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Original Article

Neuropathology of Fatal Falls in Southwestern Ontario

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ABSTRACT: ***Background:*** Fall from height is common in all age groups. In 2020 alone, over 6000 people in Canada died from fall-related injuries. Most of the published literature investigating fall-related injuries are often focused on fracture patterns, survival and recovery. Fatal falls are not well studied. The objective of this study is to characterize the demographics and craniocerebral and vertebrospinal injury patterns related to fatal falls within Southwestern Ontario. ***Methods:*** A retrospective case review was conducted at the Department of Pathology, London Health Sciences Centre, for deaths attributed to falls from 2000 to 2020. Only cases with complete autopsy and detailed neuropathology reports were included. Demographic data, comorbidity profiles and craniocerebral and vertebrospinal injuries, along with scene details, were collected and analyzed. ***Results:*** 45 cases were included, with a male sex predominance and a mean age of 60.3 ± 18.1 years. The most common head injuries were hematoma, cerebral contusions and skull base fractures. Falls from stairs were the most common. Low fall (<3 m) was associated with subfalcine herniation and was more commonly seen in older individuals (>65 years). Younger individuals were more prone to falls from a high height (>3 m), with frontotemporal lobe contusions as the most common finding. ***Discussion:*** This study provides a detailed depiction of craniocerebral and vertebrospinal injury patterns of the fatal falls in Southwestern Ontario. Our findings show low falls are a more common cause of fatalities in individuals 65 years and older, and age is a significant predictor of frontal contusions and subdural hematomas.

RÉSUMÉ : Neuropathologie des chutes mortelles dans le sud-ouest de l'Ontario. ***Contexte :*** Les chutes de hauteur sont fréquentes parmi tous les groupes d'âge. Rien qu'en 2020, plus de six mille personnes sont décédées au Canada des suites d'une chute. La plupart des publications portant sur les lésions liées aux chutes sont souvent axées sur les types de fracture, la survie et le rétablissement. Les chutes mortelles demeurent quant à elles peu étudiées. L'objectif de cette étude est donc de décrire les caractéristiques démographiques de même que les lésions cranio-cérébrales et vertébro-spinales provoquées par des chutes mortelles dans le sud-ouest de l'Ontario. ***Méthodes :*** Le service de pathologie du London Health Sciences Centre a procédé à un examen rétrospectif des cas de décès attribués à des chutes entre 2000 et 2020. Seuls ceux ayant fait l'objet d'une autopsie complète et de rapports neuro-pathologiques détaillés ont été inclus. Les données démographiques, les profils de comorbidité, les lésions cranio-cérébrales et vertébro-spinales, ainsi que les détails au sujet des lieux des décès, ont été recueillis et analysés. ***Résultats :*** Au total, 45 cas ont été inclus, avec une prédominance masculine et un âge moyen de 60,3 ± 18,1 ans. Les traumatismes crâniens les plus fréquents étaient les hématomes, les contusions cérébrales et les fractures de la base du crâne. Les chutes dans les escaliers sont les plus fréquentes. Les chutes de faible hauteur (< 3m) sont associées à une hernie sous-falciforme et sont plus fréquemment observées chez les personnes âgées (> 65 ans). Les individus plus jeunes sont plus enclins à tomber d'une hauteur élevée (> 3m), des contusions du lobe fronto-temporal étant l'observation la plus fréquente. ***Discussion :*** Cette étude fournit une description détaillée des lésions cranio-cérébrales et vertébro-spinales liées à des chutes mortelles dans le sud-ouest de l'Ontario. Nos résultats montrent que les chutes de faible hauteur sont une cause plus fréquente de décès chez les personnes âgées de 65 ans et plus, et que l'âge est un facteur prédictif important des contusions frontales et des hématomes sous-duraux.

Keywords: axonal injury; fall; intracranial hemorrhage; neuropathology; trauma

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Highlights

- Our study provides a detailed visualization of craniocerebral and vertebrospinal injuries.
- Subarachnoid hemorrhage and contusions to the frontal and temporal lobes were the most common injuries acquired in fatal falls.
- Age is the most critical risk factor in fatal fall injuries and is significantly associated with frontal contusions and subdural hematoma.

