in total which were 7.1% of all cases and 30% of all abdominal injuries. Oliguria was seen in 2 cases while pyuria, constipation, melena, haematochezia, and diarrhoea each affected 1 case.

Spinal injuries were the least presented type of injury with only 4 cases (4/42, 9.5%). In all the affected cases, the spinal trauma occurred at the thoracolumbar region between T3 to L3 vertebrae.

4.4.1 Relationship between injuries sustained and height of fall

Cats that fell from every height in the studied range (2 to 8 storeys) were affected by traumatic limb injuries. Based on Table 3, 100% (3/3,8/8,4/4) of the cats that fell 2,4, and 8 storeys were afflicted with limb injuries. Only 60% (3/5) of the cats that fell 7 storeys had limb injuries making it the level with the least prevalence. There was no association (P=0.9834) between the height of fall and the incidences of limb injuries.

Table 3: Height of fall and incidences of limb injuries

Height of fall (storeys)	Total falls (cases)	Limb injury (cases)	Percentage (%)
2	3	3	100
3	13	11	84.6
4	8	8	100.0
5	5	4	80.0
6	4	3	75.0
7	5	3	60.0
8	4	4	100.0
Total	42	36	-

The frequency of thoracic injury increased with the height of fall. Cats that were presented with thoracic injuries fell between 6 to 8 storeys (Table 4). Seventy-five percent (3/4) of cats that fell 8 storeys had thoracic injuries. Half of the cats (2/4, 50%) that fell 6 storeys and 20% (1/5) of the cats that fell 7 storeys were affected. Cats that fell less than 6 storeys high did not exhibit thoracic injuries. There was a statistically significant association (P=0.0113) between the height of fall and the incidence of thoracic injury where (P<0.05) was considered significant.

Table 4: Height of fall and incidences of thoracic injuries

Height of fall (storeys)	Total falls (cases)	Thoracic injury (cases)	Percentage (%)
2	3	0	0.0
3	13	0	0.0
4	8	0	0.0
5	5	0	0.0
6	4	2	50.0
7	5	1	20.0
8	4	3	75.0

Table 5 illustrates the distribution of orofacial injuries throughout the different heights. There was no pattern in the distribution of orofacial injuries. The highest prevalence of orofacial injuries was seen in falls from the 7th storey where 3 out of the 4 cats (75%) that fell were affected. This was followed by 8 storey falls (2/4, 50%). Falls from 7 storeys had zero incidences while 1 out of 8 cats (12.5%) that fell 4 storeys were affected. There was no association (*P*=0.6884) between the incidences of orofacial injuries and the height of fall.

Table 5: Height of fall and incidences of orofacial injuries

Height of fall (storeys)	Total falls (cases)	Orofacial injury (cases)	Percentage (%)
2	3	1	33.3
3	13	3	23.1
4	8	1	12.5
5	5	2	40.0
6	4	3	75.0
7	5	0	0.0
8	4	2	50.0
Total	42	12	-

Incidences of spinal injury were only seen in falls between 3 to 5 storeys high (Table 6). Only 15.4% (2/13) of the cases that fell 3 storeys were afflicted with spinal injuries while 12.5% (1/8) of the cats that fell from the 4th storey were affected. Whereas spinal trauma occurred in 20.0% (1/5) of the cats that fell 5 storeys. There was no statistical association (*P*=0.8158) between height of fall and incidences of spinal trauma.

Table 6: Height of fall and incidences of spinal injuries

Height of fall (storeys)	Total falls (cases)	Spinal injury (cases)	Percentage (%)
2	3	0	0.0
3	13	2	15.4
4	8	1	12.5
5	5	1	20.0
6	4	0	0.0
7	5	0	0.0
8	4	0	0.0

Abdominal injuries were presented in cases that fell between 2 to 6 storeys (Table 7). Falls from 4 storeys were 37.5% (3/8) while falls from 2 storeys were 33.3% (1/3) of all cases. There were zero incidences on the 7th and 8th storey. There was no association (*P*=0.8605) between the incidences of abdominal injury and the height of fall.

