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ORIGINAL ARTICLE

The pattern of fatal injuries of fall from height: A 10-year study

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Abstract

Introduction: Fatal falls from heights rank as the second leading cause of unnatural deaths, following road traffic accidents. Victims exhibit distinct injury patterns influenced by multiple factors. Therefore, this study aimed to assess the pattern of fatal injuries resulting from falls from height in medicolegal autopsies. *Materials and Methods:* We reviewed 340 autopsies records conducted at the Universiti Kebangsaan Malaysia Medical Centre for ten years from 2010 to 2019. Statistical analysis was performed on socio-demographic data, cause and manner of death, fall height, primary impact, toxicological analysis, and psychiatric illness. *Results:* A total of 340 cases comprising 246 males and 94 females, representing 175 Chinese, 106 non-Malaysians, 28 Malays, 27 Indians, and two Bumiputeras Sabahan/Sarawakian. Their ages ranged from 5 months to 86 years old. The findings revealed that most deceased were males aged between 19 and 40. The primary locations of falls were reported within the home (77.9%) and workplace (16.8%). In cases of falls from significant heights, multiple injuries were the leading cause of death (71.4%), with 68.3% of these incidents classified as suicides. Head injuries were prevalent in falls from lower elevations (42.3%), particularly in accidental scenarios (34.9%). In 80% of cases, toxicological analysis yielded negative results, with alcohol being the most frequently detected substance (30.9%). *Conclusions:* This study revealed that most injuries were linked to suicide. Hence, it is crucial to implement preventive measures to raise awareness among the public and mitigate similar incidents in the future.

Keywords: Fall from height, the forensic, pattern of injury, suicide, workplace accident

INTRODUCTION

The World Health Organization (WHO) has estimated that 684,000 individuals succumb to falls annually worldwide. In China, the mortality rate attributed to unintentional falls stands at 9.55 per 100,000 population.[1] Furthermore, falls represent the second leading cause of injury-related deaths, trailing behind motor vehicle accidents.[2] Each year, approximately 37.3 million cases of falls necessitate medical attention.[3] Considering the associated morbidity, falls contribute to 12.2% of injury-related disabilities, leading to significant financial losses and decreased productivity.[4]

A fall from height (FFH) refers to an incident where an individual descends to the ground from an elevated level.[5] These incidents are rising annually, mainly in densely populated urban areas, given the prevalence of work activities involving elevated heights. Occupations such as maintenance, construction, and others entail inherent risks of falls from height.[6] Globally, FFH is a significant public health issue, contributing substantially to both morbidity and mortality rates. Occurring commonly in residential and occupational settings, FFH incidents are a notable concern.[7] In urban locales characterised by high-rise structures, one can

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anticipate a notable occurrence of FFH deaths stemming from accidental, suicidal, homicidal, or dyadic circumstances, reflecting a widespread phenomenon in major cities worldwide.

Fatal FFH presents challenges for medicolegal experts and investigators, particularly regarding determining the manner of death, as reliable eyewitnesses may not always be present.[8] Analysing the pattern of injuries becomes crucial in establishing the causation of injuries and the manner of death. Therefore, it is imperative to examine the nature and pattern of injuries sustained by the victim to formulate a conclusive opinion regarding the circumstances of the fall.

FFH can be categorised as either a low-elevation fall (below 5 meters for adults and below one meter for children) or a high-elevation fall (above 5 meters for adults and above one meter for children). It may result from intrinsic factors, where events or conditions affect postural control, or extrinsic factors, where environmental conditions primarily contribute to the fall.[6] Various factors influence the severity of injuries sustained, including the height of the fall, the surface upon impact, deceleration rate, potential encounters with intermediate objects during the fall, body positioning upon landing, and individual characteristics such as age, body weight, and pre-existing medical conditions.[9]

Individuals who experience falls from height typically sustain a distinct pattern of injuries influenced by various factors such as the body's inertia, movement, the rigidity of surrounding objects, and the nature of the ground upon impact.[6] When someone falls or jumps from a height, their trajectory is typically downward and outward, and the distance from the point of descent to the ground varies. During the fall, gravitational force converts the potential energy from the height into kinetic energy. Upon impact, the body decelerates, and an equal reaction against the body itself counters the kinetic energy transferred to the ground. Consequently, the body absorbs the lost energy in the form of injuries.[6,10]

Most research on free FFH suggests that individuals who anticipate impact and land on their feet tend to sustain more numerous injuries, often concentrated on their dominant side.[11] Conversely, those relaxed upon impact typically land horizontally and may experience fewer injuries.[11,12] Teh *et al*. suggested that individuals attempting suicide are more inclined to brace for impact and aim to land on their feet, likely due to their awareness and preparedness for the fall.[11] However, Christensen argued that jumpers more frequently impact in a relaxed state, possibly because they intend to strike the ground.[12]

Limited studies in Malaysia have examined the pattern of injuries in FFH. Therefore, the objective of this study was to analyse the pattern of fatal injuries in FFH, considering socio-demographic factors, manner of death, fall height, primary impact, toxicological analysis, and psychiatric illness. This analysis aims to provide insights into the Malaysian context while comparing findings with existing studies.