Introduction

Fatal falls are defined as a descent from a current position to a lower level, resulting in injuries that lead to death. These incidents can stem from various causes, including accidents, suicides and homicides, and affect individuals across all age groups.[1] In Canada, the number of fatal falls has been increasing at an alarming rate,

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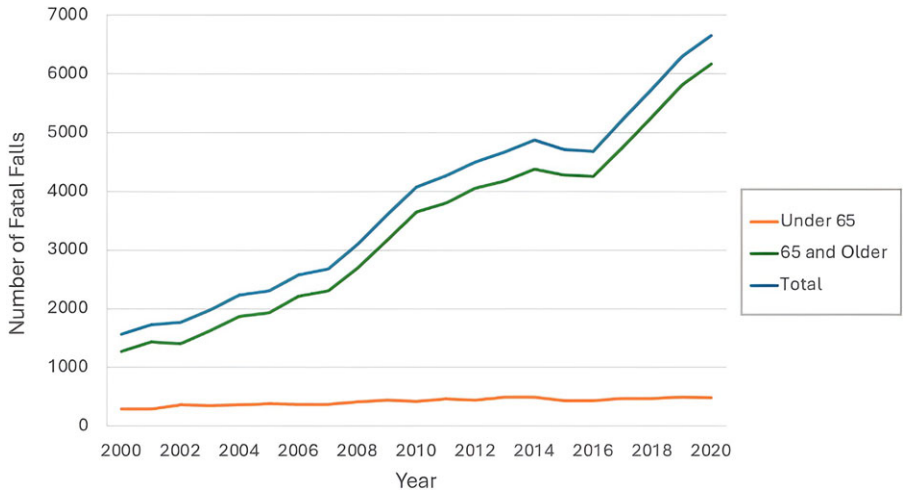

Figure 1. Fatal falls in Canada from 2000 to 2020 (Statistics Canada). The number of fatal falls is increasing each year, primarily driven by the age group 65 years and older. The number for those under 65 years old remains relatively unchanged during these 20 years.

with 6566 fatalities recorded in 2020 alone.[2] According to Statistics Canada, from 2000 to 2020, fatalities from falls among individuals aged 65 and older have increased significantly, while the rates for those under 65 have remained relatively stable (Figure 1). This trend may reflect underlying demographic changes, with the proportion of Canadians aged 65 and older increasing from 12.55% in 2000 to 17.90% in 2020.[3]

Several factors influence the types of injuries sustained by fall victims, including age, sex, pre-existing conditions, fall height and circumstances. It is essential for healthcare providers to be proactive in recognizing and informing individuals who are at risk of fall-related injuries to prevent additional harm or potential death.

Existing literature primarily focuses on fracture patterns, injury types, survival rates and recovery outcomes associated with falls.[4–5] However, fatal falls remain underexplored, particularly regarding their neuropathological implications. This retrospective study characterizes the craniocerebral and vertebrospinal injury patterns sustained by fatal falls within the Southwestern Ontario cohort. The relationships between these injuries and other intervening variables such as age, sex, comorbidities, fall height and fall surface are also investigated.

Materials and methods

Study design and data collection

This study was approved by the research ethics board of Western University (HSREB 120655). All autopsies were performed at the London Forensic Pathology Unit (FPU), the Department of Pathology, London Health Sciences Centre (LHSC). Autopsy reports between January 2000 and December 2020 were reviewed. Cases with a neuropathology consultation were included. Keywords "fall" or "descent from height" were used to search the autopsy warrant and the neuropathology consultation request form. There were 321 cases where keywords were mentioned within the reports. Sixty-three potential cases were initially identified after correlation of the final forensic autopsy reports, where the causes of death were attributed to fall-related injuries. External consult cases were excluded due to the lack of relevant clinical information. Forty-five cases were included for the final analysis. Craniocerebral injury was documented in all but one of the 45 cases due to severe autolysis. Variables affecting the impact of a fall were documented. Age, sex, scene information (location, height and landing surface), head/brain and spinal injury patterns, toxicology findings and comorbidities were obtained from the coroner's warrants, neuropathology consultation reports and final autopsy reports. Falls from height and from stairs were not mutually exclusive; stair-related falls over 3 m were classified as both a high fall and a fall from stairs.

