Original Article

Paediatric injuries due to falls from windows and balconies: an 8-year prospective and retrospective review

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Abstract

Background: Unintentional falls from windows and balconies pose a serious health risk to children. Limited Canadian data describing such falls currently exist. This study aimed to describe the frequency, demographic characteristics, injury patterns, and risk factors associated with paediatric falls from windows and balconies.

Methods: This study employed both prospective data collection and retrospective medical record review. Prospectively, consenting families were enrolled from February 2015 to February 2017; retrospectively, charts from January 2009 to December 2014 were reviewed. Children 0 to 16 years of age, who presented to the Stollery Children's Hospital (Edmonton, Alberta) emergency department due to a fall from a window or balcony, were included.

Results: A total of 102 children were included; thirty were enrolled prospectively and 72 retrospectively. Median age was 4.5 years (interquartile range 2.83 to 6.83) with 63.7% (65 of 102) males. About 87.2% (89 of 102) of falls were from windows and 12.8% (13 of 102) from balconies. The median estimated height of fall was 4.1 m (interquartile range 3.04 to 4.73). About 58.4% (59 of 101) had at least one major injury (i.e., concussion, fractured skull, internal injury, fractured limb, severe laceration), 36.6% had minor injuries only (i.e., abrasions, contusions, sprains), and 5.0% had no documented injuries. There were no fatalities. About 30.4% (31 of 102) were admitted, with 48.4% of these children (15 of 31) requiring surgery.

Conclusion: Most falls from windows and balconies occurred in children under the age of 5 years and were associated with serious morbidity, high admission rates, and need for surgery. Child supervision as well as installation of key safety features in windows may help minimize paediatric fall-related injuries.

Keywords: *Accidental falls; Balconies; Epidemiologic surveillance; Paediatrics; Paediatric emergency medicine; Windows*

Falls are a common cause of childhood injuries and the leading cause of injury-related hospitalization in children under the age of 5 years (1–4). Unintentional falls from windows and

balconies pose a particularly serious health hazard to children (2,4–6). Historically, in the late 1960s, the New York City Department of Health reported that falls from heights caused

Received: April 20, 2020; Accepted: July 3, 2020

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12% of all accidental deaths in children under the age of 15 years (7,8). Shortly thereafter, they implemented an education and prevention program 'Children Can't Fly' which resulted in a significant reduction in the number of falls (7,8). With the appropriate safety precautions in place, falls from heights are largely preventable (7–10).

There is currently limited data in Canada describing the epidemiological features of and circumstances surrounding falls from windows and balconies. Identifying the associated risk factors and then advocating for better policies and interventions to address them is necessary to protect children from these avoidable falls (2,11). In recent decades, Alberta has seen population growth (12,13), leading to construction of numerous multi-storied housing structures, creating an opportunity to positively influence regulation of building safety features to help protect children.

Our objective was to describe the frequency, demographic characteristics, injury patterns, and risk factors associated with children's falls from windows and balconies that presented to a tertiary care paediatric hospital.

METHODS

Design and setting

All children who presented to the Stollery Children's Hospital paediatric emergency department (ED) due to a fall from a window or balcony between 2009 to 2017 were eligible for inclusion in the study. The Stollery Children's Hospital is a 152-bed facility located in Edmonton, Alberta, Canada. It provides quaternary services to children from Northern Alberta, parts of British Columbia, Saskatchewan, the Northwest Territories, Yukon, and Nunavut. The paediatric ED's annual census ranged from 26,190 to 52,991 during the study period.

This study employed both prospective and retrospective data collection methods. Prospectively, consenting families presenting to the paediatric ED were enrolled for 2 years from February 12, 2015 to February 11, 2017. A retrospective chart review was further performed to encompass a 6-year period (January 1, 2009 to December 31, 2014).

Study population and data sources

This study included all children, 0 to 16 years old, who presented to the paediatric ED due to a fall from a window or balcony. Prospectively, patients were identified and consented by research assistants (RAs) who were on shift from 15:00 to 23:00 hours, 7 days per week. Outside of these hours, if a patient was noted to have come in and was admitted, the research team approached the family on the wards. Patients were excluded if they could not communicate in English.

Retrospectively, cases were identified by the Data Integration and Management Repository (DIMR) held by Alberta Health

Services (AHS). To ensure completeness, the DIMR list was cross-checked with and supplemented by reports from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP). CHIRPP is an injury surveillance system that gathers and analyzes data on injuries and poisonings being treated at 19 EDs across Canada (14).

Data collection

A study-specific case report form was designed and used for data collection. Screening, recruitment, and data collection for prospectively enrolled patients were performed by trained RAs. Retrospective data abstraction from medical records was performed by a single trained team member (NM). Data were further cleansed and reviewed by two team members (MR and WC). Study data were collected and managed using REDCap (15) electronic data capture tools hosted and supported by the Women and Children's Health Research Institute (University of Alberta). All data were entered directly into the REDCap electronic platform, using a research-dedicated iPad.