MATERIALS AND METHODS

The data were obtained from autopsy reports documenting all FFH received by the Hospital Canselor Tuanku Muhriz (HCTM) mortuary between January 1, 2010, and December 31, 2019. The Institutional Ethics Committee (Research Ethics Code No: JEP-2020-409) approved the study.

The site of injury was classified into four anatomical body regions using a modified version of the Injury Severity Score (ISS) as proposed by Stevenson *et al*.[13]: 1) head, face, and neck; 2) chest or thorax; 3) abdomen and pelvic; and 4) extremities. The pattern of injuries was characterised as either isolated injury, which refers to injuries confined to one body region, or multiple injuries or polytrauma, defined as injury occurring in three or more body regions.

The cases were evaluated based on the following parameters:

A) Incidence: The incidence rate of deaths attributed to FFH was higher than the total number of deaths recorded during the study period.
B) Socio-demographic factors: Characteristics such as the victims' age, gender, ethnic background, and occupation.
C) Autopsy findings and medicolegal data: Details including the location of the fall, history of psychiatric conditions, specific anatomical sites of injury, height of the fall, manner of death, and results of toxicological analyses.
D) Correlation between the probable primary impact site and the pattern of fatal injuries.
E) Association between the manner of death and the pattern of fatal injuries.
F) Relationship between the height of the fall and the severity of injuries sustained.

FFH was divided into two categories: low-elevation falls (< 5 m) and high-elevation falls

(> 5 m).[14] Blood and urine toxicological analyses were conducted to identify levels of ethyl alcohol, amphetamine-type stimulants, ketamine, and other commonly detected drugs. The primary point of impact from the fall was classified into three groups: head, trunk (encompassing the anterior and posterior aspects of the torso) and feet.

Forensic autopsies are typically conducted in compliance with instruction from legal authorities in circumstances related to suspicious, sudden, obscure, unnatural, litigious, or criminal deaths. The information derived from these autopsies serves legal purposes, aiding the pursuit of justice. In the mortuary, autopsies were performed using Lettule's method, which involves the *en masse* removal of viscera followed by organ dissection. Statistical analysis was performed using the SPSS version 28 statistical software package (SPSS Inc., Chicago, ILL Company). The Shapiro-Wilk test assessed the fit of quantitative data to a normal distribution. Non-parametric tests such as the Mann-Whitney U-test and the Kruskal-Wallis test determined differences between variables with continuous scores. Pearson's chi-square test was employed for qualitative data. Continuous parameters were reported as mean ± standard deviation (SD). A 'p' value of <0.05 was considered statistically significant, while a 'p' value <0.01 was considered highly significant.[15]

RESULTS

A total of 340 autopsied cases of fatal FFH were included in the study, comprising 246 males and 94 females, ranging in age from 5 months to 86 years. The ethnic distribution comprised 175 Chinese, 106 non-Malaysians, 28 Malays, 27 Indians, and 2 Bumiputera Sabahan/Sarawakian individuals. Participants were categorised into age groups, i.e. < 18 years, 19 – 40 years, 41 – 60 years, and > 61 years. Among the 340 deaths caused by FFH injuries, representing approximately 1.9% of the total 17,934 deaths, the highest mortality rate occurred in 2015 (2.49%), while the lowest was in 2011 (1.23%) (Table 1).

Demographic profiles

The study revealed that the majority of fatalities (56.8%) occurred in the age group of 19 – 40 years, followed by the 41 – 60 years age group (23.8%), individuals over 61 years old (13.2%), and those under 18 years old (6.2%). Males constituted the majority of cases (72.4%), with an average age of 38.2 years, while females accounted for 27.6% of cases, with an average age of 40.4 years (FIG. 1). In terms of ethnic distribution, the Chinese group was most commonly involved in FFH incidents (51.5%), followed by non-Malaysians (31.2%), Malays (8.5%), Indians (8.2%), and Bumiputera Sabahan/Sarawakian individuals (0.6%).