Neuropathology procedures

For all 45 cases included in this study, formal neuropathology consultations were performed. Whole brain or brain slices were retained and fixed in 10% neutral buffered formalin for 10 days before gross examination. Injuries were documented with photography. Representative sections were taken for microscopic examination using routine procedures.[6,7]

Given that the case selection spans a 20-year period, the brain sampling protocols exhibited some variation over time. Nevertheless, a two-tiered framework was generally followed as a guiding principle. Tier 1 sampling comprised a set of core neuroanatomical regions collected in all cases, including representative cortical areas (frontal, temporal, parietal, occipital lobes and cingulate), subcortical structures (amygdala, hippocampus, basal ganglia, thalamus), the brainstem (midbrain, pons, medulla) and cerebellum (cerebellar vermis and hemisphere). Tier 2 sampling encompassed case-specific regions based on clinical context and gross pathology. This included additional sections through visible lesions (e.g., cortical contusions) or areas of clinical concern. In cases where diffuse axonal injury (DAI) was suspected, given the often subtle or absent gross findings, an expanded sampling protocol was employed. Targeted regions in such instances included the corpus callosum, internal capsule with adjacent deep gray matter, cerebellar white matter, caudal midbrain and rostral pons.

Additional neuropathological findings, such as neurodegenerative diseases and cerebral vascular diseases, were also documented where applicable. There is no established guideline for screening neurodegenerative diseases in this setting. A neurogenerative workup is typically initiated in decedents aged 65 years or older or when morphological features suggestive of such pathology are identified, such as amyloid plaques or Lewy bodies, which are often readily detectable on routine hematoxylin and eosin (H&E) stained sections.

Toxicology analyses were performed on all cases at the Ontario Centre of Forensic Sciences (www.ontario.ca/cfs).

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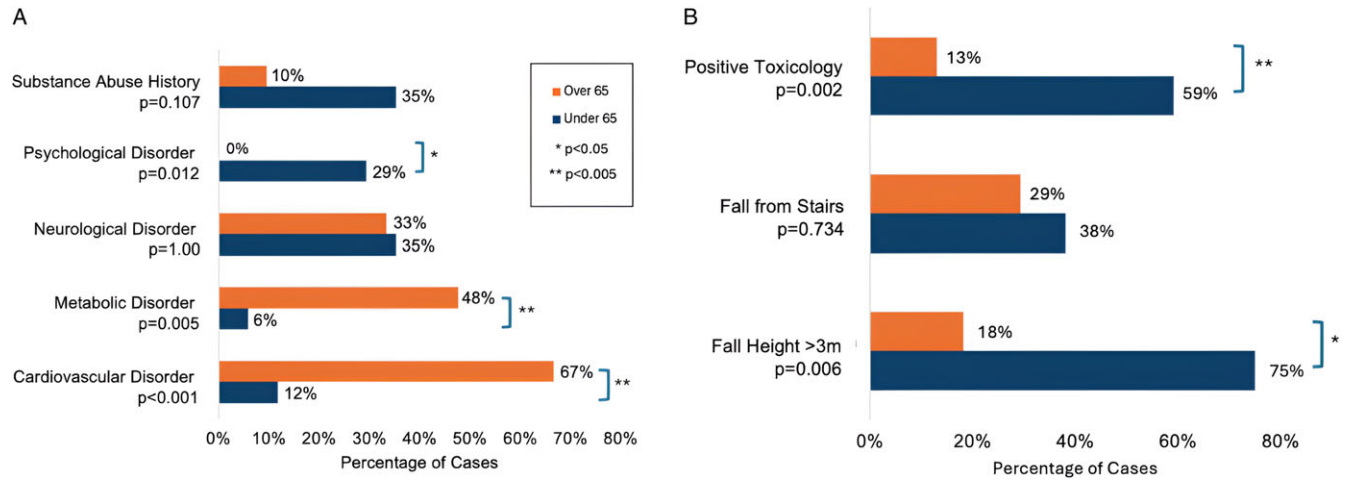

Figure 2. Relationship among comorbidities, fall circumstances and age of death. (A) There are more substance use and psychological disorder histories in decedents who died under 65 years old, while more metabolic and cardiovascular disorders are observed in decedents over 65 years. (B) Younger decedents were more likely to have positive postmortem toxicology and to have fallen from greater heights in fatal fall cases. Falls from height were identified as most commonly from construction sites, home balconies and barns.