Table 7: Height of fall and incidences of abdominal injuries

Height of fall (storeys)	Total falls (cases)	Abdominal injury (cases)	Percentage (%)
2	3	1	33.3
3	13	3	23.1
4	8	3	37.5
5	5	1	20.0
6	4	1	25.0
7	5	0	0.0
8	4	0	0.0
Total	42	9	-

The highest prevalence of shock was from falls from the 4th storey where 50% (4/8) of the cases were affected (Table 8). There were more incidences of shock in the lower storeys compared to the higher storeys. However, there was no statistical association (*P*=0.5116) between height of fall and incidences of shock.

Table 8: Height of fall and incidences of shock

Height of fall (storeys)	Total falls (cases)	Shock (cases)	Percentage (%)
2	3	0	0.0
3	13	3	23.1
4	8	4	50.0
5	5	0	0.0
6	4	1	25.0
7	5	1	20.0
8	4	0	0.0
Total	42	9	-

5.0 DISCUSSION

This study focused on pet cats affected by High-rise Syndrome when falling from heights of more than 2 storeys. Studies have reported an increase in popularity of high-rise buildings as a choice of residence amongst those staying in urban areas (Lim, 2022; Chung, 2021). Cat ownership has also been increasing over the years (Euromonitor, 2022).

In this study, 13 per 100 cats that were presented for traumatic cases in 2020-2021 were cases of HRS. Most of the affected cats were young adults aged between 1 to 6 years old. The mean age of the cats was 2.3 years old. This was parallel to other studies (Appendix III A) where the mean ages were between 1 to 3 years old (Merbl et al., 2013; Zimmerman et al., 2013; Collard et al., 2005). Younger cats were usually affected due to the differences in behaviour compared to older cats. They were more likely to be inexperienced at performing species-typical behaviour such as playing and hunting which increased their risk of falling off balconies and ledges (Merbl et al., 2013; Vnuk et al., 2004). Thus, our study confirmed previous reports that younger cats were more susceptible to HRS.

Zimmerman et al. (2013) reported 50% males and 50% females in their study. Merbl et al. (2013) reported 57% males and 43% females. In this study, 55% of the cases were males and 45% were females. Similar to our findings, most studies (Appendix III B) reported no sex predilection amongst the cases.

There were slightly more unneutered cats compared to neutered cats that were presented. Vnuk et al. (2004) suggested the possibility of discrepancies due to sexual motivation. Unneutered cats may be more prone to HRS in response to mating behaviour. However, our study found no or a negligible relationship between the neuter status and cats affected with HRS.

According to Oxley and Montrose (2016), breed can impact cat behaviour, which can influence incidences of HRS. Docile breeds such as Persians were less likely to be affected by HRS while active breeds such as Siamese were more likely to be afflicted with HRS. In this study, the majority of the cases were DSH at 43% followed by mixed breed at 19% and Persian at 12%. Active breeds such as the Bengal and Maine Coon made up 5% and 2% of cases respectively. It can be said that the DSH were overrepresented while the less common breeds such as the Bengal, Maine Coon, and Scottish Fold were underrepresented.

The mean height of fall in this study was 4.5 storeys. Most of the cats fell from the 3rd storey (n=13, 31%) followed by the 4th storey (n=8,19%) whereas the least number of falls were from the 2nd storey (n=3, 7%). The mean height of fall of this study was higher than most studies. No falls were recorded above the 8th floor. This could have been because cats that fell more than 8 storeys did not survive and thus were not represented. The least number of falls were from the 2nd storey. Cats that fell from the 2nd storey may also be underrepresented as they may not have exhibited obvious signs of injury and were thus not brought to the hospital. Some studies, pioneered by Robinson (1976) have associated HRS with a triad of injuries, namely epistaxis, hard palate fractures, and pneumothorax (Vnuk et al., 2004; Whitney & Mehlhaff, 1987). In this study, epistaxis was found in 16.7% (7/42) of cases while hard palate fractures were only seen in 9.5% (4/42) of cases. Pneumothorax was only presented in 4.8% (2/42) of cases.