Location of fall and occupation

The current study's findings indicate that falls at home (77.9%) were prevalent across all age groups, whereas workplace falls primarily involved individuals aged 19 – 40 (18.1%). Notably, both accidental and suicidal deaths were notably frequent in the 19 – 40 years age group, with incidence rates of 24.9% and 55.4%. (Fig. 2).

TABLE 1: Descriptive statistics of falls from height (FFH) deaths

Year	Total deaths (n)	Deaths due to fall from height	Prevalence (%)
2010	1553	28	1.80
2011	1948	24	1.23
2012	1710	27	1.58
2013	1754	33	1.88
2014	1877	40	2.13
2015	1806	45	2.49
2016	1737	30	1.73
2017	1740	40	2.30
2018	1883	35	1.86
2019	1926	38	1.97
Total	**17,934**	**340**	**1.90**

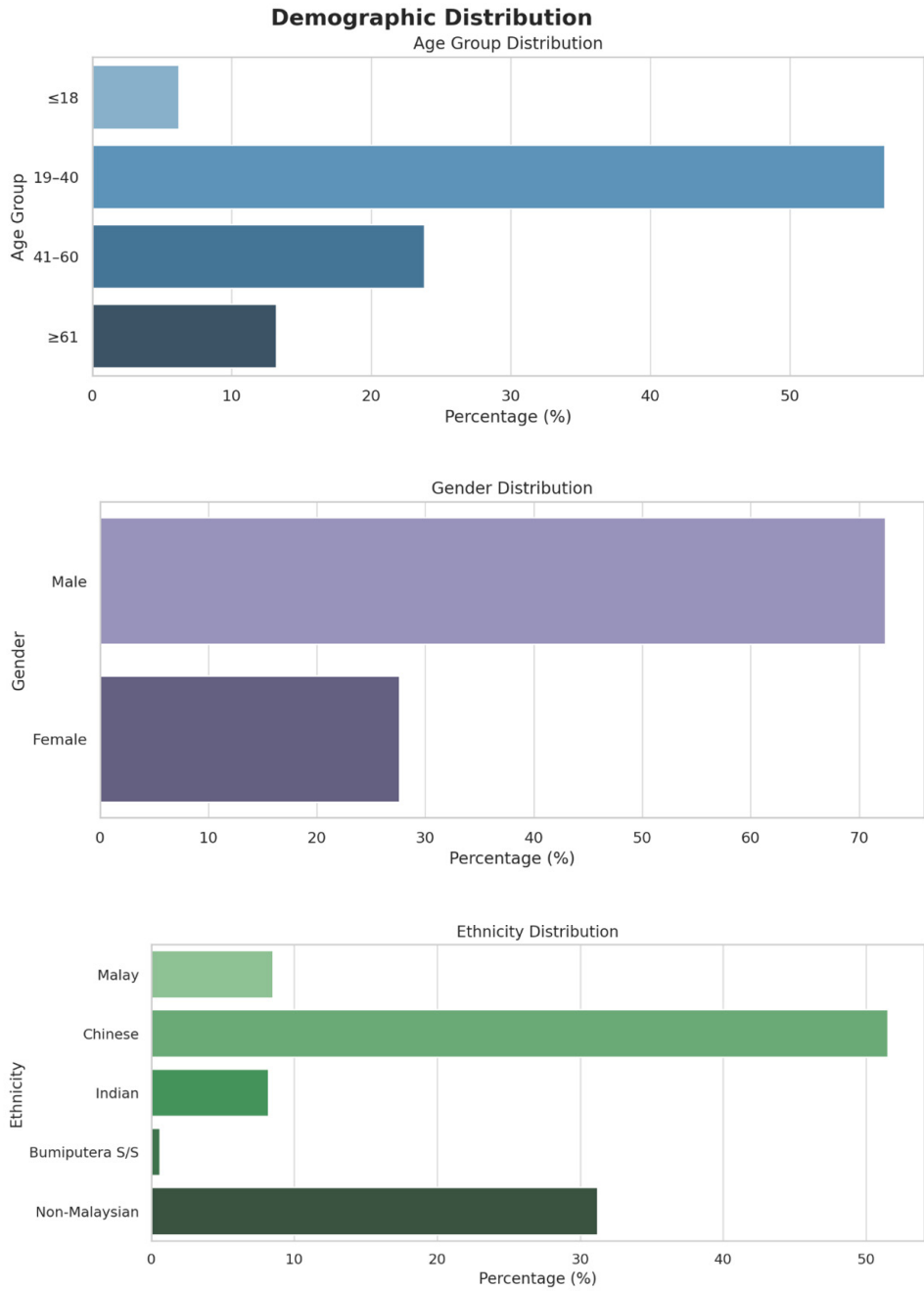

FIGURE 1. The distribution of cases is according to sex, age, and ethnicity.