Table 1. Summary of patient demographics and fall circumstances

	Number	Percentage (%)
Sex		
Male	34	75.6
Female	11	24.4
Age		
<65	22	48.9
≥65	23	51.1
Comorbidities		
Cardiovascular disease	16	42.1
Metabolic disorder	11	28.9
Neurological disorder	13	34.2
Psychiatric disorder	5	13.2
Substance abuse	8	21.1
Other	7	18.4
Circumstances of fall		
Stairs	22	64.7
Non-stairs	12	35.30
Height of fall		
High (>3 m)	14	51.9
Low (<3 m)	13	48.1
Positive toxicology	13	29.5
Fall location		
Home	29	64.4
Work	9	20.0
Other	3	6.67
Undetermined	4	8.89

Statistical analysis

Descriptive statistics were used to identify the most frequently observed neuropathological injuries and comorbidities. Contingency tables were created, and Fisher's exact test was conducted to identify associations between the injury patterns and predictor variables (age, sex, toxicology, comorbidities, fall location and height of fall). The significance of the association was assessed using an alpha level of 0.05. To conduct logistic regression between these variables, toxicology and comorbidities were converted into binary (absent or present), as were the height of fall (>3 m or 0–3 m), age (older; ≥65 or younger; <65) and fall circumstances (stairs or no stairs). All statistical analyses were performed using the SPSS 29 (IBM Corp., Armonk, NY, USA) statistical software. Figures were generated using Microsoft Excel and BioRender.com.

Results

Patient demographics and fall circumstances

Of the 45 cases studied, 34 (75.6%) were male, and 11 (24.4%) were female. The mean age was 60.3 ± 18.1 years. Approximately half (48.8%) of our cases were under the age of 65. The mean time of survival was 50.8 hours, with two victims dying at the scene. Demographic information, comorbidities and information surrounding the circumstances of death are detailed in Table 1. The most common fall location was home (64.4%), followed by work (20.0%), which was most frequently from barns and construction sites. Cardiovascular disease was the most common pre-existing condition, followed by neurological disorders and metabolic disorders (e.g., diabetes) (Supplemental Table 1). Eight (18.2%) participants had a history of substance abuse, while 13 (29.5%) had a positive postmortem toxicology report (e.g., an elevated blood alcohol level). The majority of these patients were younger than 65 years old (Figure 2). There was a significant association ($\alpha = 0.05$) between the presence of psychological disorders and younger age (Figure 2A and B).

In terms of the circumstances of falls, stairs were the most common location. Falling from stairs was more common than all other falls combined (Table 1), accounting for 64.7% of all cases. There was no difference observed when we compared the individuals older than 65 years with their younger counterparts who fell from stairs. On the other hand, there was a significant association ($\alpha = 0.05$) between a height of fall and age, with the younger group having 13.5 times higher odds of sustaining a fall

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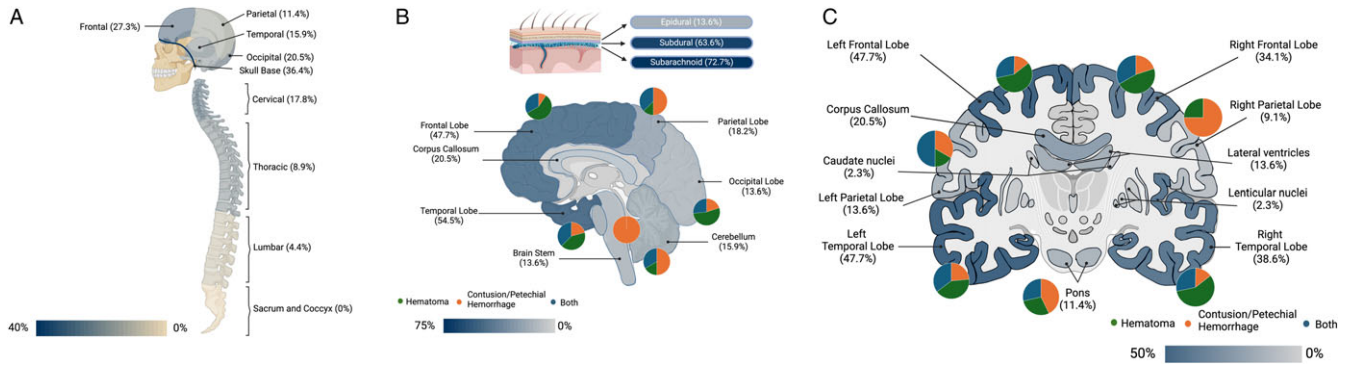

Figure 3. Neuropathology findings. (A) Distribution of the skull and spinal fractures. Skull base fracture is most common, followed by frontal, occipital and cervical spinal fractures. (B) Distribution of the intracranial injuries. Percentages of cases that had at least one intraparenchymal injury in each of the brain areas are indicated, and the specific injuries are illustrated as pie charts. Subarachnoid hemorrhage is most common, followed by temporal and frontal lobe contusions. (C) The left side injury is slightly more common than the right side.

from a greater height (>3 m). These high falls (long falls) were identified as most from construction sites, home balconies and barns. In addition, younger individuals were more commonly found to be intoxicated or under the influence at the time of fall, as shown by the positive postmortem toxicology report (OR = 9.63) (Figure 2).