Study tool

For each case, the following data points were collected: patient demographic characteristics (age, sex, height, weight, first three digits of postal code), Canadian Triage and Acuity Scale (CTAS) score, ED services utilized (social work, Child and Adolescent Protective Services, mode of arrival), discharge information (disposition, diagnosis, admission, length of stay in ED, length of admission, surgeries performed), circumstances surrounding the fall (location, estimated height, type of building, witnesses), presence and utilization of window safety features (screen, guards, stops), and presence of furniture or other objects by the window. For retrospective charts, we attempted to gather the same data points; however, much of this data was undocumented. This led to a high proportion of missing data.

Statistical analysis

Parametric data were described using means and standard deviations. Nonparametric data were described using medians and ranges. Chi-squared testing was used to test for significant differences between categorical data. Mann-Whitney test was used to test for significant differences between interval data. Statistical analysis was performed using Stata 14.2.

Ethics approval

Ethics approval (Pro00038784) was obtained from the University of Alberta's Health Research Ethics Board (Edmonton, Alberta).

RESULTS

A total of 102 children were included in the analyses. Prospectively, 36 patients presented to the paediatric ED

who met the inclusion criteria. Six of them were excluded from the study, as three presented outside of RA recruitment hours and were discharged home, two were missed, and one refused consent. Thus, 30 participants are included in the prospective study ([Supplementary Appendix 1](#)). Retrospectively, 129 medical records were identified: 54 were excluded as they fell from a structure other than a window or balcony (e.g., roof, playground structure, tree), and 3 records were duplicates. Thus, 72 participants were identified and analyzed in the retrospective study ([Supplementary Appendix 2](#)).

Demographics and incidence

A total of 102 children were included in the final analyses, with 63.7% (65 of 102) being males. The overall median age was 4.5 years (range 1.3 to 16.7) ([Table 1](#)). Two separate age

clusters were observed: the first ranging from 1 to 8 years with the mean age being 4.0 years, and the second ranging from 11 to 16 years with a mean age of 14.2 years ([Supplementary Appendix 3](#)). The younger age group was 65.9% (56 of 85) male, while the older one was 52.9% (9 of 17) male.

Between 2009 and 2016, the average annual incidence of falls per 100,000 children was 10.3 in the 0- to 4-year age group, 3.5 in the 5- to 9-year age group, 1.8 in the 10- to 14-year age group, and 5.4 overall for the 0- to 14-year age span.

Fall characteristics and circumstances

Overall, 87.3% (89 of 102) of falls occurred from a window and 12.8% (13 of 102) from a balcony. The estimated height of fall ranged from 0.6 m to 13.7 m, with a median height of

Table 1. Summary statistics for demographics and fall characteristics

	Balconies (N=13)	Windows (N=89)	All children (N=102)
Demographics			
Child age (years), N=102			
Median (IQR)	4.8 (2.9–11.8)	4.3 (2.8–6.5)	4.46 (2.8–6.8)
Child sex, N=102			
Males, n (%)	9 (69.2%)	56 (62.9%)	65 (63.7%)
Fall characteristics and circumstances			
Fall type, N=102			
Window, n (%)			89 (87.3%)
Balcony, n (%)			13 (12.7%)
Location of fall, N=67	n=8	n=59	n=67
Child's home, n (%)	4 (50%)	55 (93.2%)	59 (88.1%)
Friend's home, n (%)	1 (12.5%)	1 (1.7%)	2 (3.0%)
Group home, n (%)	0 (0%)	2 (3.4%)	2 (3.0%)
Child care, n (%)	0 (0%)	1 (1.7%)	1 (1.5%)
School gym, n (%)	1 (12.5%)	0 (0%)	1 (1.5%)
Church, n (%)	1 (12.5%)	0 (0%)	1 (1.5%)
Restaurant, n (%)	1 (12.5%)	0 (0%)	1 (1.5%)
Fall height (m), N=72	n=10	n=62	n=72
Median (IQR)	3.7 (1.3–4.3)	4.3 (3.0–5.5)	4.1 (3.0–4.7)
Multi-family dwelling, N=28	n=4	n=24	n=28
Yes, n (%)	1 (25%)	12 (50%)	13 (46.4%)
Home: owned vs rented, N=31	n=3	n=28	n=31
Owned, n (%)	1 (33.3%)	13 (46.4%)	14 (45.2%)
Rented, n (%)	2 (66.7%)	15 (53.6%)	17 (54.8%)
Witness present, N=56	n=7	n=49	n=56
Yes, n (%)	5 (71.4%)	23 (46.9%)	28 (50%)
Climbing on furniture led to fall, N=29			
Yes, n (%)		26 (89.7%)	

IQR Interquartile range. Only 28 data points for multi-family dwelling.