Height of fall and pattern of fatal injuries

Regarding the height of the fall, the data revealed that 269 cases (79.1%) and 71 cases (20.9%) occurred from high and low altitudes, respectively. The injury site was classified into four anatomical body regions using a modified version of the Injury Severity Score (ISS) proposed by Stevenson *et al*.[13]

Table 2 reveals that head and neck injuries were the most common isolated injuries, accounting for 48 cases (41., followed by multiple injuries involving the head, neck, and thorax (34 cases) and thorax injuries (24 cases). Multiple injuries involving the head, neck, and thorax were the predominant injury patterns across all age groups. Notably, no deaths were attributed to isolated abdomen or pelvis injuries.

Out of 290 fatalities involving head/neck

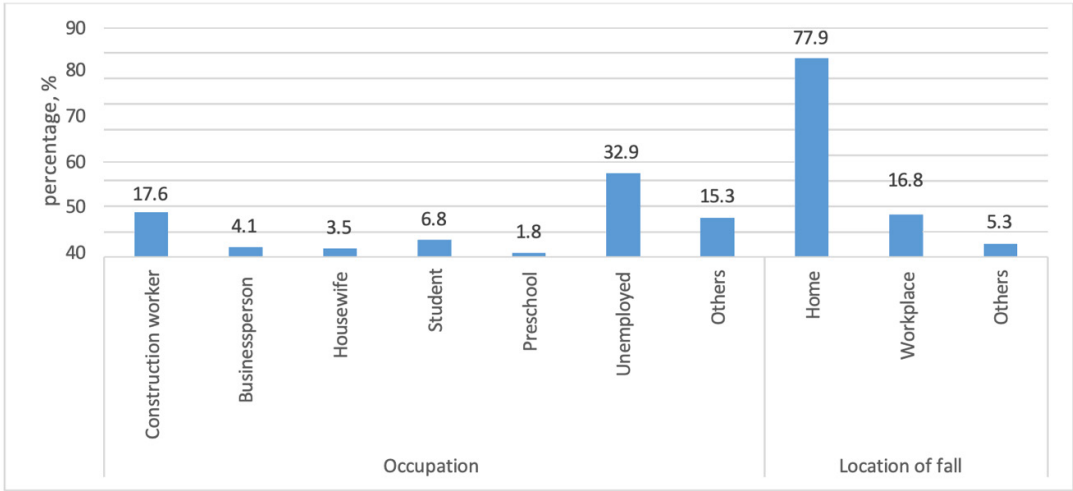

FIGURE 2. The distribution of cases according to occupation and location of fall

TABLE 2: Relationship between age of victim and place of fall, manner of death, height of fall and pattern of fatal injuries

Parameters value		Age group (years)				Total	X^2	'P'
		≤18	19 – 40	41 – 60	≥61	*n* (%)		
		n (%)	n (%)	n (%)	n (%)			
Place of fall	Home	21 (100)	147 (76.2)	61 (75.3)	42 (93.4)	271 (79.7)	13.33	0.038*
	Work	0 (0)	35 (18.1)	14 (17.3)	2 (4.4)	51 (15)		
	Others	0 (0)	11 (5.7)	6 (7.4)	1 (2.2)	18 (5.3)		
Manner of death	Accidental	10 (47.6)	48 (24.9)	20 (24.7)	8 (17.8)	86 (25.3)	38.38	<0.001**
	Suicide	9 (42.8)	107 (55.4)	52 (64.2)	37 (82.2)	205 (60.3)		
	Homicide	1 (4.8)	0 (0)	0 (0)	0 (0)	1 (0.3)		
	Uncertain	1 (4.8)	38 (19.7)	9 (11.1)	0 (0)	48 (14.1)		
Height of fall	Low	7 (33.3)	34 (17.6)	19 (23.5)	11 (24.4)	71 (20.9)	3.89	0.274
	High	14 (66.6)	159 (82.4)	62 (76.5)	34 (75.6)	269 (79.1)		
Fatal injury	Head / neck	6 (28.5)	26 (13.5)	13 (16)	3 (6.7)	48 (14.1)	26.17	<0.001**
	Thorax	1 (4.8)	9 (4.7)	6 (7.4)	10 (22.2)	26 (7.6)	7.54	0.057
	Abdomen / Pelvis	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	-	-
	Head / neck and thorax	1 (4.8)	24 (12.4)	2 (2.5)	7 (15.6)	34 (10)	40.12	<0.001**

injuries, 228 subjects (78.6%) exhibited skull fractures, and all types of intracranial injuries displayed a significant association with skull fractures ($p<0.05$). Among the 283 cases demonstrating chest or thoracic injury as the primary site, 273 (94.5%) were linked with rib(s) or sternal fractures, along with injuries to other intra-thoracic organs ($p<0.01$). The majority of cases (70.6%) associated with abdomen/pelvic injury presented with haemoperitoneum, characterised by minimal blood in the peritoneal cavity (59.8%). The liver was identified as the most commonly injured organ in the abdomen (Table 3). Thoracic fracture/dislocation of the spine emerged as the most prevalent vertebral injury, accounting for 21.8% of cases.