Neuropathology findings

The neuropathological findings were summarized in Table 2. The mean number of craniocerebral or vertebrospinal injuries suffered was 7.69, with 16 being the greatest number of distinct injury types sustained by one individual. Craniocerebral injuries were grouped according to injury type and location, with multiple instances of the same injury type (such as multiple contusions) counted as one injury. Acute subarachnoid hemorrhages were the most documented injury among all cases (72.7%), followed by subdural and intraparenchymal hemorrhages (63.6%). Epidural hemorrhages were seen in 13.6% of the cases. In terms of cerebral contusions, the frontal and temporal lobes were the most common sites (47.7% and 45.5%, respectively), followed by the parietal and occipital lobes. Fractures to the skull base (36.4%) and frontal bone (27.3%) were the most common injuries to the cranium (Table 2 and Figure 3B and C). DAI, a type of severe diffuse traumatic brain injury often obtained in high-energy motor vehicle collisions (MVC), was also among the commonly documented injuries, accounting for 36.4% of all fatal fall cases. Secondary injuries, such as brain swelling and hypoxic-ischemic encephalopathy, were reported in 29.5% and 36.4% of the cases, respectively (Table 2). Vertebrospinal injuries were documented in less detail in the neuropathology reports. Injuries to the cervical spine were more frequent than in other spinal areas (17.8%) (Figure 3A). We then explored the association between case circumstances and injury patterns. Interestingly, our results showed that females are 4.83 times more likely than males to have an intraparenchymal hematoma. We also found low fall (also referred to as short fall for heights under 3 m) to be significantly associated with brain edema and the presence of subfalcine hernia ($p = 0.006$). Additionally, age was found to be significantly associated with subdural hematoma and frontal contusion, with individuals 65 years of age and older being 1.3 times more likely to suffer subdural hematomas and those under 65 more likely to suffer frontal contusions (OR = 4.0) (Table 3). No significant association was found between other variables and craniocerebral injuries. No associations were found in vertebrospinal injuries.

Discussion

In this study, we provide a comprehensive analysis of fatal falls in Southwestern Ontario over the last 20 years. Our findings reinforce existing evidence regarding the demographic and clinical factors associated with fatal falls while offering new insights into injury patterns and their underlying mechanisms.

There is a significant male predominance (75%), which has also been shown in studies by *Caki et al.* (82.5%), *Kort et al.* (86.6%) and *Obeid et al.* (77.8%). [8–10] This gender disparity has been previously attributed to men's greater engagement in high-risk activities or occupations.[6] However, no definitive association can be established in our study due to the limited sample size of our cohort. Interestingly, females were significantly more likely to sustain intraparenchymal hematomas (OR = 4.83), a finding that warrants further investigation. Gender-specific anatomical or physiological differences, such as hormonal influences on vascular integrity, could play a role in this disparity. Future research should explore these potential mechanisms to better understand and address gender-related vulnerabilities in fall injuries.

The mean age of 60.3 years and nearly equal distribution of cases above and below 65 years indicate that falls impact both middle-aged and older populations, albeit with differing underlying risk factors. Older adults (≥65 years) were significantly more likely to have pre-existing cardiovascular or metabolic conditions, aligning with previous studies linking these comorbidities to increased fall risk, such as hypertension,[11,12] arthritis[13,14] and diabetes.[15] Gait disorders, a common consequence of such conditions, likely contribute to imbalance and fall susceptibility.[16] Moreover, medication use, particularly diuretics and polypharmacy, represents a modifiable risk factor for falls and should be a focus of preventive efforts in this population.[17]

Another finding from our cohort is that individuals over the age of 65 are significantly more likely to fall from a low height of under 3 m. Most of these low falls resulted in minor trauma and occurred at home and from standing height, including scenarios such as in the washroom, getting out of bed or at the bottom of stairs. This population's heightened susceptibility to fatality from ground-level falls is consistent with *Spaniolas et al.,* who reported a threefold increase in mortality among individuals over 70 years following

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Table 2. Summary of neuropathology findings. (*There were 45 cases included. Craniocerebral injury was not documented in one of the 45 cases due to severe autolysis.)