This study had a higher incidence of limb injuries at 85.7% (36/42) compared to the triad of injuries. This is followed by orofacial injuries at 28.6% (12/42). Merbl et al. (2013) reported 48% of orthopaedic injuries, followed by 46% of thoracic injuries and 37% of orofacial injuries. Collard et al. (2005) had almost similar findings with 42.9% of limb fractures, followed by 41.7% of pulmonary contusions and 38.9% cases of pneumothorax. Our study was consistent with

most literature (Appendix IV) where limb injuries were the most presented injury. However, this was usually followed by thoracic injuries in other studies.

Limb injuries were evenly distributed across all heights. The measure of association showed no association between height of fall and incidences of limb injuries. 100% of cats that fell 2,4, and 8 storeys had limb injuries. The least incidences of limb injuries were seen on the 7th storey where 60% (3/5) were affected. Thus, more than half of the cats that fell had limb injuries regardless of the height. This can be attributed to the mechanics of a falling cat which enable them to right themselves mid-air and land limb-first. They twist their bodies as they fall and extend their feet downwards (Pilitowski, 2016; Bonner et al*.,* 2012). Landing with their feet extended increases the occurrence of long bone fractures while reducing the chances of severe thoracic and abdominal injury.

There were more hindlimb injuries compared to forelimb injuries. The ratio between forelimb and hindlimb injuries in this study was 4:7. Vnuk et al. (2004) had a ratio of 5:8 while Catalkaya et al*.* (2022) reported a ratio of 3:5. Papazoglou et al*.* (2001) reported a ratio of 1:2 in their study.

Pelvic injuries had the most incidences at 26% (11/42) followed by tibial fractures at 19% (8/42) and femoral fractures at 14% (6/42). Other literatures reported femoral fractures as the most occurred limb injury (Catalkaya et al*.*, 2022; Vnuk et al*.,* 2004). Catalkaya et al. (2022) reported only 2.8% pelvic injuries while Merbl et al. (2013) and Vnuk et al*.* (2004) reported 15.9% and 9% of pelvic injuries respectively.

Orofacial injuries were also distributed rather evenly throughout the different heights. Most of the orofacial injuries were epistaxis (7/42, 16.7%) followed by cleft palate (4/42, 9.5%). Cleft palates were seen in cases that fell from the 4th, 5th, 6th, and 8th storeys. The only severe

orofacial injury presented was a temporomandibular joint (TMJ) luxation which was seen in only 1 case. It is considered severe due to the uncertain prognosis associated with that injury. The TMJ luxation occurred in a case that fell from the 2nd storey. Cats that right themselves can land limbs-first which minimizes head trauma (Bonner et al., 2012). Thus, cats that fell a shorter distance may not have been able to orient themselves.

Interestingly, incidences of thoracic injury increased as the height of fall increased. Only falls from the 6th to 8th storeys reported thoracic injuries. There was one(1) case of sternebral luxation which happened in a fall from 8 storeys. Pneumothorax and pulmonary contusion were both only seen in 4.7% (2/42) of cases. The 2 cases of pneumothorax were from falls from the 6th and 7th storey. Pulmonary contusion occurred in 2 cases that fell 6 and 8 storeys. There was a statistical association (*P*=0.0113) between height of fall and incidences of thoracic injury. Thus, the alternate hypothesis was accepted.

Merbl et al. (2013) reported 46% of thoracic injuries amongst all cases in which 21.5% of the cases were of pneumothorax and 18.7% of the cases were of pulmonary contusions. Their cases of pneumothorax were also only present in falls from middle or high floors. Vnuk et al. (2004) reported 20% of pneumothorax cases and 13.4% of pulmonary contusions.

On the contrary, spinal injuries were only seen in falls from the 3rd to 5th storeys. Spinal injuries made up 10% (4/42) of all cases making it the least commonly affected body system. All the spinal injuries occurred between T3 to L3 vertebrae. Vnuk et al. (2004) observed only 2.5% (3/119) cases of spinal injuries. Of those 3 cases, one occurred at the thoracic column and two at the lumbar spine. Papazoglou et al. (2001) observed spinal injuries in 15% of their cases, of which majority were falls below 5 storeys. Zaghloul and Samy (2018) reported that spinal injuries were only observed in falls from the 2nd and 3rd storeys. Lower height falls can contribute to

spinal trauma as the cats are unable to orient their bodies in time (Zaghloul and Samy, 2018; Papazoglou et al., 2001)

Falling cats reach terminal velocity at a height of between 5 to 7 storeys. At terminal velocity, the cats can orient their limbs and spread their bodies to increase drag thus slowing their fall. This posture reduces the occurrence of fractures. However, it increases the likelihood of thoracic, abdominal, and head injuries (Villazon, 2020; Merbl et al., 2013).