Toxicology profiles

In the majority of fatalities (80%), toxicological analysis yielded negative results. Among cases

TABLE 3: The distribution of injuries in falls from height

Parameters	**Frequency, n (%)**		**MWU**	**'p' value**
Head injury	With skull fracture	Without skull fracture		
Subgaleal haematoma	215 (79.9)	54 (20.1)	6884	<0.001**
Epidural haemorrhage	16 (88.9)	2 (11.1)	12100	0.043*
Subdural haemorrhage	39 (86.7)	6 (13.3)	11268	0.003**
Subarachnoid haemorrhage	217 (80.4)	53 (19.6)	6658	<0.001**
Intracerebral haemorrhage	37 (100)	0 (0)	10696	<0.001**
Cerebral contusion	78 (87.7)	11 (12.3)	9654	<0.001**
Cerebral laceration	157 (96.3)	6 (3.7)	4660	<0.001**
Intra-thoracic injury	With rib fracture	Without rib fracture		
Haemothorax	275 (97.2)	8 (2.8)	1576	<0.001**
Cardiac injury	218 (96.5)	8 (3.5)	2944	<0.001**
Great vessel injury	189 (97.4)	5 (2.6)	1870	<0.001**
Pulmonary injury	281 (96.2)	11 (3.8)	3202	<0.001**
Oesophagus injury	2 (100)	0 (0)	6960	0.566
Abdomen/pelvis				
Haemoperitoneum a) No b) Minimal (<100ml) c) 100 – 500ml d) >500ml	 100 (29.4) 203 (59.8) 27 (7.9) 10 (2.9)			
Liver injury	236 (69.4)			
Splenic injury	176 (51.8)			
Kidney(s) injury	194 (57.1)			
Stomach injury	16 (4.7)			
Intestinal injury	90 (26.5)			
Pelvic injury	190 (55.9)			
Fracture/dislocation of vertebra (n=340)				
Atlanto-occipital dislocation	10 (2.9)			
Cervical fracture/dislocation	12 (3.5)			
Thoracic fracture/dislocation	12 (3.5)			
Lumbar fracture/dislocation	38 (11.2)			
Sacral fracture	12 (3.5)			

*p<0.05, **p<0.01, MWU: Mann-Whitney U-test

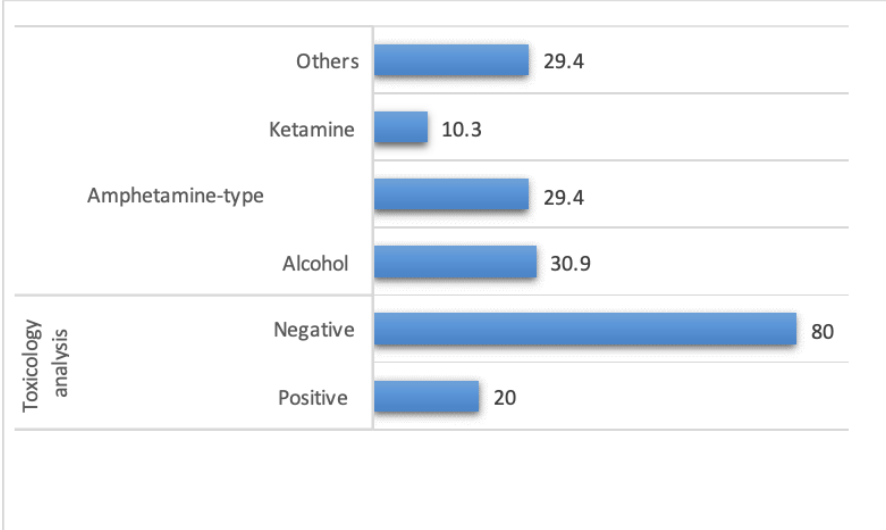

FIGURE 3: The distribution of toxicological analysis and types of toxins detected.

where toxins or poisons were detected, alcohol was the most frequently identified substance (30.9%), followed by amphetamine-type stimulants (29.4%), other substances (29.4%), and ketamine (10.3%) (Fig. 3).