	Number ($n = 45$*)	Percentage (%)
Craniocerebral injury		
Skull fractures		
Base	16	36.4
Frontal	12	27.3
Occipital	9	20.5
Parietal	5	11.4
Temporal	7	15.9
Hemorrhages		
Epidural	6	13.6
Subdural	28	63.6
Subarachnoid	32	72.7
Intraparenchymal	28	63.6
Contusions/petechial hemorrhages		
Frontal lobe	21	47.7
Temporal lobe	24	54.5
Parietal lobe	8	18.2
Occipital lobe	6	13.6
Cerebellum	7	15.9
Brain stem	6	13.6
Diffuse axonal injury	16	36.4
Secondary changes		
Hypoxic ischemic encephalopathy	16	36.4
Brain swelling/herniation	13	29.5
Uncal	7	15.9
Subfalcine	10	22.7
Tonsillar	2	4.5
Diencephalon	3	6.8
Vertebrospinal injuries		
Spinal fractures		
Cervical	8	17.8
Thoracic	4	8.9
Lumbar	2	4.4

Table 3. Results of the Fisher's exact test for craniocerebral injuries and select variables. Only results with significant association are reported

	p-value
Female sex and intraparenchymal hematoma	0.048
Low height fall (<3 m) and subfalcine herniation	0.006
Older age and subdural hematoma	0.002
Younger age and frontal contusion	0.038

ground-level falls.[18] These falls frequently resulted in subdural hematomas, likely due to age-related brain atrophy, which increases the risk of bridging vein rupture during minor trauma. Anticoagulant and antithrombotic medication use may further compound this risk, emphasizing the importance of careful medication management in older adults.[19–21–19]

Younger individuals, on the other hand, exhibited a higher incidence of falls from greater heights (>3 m) and a greater prevalence of intoxication or substance use. Nearly 30% of this group had positive toxicology reports, and they were 13.5 times more likely to fall from significant heights. These findings suggest that risk-taking behaviors and intoxication play a substantial role in the circumstances of fatal falls among younger adults. Although no direct association was found between toxicology and specific brain injuries, the link between substance use and fall risk warrants targeted preventive strategies.

Several studies have shown head injury to be the most common fatal injury in falls from a height.[8,21–26] Subarachnoid hemorrhage is the most frequent brain injury in our cohort (72.7%), followed by cerebral contusions, specifically to the frontal and temporal lobes. These two injuries are common in cases of traumatic brain injuries and are often detected together.[26] *Alexis et al.* reported 81.3% and 40.8% of autopsy cases suffered subarachnoid hemorrhage and cerebral contusions, respectively,[27] and other studies showed similar findings.[8,25] Skull base fractures and frontal bone fractures were also frequently observed in our cohort. *Thierauf et al.* observed 291 cases of fatal falls from stairs, ground height and from a greater height and found 47% of the cases sustained skull base fractures, the majority of which had fallen from a height and down the stairs.[28] Similarly, *Preuss et al.* also noted that skull base fractures occurred in 75% of cases from stairs.[29] DAI, a severe diffuse brain injury typically seen in high-energy trauma (e.g., MVC), is also prevalent in our cohort (36.4%), suggesting that falls, particularly from greater heights, can mimic the injury patterns of MVC.

Quantitative assessment of hemorrhage size, particularly epidural and intracerebral hemorrhages, may offer additional contextual information. However, such measurements were not consistently or systematically recorded in the autopsy reports spanning the 20-year study period. Consequently, hemorrhage dimensions were not extracted or categorized in this study, as retrospective estimation would be subject to considerable variability. Notably, existing literature suggests that the size or severity of intracranial hemorrhage does not reliably correlate with the height of a fall, particularly in pediatric populations.[30] Likewise, alcohol intoxication has not been shown to significantly modify injury patterns. A retrospective study of fatal falls found no meaningful association between positive blood alcohol concentration and the nature or severity of head injuries.[28]

A notable finding in this study is that a low fall of under 3 m was significantly associated with brain swelling and subfalcine herniation, highlighting the severe consequences of seemingly minor falls. A possible explanation is that in cases of low falls, the impact may not generate sufficient force to cause widespread brain injury but can instead lead to localized injuries such as subdural hematomas or contusions. These localized injuries will subsequently lead to secondary brain swelling and elevate intracranial pressure, particularly if the hematoma is unilateral. This is consistent with our cohort findings, where only two individuals died at the scene and the majority survived for a short period of time following the initial impact. A mean survival time of approximately 50.8 hours was observed. The extended survival interval may have allowed the progression of secondary brain swelling and herniation, providing a potential mechanism for delayed fatality after minor

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trauma. In contrast, falls from greater heights typically result in more extensive and diffuse brain injuries, such as DAI, and often lead to the patient dying at the scene. This emphasizes the importance of prompt medical evaluation for low falls.