Abdominal injuries did not display any pattern in relation to the height of fall. It was 21% (9/42) of all cases. All of the abdominal injuries were presented as clinical signs in the form of urinary tract and intestinal dysfunction. The most presented injury was haematuria at 7.1% (3/42) followed by oliguria at 4.8% (2/42).

Merbl et al. (2013) reported 15% of abdominal injuries amongst all the body systems. Abdominal pain and hematuria were the most presented abdominal injury at 9.3% and 4.7% respectively. Papazoglou et al. (2001) reported only 1% (n=2) of abdominal injuries in their study. Of the two cases, one was a ruptured bladder, and the second case was a herniated diaphragm.

Fifteen percent (9/42) of the cases in this study had injuries that were characteristic of shock. The characteristic clinical signs of shock were tachycardia, weak pulse quality, pale mucous membranes, prolonged capillary refill time, tachypnea, and hypothermia (Merbl et al., 2013; Vnuk et al., 2004). In this study, most cases of shock presented pale mucous membranes (5/42, 11.9%) followed by hypothermia (4/42, 9.5%). There was one case each of tachycardia and prolonged capillary refill time.

Vnuk et al. (2004) diagnosed shock in 10.9% of all their cases. Merbl et al. (2013) diagnosed shock in 15% of their cases. Like our study, their most presented sign of shock were pale mucous membranes at 11.2% followed by hypothermia at 9.3%.

6.0 CONCLUSION

In the present study, there were no sex and breed predilections towards High-rise Syndrome. Age proved to be a risk factor as younger cats were more likely to be affected. Limb injuries were the most presented injury while orofacial injuries were the second most common. Cats that fell from higher storeys were more predisposed to thoracic injuries. Thoracic injury incidences were only observed in the higher storeys whereas spinal injuries were confined to the lower storeys.

7.0 RECOMMENDATIONS

This study had several limitations. Firstly, cases with incomplete medical records, namely radiographic evidence, were excluded from the study which introduced a form of bias. As a retrospective study, there were some cases with missing data which may have decreased the strength of the statistical analyses. Definition of some injuries, for example the signs of shock, were variable amongst papers. This could impact the assessment of the injury.

Future research can evaluate the injuries in comparison to the prognostic value. Haematological findings can also be included in measuring its association with the prognostic value. This can aid veterinarians in selecting the most effective diagnostic tools as well as treatment plan for cats affected with HRS.

HRS is a highly preventable condition. This can be done by keeping pets indoors and ensuring windows and balconies are inaccessible to the cats. Pet owners should consider incorporating cat-friendly architecture in their homes such as window screens and cat patios to provide enrichment to their cats without endangering them.

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APPENDIX

I A: Prevalence of HRS in cases of traumatic injuries presented to UVH between 2020-2021

	Frequency	Percentage
HRS	42	13.4%
Other traumatic cases	272	86.6%
Total	314	100%

I B: Common injuries presented to UVH by cats with HRS

Body system	Injury/Clinical signs	Number of cases	% (amongst cases)	% (within body system)
Thoracic	Lung contusion	2	4.8	28.6
	Haemoptysis	2	4.8	28.6
	Pneumothorax	2	4.8	28.6
	Sternebrae luxation	1	2.4	14.2
Shock	Pale mucous membranes	5	11.9	45.4
	Hypothermia	4	9.5	36.4
	Tachycardia	1	2.4	9.1
	Prolonged CRT	1	2.4	9.1
Abdominal	Haematuria	3	7.1	30.0
	Oliguria	2	4.8	20.0
	Pyuria	1	2.4	10.0
	Constipation	1	2.4	10.0
	Diarrhea	1	2.4	10.0
	Melena	1	2.4	10.0
	Haematochezia	1	2.4	10.0