Pre-existing psychiatric illness

In most cases (81.5%), there was no association with any psychiatric illness or symptoms observed in this study. However, 18.5% of cases had a history of psychiatric illness, with 47 cases presenting with depression and 16 cases with schizophrenia. These cases predominantly involved suicidal deaths (96.8%), with unintentional or accidental deaths accounting for 3.2% of cases. This suggests a significant association between the manner of death and psychiatric illness. (Table 4)

Site of primary impact

According to anatomical region, the trunk was identified as the primary body impact in 82.7% of fatal falls, significantly correlated with multiple sites of injury or polytrauma as the cause of death. The head was identified as the initial body impact in 15.2% of cases, followed by the foot in 2.1% (Table 5).

Correlation between manner and pattern of fatal injuries

The findings of this study revealed that head injury (34.9%) was the leading cause of fatal injuries, followed by multiple injuries (30.2%), particularly in unintentional or accidental falls. While multiple injuries were more prevalent in homicide cases, they were predominant (68.3%) in suicides. Significant associations were observed between the manner of death and head/neck injuries, thoracic injuries, multiple injuries ($p<0.01$) and combined injuries of the thorax and abdomen/pelvis ($p<0.05$) (Table 6).

This study further illustrated that multiple

TABLE 4: The relationship between the manner of death and psychiatric illness or symptoms

Manner of death	With psychiatric illness/symptoms n (%)	Without psychiatric illness/symptoms n (%)	Total	X^2 test	'p' value
Accidental	2 (3.2)	84 (30.3)	86	78.186	<0.001**
Suicide	61 (96.8)	144 (52)	205	33.605	<0.001**
Homicide	0	1 (0.4)	1	-	-
Uncertain	0	48 (17.3)	48	-	-
Total	63 (18.5)	277 (81.5)	340		

*p<0.05, **p <0.01, Psychiatric illness/symptoms: depressive disorders, schizophrenic disorders.

TABLE 5: Fatal injury by anatomical region in relation to probable site of primary impact

Fatal injury	Primary impact			Total	X^2	'p' value
	Head	Trunk	Foot			
Head/neck	42	5	1	48	63.875	<0.001**
Thorax	0	24	2	26	18.615	<0.001**
Abdomen/pelvic	0	0	0	0	-	-
Head/neck and thorax	4	30	0	34	19.882	<0.001**
Head/neck and abdomen/pelvic	3	6	0	9	1.000	0.317
Thorax and abdomen/pelvic	0	22	2	24	16.667	<0.001**
Multiple injuries	3	194	2	199	368.573	<0.001**

*p<0.05, **p <0.01

injuries were more prevalent (71.4%) in falls from high elevations, whereas head injuries were frequent (14.2%) in falls from low elevations. Therefore, a significant correlation was observed between the height of the fall and the severity of fatal injuries (Table 7).

DISCUSSION

The present study documented 340 cases of fatal FFH, representing approximately 1.9% of the total cases (17,934) received at the mortuary over ten years. This incidence rate is comparable to findings from other studies. For instance, Mirza *et al*. (2013) reported a death rate of about 1.29% in Karachi[16], while Haggag *et al*. (2016) observed 3.25% of deaths in Cairo.[5] Hyder *et al*. (2007) indicated an annual incidence of FFH of 2.81 per 100,000 inhabitants.[17]

The current study revealed that the majority of FFH deaths occurred in the age group of 19 – 40 years (56.8%), followed by the age group of 41 - 60 years (23.8%), age group ≥ 61 years (13.2%), and age group ≤ 18 years (6.2%). This finding aligns with Murthy *et al*., who found that the highest number of fatal falls occurred in the age group of 21-30 years (34.61%), with the fewest falls observed in the age groups of 61-70 years and 81-90 years, each accounting for approximately 1.9%.[6] Similarly, Grivna *et al*. reported that the majority of victims (68%) were adults aged 20–54 years old, with a smaller proportion of cases involving children under 19 years old (22%).[18] While Al *et al*. found a higher mortality rate in patients over 60 years of age[19], Suleyman *et al*. reported that 42.6% of fatal falls occurred in the younger age group of ≤15 years old.[20]

Our study found that the majority of the deceased (56.8%) were in the 19–40-year age group, with suicide being the most common manner of death. This contradicts the study by Mirza *et al*., which found that individuals in the 19–40 age group are frequently engaged in sports