In conclusion, this study characterizes the craniocerebral and vertebrospinal injury patterns and circumstances of fatal falls in Southwestern Ontario from 2000 to 2020. Subarachnoid hemorrhage and intraparenchymal hemorrhage were the most common injuries, with the frontal and temporal lobes and the skull base being the most frequently injured areas. Age was a significant predictor of injury type, with older adults more prone to subdural hematomas and younger individuals to frontal/temporal contusions. These findings underscore the importance of targeted prevention and early intervention strategies to mitigate the impact of falls across diverse populations. Future large-scale studies using statistical modeling are warranted to further explore these findings and develop evidence-based fall prevention measures.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/cjn.2025.10378.

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Author contributions. RXC: development of methodology, data analysis, original draft preparation; AEB: data collection, curation and analysis; WH: data analysis; QZ: project conceptualization, supervision, funding acquisition, manuscript review and editing.

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Competing interests. The authors have no competing interests to disclose.

References

1. Casali MB, Battistini A, Blandino A, Cattaneo C. The injury pattern in fatal suicidal falls from a height: an examination of 307 cases. *Forensic Sci Int*. 2014;244:57–62. doi: 10.1016/j.forsciint.2014.08.004.
2. Statistics Canada. Deaths and age-specific mortality rates, by selected grouped causes. Table 13-10-0392-01. Release date: 2025-02-19. Available from: doi: 10.25318/1310039201-eng.
3. Statistics Canada. Population estimates on July 1, by age and gender. Table 17-10-0005-01. Release date: 2024-09-25. Available from: doi: 10.25318/1710000501-eng.
4. Içer M, Güloğlu C, Orak M, Ustündağ M. Factors affecting mortality caused by falls from height. *Ulus Travma Acil Cerrahi Derg*. 2013;19:529–535. doi: 10.5505/tjtes.2013.77535.
5. Kent A, Pearce A. Review of morbidity and mortality associated with falls from heights among patients presenting to a major trauma centre. *Emerg Med Australas*. 2006;18:23–30. doi: 10.1111/j.1742-6723.2006.00800.x.
6. Ding JJ, Liu P, Rebernig H, et al. Vagus nerve stimulation does not alter brainstem nuclei morphology in patients with refractory epilepsy. *Epilepsy Behav*. 2021;118:107940. doi: 10.1016/j.yebeh.2021.107940.
7. Zhang Q, Suller-Marti A, Ding JJ, et al. Epilepsy-associated death in the Southwestern Ontario: a clinicopathological correlation study. *Brain Pathol*. 2023;33(2):e13121. doi: 10.1111/bpa.13121.
8. Çakı IE, Karadayı B, Çetin G. Relationship of injuries detected in fatal falls with sex, body mass index, and fall height: an autopsy study. *J Forensic Leg Med*. 2021;78:102113. doi: 10.1016/j.jflm.2020.102113.
9. Kort I, Belhaj A, Kebsi D, Gharbaoui M, Bellali M, Allouche M. A 13-year study of fatal falls from height in northern Tunisia. *Am J Forensic Med Pathol*. 2022;43:340–346. doi: 10.1097/PAF.0000000000000769.
10. Obeid NR, Bryk DJ, Lee T, et al. Fatal falls in New York City: An autopsy analysis of injury patterns. *Am J Forensic Med Pathol*. 2016;37:80–85.
11. Deng R, Li B, Qin M, et al. The characteristics and risk factors of fatal falls among adults aged 60 and above in Southwest China. *Sci Rep*. 2024;14:7020. doi: 10.1038/s41598-024-54265.
12. Sibley KM, Voth J, Munce SE, Straus SE, Jaglal SB. Chronic disease and falls in community-dwelling Canadians over 65 years old: a population-based study exploring associations with number and pattern of chronic conditions. *BMC Geriatr*. 2014;14:22. doi: 10.1186/1471-2318-14-22.