Spinal	Thoracic vertebrae compression	2	4.8	40.0
	Thoracic vertebrae fracture	1	2.4	20.0
	Thoracolumbar fracture	1	2.4	20.0
	Lumbar vertebrae fracture	1	2.4	20.0
Orofacial	Epistaxis	7	16.7	38.9
	Cleft palate	4	9.5	22.2
	Lip wound	3	7.1	16.6
	Canine tooth fracture	2	4.8	11.1
	Mandibular fracture	1	2.4	5.6
	TMJ luxation	1	2.4	5.6
Limb	Humeral fracture	4	9.5	9.1
	Radial-ulnar fracture	3	7.1	6.8
	Elbow joint luxation	3	7.1	6.8
	Carpal fracture	2	4.8	4.5
	Femoral fracture	6	14.3	13.7
	Tibial fracture	8	19.1	18.2
	Fibular fracture	7	16.7	15.9
	Pelvic fracture	11	26.2	25.0

*Each case may be affected by single or multiple injuries

APPENDIX

II: Distribution of 44 limb injuries in 42 cats with HRS according to height of fall

Height of fall (storeys)	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Total injured cases (no. of affected cats)	3	12	7	4	3	3	4	36
Total forelimb injuries	**-**	**5**	**2**	**1**	**-**	**2**	**2**	**12**
Humerus	-	2	1	-	-	1	-	4
Radius-ulna	-	1	1	-	-	-	1	3
Elbow	-	2	-	-	-	-	1	3
Carpal	-	-	-	1	-	1	-	2
Total hindlimb injuries	**2**	**5**	**4**	**2**	**6**	**2**	**-**	**21**
Femur	-	4	-	2	-	-	-	6
Tibia	1	1	2	-	3	1	-	8
Fibula	1	-	2	-	3	1	-	7
Pelvic injuries	2	4	3	1	-	-	1	11

* each case may be affected by single or multiple limb injuries

APPENDIX

III A: Average age of cats affected by HRS reported in different articles

Source	Whitney & Mehlhaff	Dupre *et al.*	Papazoglou *et al.*	Vnuk *et al.*	Collard *et al.*	Merbl *et al.*	Zimmerman *et al.*	Our study
Year	1987	1995	2001	2004	2005	2013	2013	2022
Avg Age (years)	2.7	2.5	1.2	1.8	2.6	2.9	2.8	**2.3**

III B: Percentage of sexes affected by HRS reported in different articles

Source	Whitney & Mehlhaff	Papazoglou *et al.*	Vnuk *et al.*	Merbl *et al.*	Zimmerman *et al.*	Our study
Year	1987	2001	2004	2013	2013	2022
Gender	48% M 48% F	52% M 47% F	42% M 53.8% F	57% M 43% F	50% M 50% F	**55% M 45% F**

III C Average height of fall of cats with HRS reported in different articles

Source	Whitney & Mehlhaff	*Papazoglou et al.*	Vnuk *et al.*	Bonner *et al.*	Zimmerman *et al.*	Our study
Year	1987	2001	2004	2012	2013	2022
Avg height (storeys)	5.5	3.7	4	2.65	3.3	**4.5**

APPENDIX

IV: Most common injuries presented by cats with HRS reported in different articles

Source	Most common injuries
Whitney & Mehlhaff (1987)	Pulmonary contusions (68%) Pneumothorax (63%) Facial trauma (57%) Limb fractures (39%)
Dupre *et al.* (1995)	Limb fractures (52.3%) Pulmonary contusions (51.1%) Pneumothorax (28.9%)
Papazoglou *et al.* (2001)	Limb fractures (50%) Spinal trauma (15%)
Collard *et al.* (2005)	Limb fractures (42.9%), Pulmonary contusions (41.7%) Pneumothorax (38.9%)
Vnuk *et al.* (2004)	Limb fractures (46.2%) Thoracic trauma (33.6%) Pneumothorax (20%)
Merbl *et al.* (2013)	Orthopedic injuries (48%) Respiratory injuries (46%) Facial injuries (37%)