TABLE 6: The relationship between manner of death and pattern of fatal injuries

Site of fatal injury	Manner of death				X^2	p value
	Accidental	Suicide	Homicide	Undetermined		
Head/neck	30	10	0	8	18.50	<0.001**
Thorax	9	15	0	2	9.776	0.008
Abdomen/pelvis	0	0	0	0	-	-
Head/neck and thorax	7	23	0	4	18.412	<0.001**
Head/neck and abdomen/pelvis	5	4	0	0	0.111	0.739
Thorax and abdomen/pelvis	9	13	0	2	7.750	0.021*
Multiple injuries	26	140	0	32	229.16	<0.001**
Total	86	205	0	48		

*p<0.05, **p<0.01

TABLE 7: The relationship between the height of fall and fatal injuries

Anatomical Region	Low *n* (%)	High *n* (%)	Total *n* (%)	X^2	'p' value
Head/neck	30 (42.3)	18 (6.7)	48 (14.2)	3.00	0.083
Thorax	18 (25.4)	8 (3)	26 (7.6)	3.85	0.05*
Abdomen/pelvis	0 (0)	0 (0)	0 (0)	-	-
Head/neck and thorax	8 (11.3)	26 (9.6)	34 (10)	9.53	0.002**
Head/neck and abdomen /pelvis	1 (1.4)	8 (3)	9 (2.6)	5.44	0.02*
Thorax and abdomen/pelvis	7 (9.8)	17 (6.3)	24 (7.1)	4.17	0.041*
Multiple injuries	7 (9.8)	192 (71.4)	199 (58.5)	171.99	<0.001**

*p<0.05, **p<0.01

activities or work, making them more prone to accidents or assaults and thereby contributing to a higher incidence of fatal falls.[16]

The results indicated that FFH were most prevalent among males (72.4%), which aligns with findings by Cripps and Carman[21] and Thierauf *et al*., who reported rates of about 71% and 74.9%, respectively.[22] Driscoll *et al*. demonstrated that men faced a tenfold higher risk of fatal falls compared to women.[23] This increased prevalence in males is attributed to the stress and strain experienced in work or daily life.[24] Mirza *et al*.[16] and Ramadan *et al*.[25] explained that males often engage in outdoor jobs or tasks at elevated heights, increasing their exposure to fatal falls. However, some studies have indicated a higher prevalence of fall-related injuries and deaths among women.[26-28]

In the present study, skull fractures were responsible for approximately 78.6% of deaths from FFH, a finding consistent with research by Kohli and Banerjee.[29] Generalised head injuries involving the skull, meninges, and brain with intracranial haemorrhage were observed in nearly all cases. It was evident that head injury significantly increased the likelihood of death.[30] Similar autopsy findings were reported in fatal falls in Egypt, where the head was the most affected region, and the neck was the least affected.[5,25] Scalp injuries, skull fractures with meningeal haemorrhages, and brain injuries resulting in traumatic shock and multiple organ damage were commonly observed.

Although head injuries accounted for only 27% of cases of fatal falls, they were prevalent in falls from heights greater than thirty feet (9 m).[31-33] Therefore, significant head and body injuries were unlikely in falls from a shortfall or ground level.[34] The injury pattern described in this study was consistent with existing literature, where the head and thorax were the most affected regions, followed by the abdomen and pelvis, and then the extremities.[5,8,25] The common injury pattern involved the head, thorax, and abdominal injuries, with neck injuries following suit.[35]

In the majority of cases, the primary impact in fatal falls was determined to be the trunk (82.7%), encompassing the sides, front, and back of the trunk, and significantly associated with multiple sites of injury or polytrauma as the cause of death. However, only 15.2% of cases exhibited the primary impact on the head, followed by the foot (2.1%). Nonetheless, the head was the most common site of primary impact in falls from height.[36] Internal organs such as the liver and lungs are commonly injured due to deceleration injury on the primary side impact. The primary site of impact may aid in determining the manner of death in fatal falls.[25] The morbidity and mortality in fatal falls may be influenced by the initial body impact that contacts the ground and the resulting injuries from the fall.[37]

In the present study, multiple injuries (58.5%) were identified as the most common cause of death, followed by head/neck injuries (14%), head/neck and chest injuries (10%), chest injuries (7.6%), chest and abdomen injuries (6.8%), head/neck and abdomen injuries (2.6%), and abdomen injuries (0.3%). This finding is consistent with existing literature, where fatal falls have predominantly resulted in multiple injuries or polytrauma.[11,32,37-39] However, other studies have indicated that the head was the most common anatomical site of fatal falls.[40-42]

In the intrathoracic region, cardiac injuries

were observed in 66.47% of cases, while rib or sternal fractures were present in 96.5% of cases. This underscores the protective function of the rib cage, particularly evident in falls ranging between 10-20 feet.[29] It was concluded that as the height of falls increased, there was a corresponding rise in the incidence of internal injuries, such as those affecting the chest and abdomen.[33] Within the abdomen, the liver was the most commonly affected organ (69.4%), followed by the stomach (4.7%), which may evade damage due to its position and hollow nature.