13. Mikos M, Kucharska E, Lulek AM, Kłosiński M, Batko B. Evaluation of risk factors for falls in patients with rheumatoid arthritis. *Med Sci Monit*. 2020;26:e921862. doi: 10.12659/MSM.921862.
14. Guo X, Pei J, Wei Y, Zhang G, Yan F, Han L. Prevalence and risk factors of falls in adults with rheumatoid arthritis: a systematic review and meta-analysis. *Semin in Arthritis Rheum*. 2023;60:152186. doi: 10.1016/j.semarthrit.2023.152186.
15. Rashedi V, Iranpour A, Mohseni M, Borhaninejad V. Risk factors for fall in elderly with diabetes mellitus type 2. *Diabetes Metab Syndr*. 2019;13:2347–2351. doi: 10.1016/j.dsx.2019.06.001.
16. Montero-Odasso M. Gait disorders, and fall risk in healthy neurological older individuals. In: Barbieri F, Vitório R, editors. *Locomotion and posture in older adults*. Cham: Springer; 2017:91–114. doi: 10.1007/978-3-319-48980-3_7.
17. Abu Bakar AA, Abdul Kadir A, Idris NS, Mohd Nawi SN. Older adults with hypertension: prevalence of falls and their associated factors. *Int J Environ Res Public Health*. 2021;18:8257. doi: 10.3390/ijerph18168257.
18. Spaniolas K, Cheng JD, Gestring ML, Sangosanya A, Stassen NA, Bankey PE. Ground level falls are associated with significant mortality in elderly patients. *J Trauma*. 2010;69:821–825. doi: 10.1097/TA.0b013e3181efc6c6.
19. Sundblom J, Sandberg E, Ronne-Engstrom E. Trauma mechanisms and surgical outcomes in the elderly patient with chronic subdural hematoma. *Can Geriatr J*. 2022;25:40–48. doi: 10.5770/cgj.25.519.
20. Uno M, Toi H, Hirai S. Chronic subdural hematoma in elderly patients: is this disease benign? *Neurol Med Chir (Tokyo)*. 2017;57:402–409. doi: 10.2176/nmc.ra.2016-0337.
21. Baechli H, Nordmann A, Bucher HC, Gratzl O. Demographics and prevalent risk factors of chronic subdural haematoma: results of a large single-center cohort study. *Neurosurg Rev*. 2004;27:263–266. doi: 10.1007/s10143-004-0337-6.
22. Ratnaike TE, Hastie H, Gregson B, Mitchell P. The geometry of brain contusion: relationship between site of contusion and direction of injury. *Br J Neurosurg*. 2011;25:410–413. doi: 10.3109/02688697.2010.548879.
23. Inamasu J, Hasegawa M, Hayashi T, Kato Y, Hirose Y. Hemispheric differences in the surgical outcomes of patients with traumatic acute subdural hematoma. *J Negat Results BioMed*. 2014;13:10. doi: 10.1186/1477-5751-13-10.
24. Abder-Rahman H, Jaber MS, Al-Sabaileh SS. Injuries sustained in falling fatalities in relation to different distances of falls. *J Forensic Leg Med*. 2018;54:69–73. doi: 10.1016/j.jflm.2017.12.001.
25. Legaspi C, Hickey T, Pickup M, Han Y. Investigation of injuries sustained from falls down stairs. *J Forensic Leg Med*. 2023;98:102561. doi: 10.1016/j.jflm.2023.102561.
26. Hörauf JA, Nau C, Mühlenfeld N, Verboket RD, Marzi I, Störmann P. Injury patterns after falling down stairs—High ratio of traumatic brain injury under alcohol influence. *J Clin Med*. 2022;11(3):697. doi: 10.3390/jcm11030697.
27. Alexis RJ, Jagdish S, Sukumar S, Pandit VR, Palnivel C, Antony MJ. Clinical profile and autopsy findings in fatal head injuries. *J Emerg Trauma Shock*. 2018;11:205–210. doi: 10.4103/JETS.JETS_127_17.
28. Thierauf A, Preuss J, Lignitz E, Madea B. Retrospective analysis of fatal falls. *Forensic Sci Int*. 2010;198:92–96. doi: 10.1016/j.forsciint.2010.01.010.
29. Preuss J, Padosch SA, Dettmeyer R, Driever F, Lignitz E, Madea B. Injuries in fatal cases of fall downstairs. *Forensic Sci Int*. 2004;141:121–126. doi: 10.1016/j.forsciint.2003.12.016.
30. Ibrahim NG, Wood J, Margulies SS, Christian CW. Influence of age and fall type on head injuries in infants and toddlers. *Int J Dev Neurosci*. 2012;30:201–206. doi: 10.1016/j.ijdevneu.2011.10.007.