Direct impact from a fall may lead to head injury, while deceleration-type injuries occurring immediately after impact may cause visceral and cerebral injuries, resulting in multiple injuries.[9] In falls, the body's movement generates mechanical force, causing injuries. Initially, body inertia provides counterforce, while the rigidity of stationary objects against which the body falls provides additional resistance. Upon impact, the falling body experiences deceleration forces, and the kinetic energy transferred to the ground is offset by an equal amount of energy exerted against the body. The energy dissipated is absorbed by the individual in the form of injuries.[43]

This study revealed that toxicological analysis yielded negative results in most cases (80%). Among cases with positive toxicological findings, alcohol emerged as the most prevalent toxin (30.9%), followed by amphetamine-type stimulants (29.4%), other substances (29.4%), and ketamine (10.9%). This aligns with existing literature indicating alcohol is a significant contributor to fatal falls.[6,44,45] Psychoactive drugs have been identified as indicators of fatal falls, with alcohol detected in 48.6% of unintentional falls and 35.3% of suicides.[22,46] However, positive toxicological findings were observed in 75% of undetermined deaths, 70% of suicides, and 36% of accidents.[47]

Determining whether a fall from height is accidental or suicidal involves assessing the subject's social, medical, and psychiatric history, alongside circumstantial evidence at the death scene and toxicological results. This study indicated that suicidal falls accounted for the highest proportion of deaths (60.3%), followed by accidental deaths (25.3%) and undetermined cases (14.1%), which resonates with other studies regarding suicide-related falls.[32,33] The WHO estimates that there were over 700,000 deaths from suicide in the world in 2019, with an estimated suicide rate of 9.0 per 100,000 per year.[48] In 2023, Malaysia recorded 1,087 suicide cases, a 10% increase (106 cases) compared to the 981 cases the previous year. According to Royal Malaysia Police statistics, over the past five years, the highest number of suicide cases was reported in 2021, with 1,142 cases. The 2022 National Health and Morbidity Survey revealed a rise in suicidal behaviour among teenagers aged 13 to 17. The prevalence of suicidal ideation increased from 10% in 2017 to 13.1% in 2022, while suicide attempts rose from 6.9% to 9.5% over the same period.[49] This supports our study's finding that suicide was the most common manner of death, predominantly affecting individuals in the 19–40 age group. However, other studies have reported a higher prevalence of accidental falls.[5,8,24,25]

The injury pattern may provide insights into the height from which a fall occurred and the primary site of impact.[6] Identifying the actual or probable anatomical site of the primary body impact can aid in reconstructing events and assessing the manner of death, as extensive injuries may be indicative of the primary impact.[36] However, various injuries can also occur on other body parts. Furthermore, the current study revealed a significant association between injury patterns and the height of the fall, which is supported by the study that emphasises the significance of fall height in determining trauma severity, whether from a height exceeding 5 meters or below 5 meters.[50]

Fall height can be categorised into two groups: high-elevation falls (>5 meters) and low-elevation falls (<5 meters).[14] In this study, the majority of cases involved FFH greater than 5 meters, consistent with findings by other studies.[6,25] However, it has been noted that fall height is not always a reliable indicator of injury extent or pattern.[51] This is because a falling body undergoes deceleration upon impact, and injuries may result from absorbing lost energy, with the amount of kinetic energy transferred to the ground reacting with an equal amount of energy against the body.[52]

This study demonstrated that most fatal falls occurred at home, aligning with previous research, particularly in increasing urbanisation, leading to tall buildings in confined living spaces.[53-55] However, other studies have reported that falls from height were common in the workplace, particularly on construction sites.[16,18,56,57]

Study limitations

The limitations of this study encompassed aspects of its design and methodology that could have influenced the interpretation of the findings. The sample consisted of cases collected retrospectively from available records, and not all cases had undergone site visits to accurately determine the height of the fall or manner of death. Additionally, the study was confined to a single institution and conducted within a specific timeframe, potentially limiting the generalisability of the findings. Furthermore, the records' absence of injury severity scores precluded a precise injury severity assessment. Future studies may need to encompass a broader sample and cover all patterns of injury to provide a more comprehensive analysis of the present results.

CONCLUSION

In summary, this study has undertaken a thorough examination of the injury patterns in fatal FFH, highlighting a predominant association with suicide. As such, it underscores the importance of implementing protective measures to raise awareness among individuals, mitigate psychosocial risks, and prevent similar incidents from occurring in the future.

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