4.1 (interquartile range [IQR] 3.0 to 4.7) meters. Fifty-nine out of 67 families (88.1%) reported the fall to have occurred at the child's own home, with 46.4% (13 of 28) occurring in multi-family dwellings. Fifty percent (28 of 56) reported a witness being present at the time of the fall, with 58.8% (10 of 17) being over the age of 16 years; 89.7% (26 of 29) of families reported that the child had climbed onto furniture or another object by the window prior to falling (Table 1). The effect of fall height on ED disposition (admit or discharge), no injury (yes or no), severe injury (yes or no), and surgery (yes or no) was explored using the Mann–Whitney test. Although there is a trend, none of these analyses met with statistical significance ($P < 0.05$).

Falls were observed throughout the year; however, 69.6% (71 of 102) of falls occurred between the months of May through August. The number of falls per year ranged from 5 (2009) to 18 (2016).

ED visit

Seventy-five out of 102 children (73.5%) were brought to the ED by Emergency Medical Services, 24.5% (25 of 102) via private vehicle, and 2.0% (2/102) via air ambulance. CTAS score ranged from 1 (Resuscitation) to 5 (Non-urgent). Eighty children (78.4%) were scored as CTAS 1 (Resuscitation) or 2 (Emergency). Social work and/or the Child and Adolescent Protection Centre were noted as being involved in 36.8% (14 of 24) of prospective cases, following the incident (Table 2).

Injury patterns

Major injuries included concussion, fractured skull, internal injuries, fractured limbs, and/or severe lacerations, whereas minor injuries were defined as minor lacerations, abrasions, contusions, bruising, and sprains. Out of the 102 patients enrolled, 1 left the ED without being seen by a physician. The injuries for the remaining patients ranged from 58.4% (59 of 101) having at least one major injury, 36.6% (37 of 101) having minor injuries, and 5.0% (5 of 101) having no documented injuries (Table 2). Concussion was the most frequent major injury (30 of 59; 49.2%), followed by a fractured lower limb (15 of 59; 25.4%), fractured upper limb (14 of 59; 23.7%), internal thoracic or abdominal injuries (13 of 59; 22.0%), fractured skull (11 of 59; 18.6%), and severe skin injuries (2 of 59; 3.4%). There were no deaths reported.

Discharge information

Seventy children (68.6%) were discharged home from the ED and 30.4% (31 of 102) were admitted. The ED length of stay ranged from 1.2 to 15.5 hours, with a median length of stay of 3.3 (IQR 2.1 to 6.3) hours (Table 2).

The rate of admission varied from 0% (0 of 5) among children with no injury, 2.7% (1 of 37) among those diagnosed with a minor injury only, and 50.8% (30 of 59) among those

with a severe injury. Among admitted patients, 48.4% (15 of 31) required surgery and the median length of admission was 46 (IQR 24 to 70) hours. Surgery was required for 4 upper limb orthopaedic injuries, 10 orthopedic lower limb injuries, 1 neurosurgical procedure, and 1 plastic surgery procedure.

Utilization of window features

Prospectively enrolled participants with falls from a window were asked about the presence of window screens, guards, and stops; 96.2% (25 of 26) had screens in place, while only 26.9% (7 of 26) had either guards or stops in place. Out of these seven, only one stated that they were in use at the time of the fall.

DISCUSSION

Over an 8-year span, we identified 102 incidents of falls from windows or balconies presenting to Edmonton's only paediatric ED. The majority of falls occurred in preschool-aged boys, with a window in the child's home being the most common location of fall. Falls were associated with high morbidity. Nearly 60% of children sustained at least one serious injury including concussion, fractured skull, internal injuries, fractured limbs, or severe lacerations. Using similar definitions for injuries, the US Consumer Product Safety Commission reported 45% of fall-related injuries to be serious and approximately one-third to be minor injuries only (5). Vish et al. reported that 70% of children suffered major injuries, 4% of which were ultimately fatal (6). No fatalities were identified in our study cohort, and local media did not report any paediatric falls-related fatalities during the study period either.

The overall median age of children included in our study was 4.5 years. These data are consistent with previous studies conducted in the USA and internationally (4,5,16). Harris et al. reported a mean age of 5.1 years and a median age of 3 years in a nationally representative sample of 98,415 children, who were identified using the US National Electronic Injury Surveillance System (5). There was no significant age difference in our study between window and balcony falls. A distinct bimodal age distribution was observed, however, with a younger cohort of 1 to 8 years and an older cohort of 11 to 16 years. Similar bimodal distributions have been described in previous literature (4). It is hypothesized that alcohol/substance abuse or other mental health challenges may play a role in the older cohort, although this was not explored in our study (10). Children under the age of 5 years remain at highest risk of sustaining accidental falls from heights (2,3,5,6,9,10,16–18). This may be due to increased curiosity, newfound independence, an inherent interest in exploring their surrounding environment, as well as more time spent at home (9).

Previous research around fall-related injuries indicates that boys outnumber girls by a 1.2:1 to 2:1 ratio (4–7,9,18,19). This is congruent with our study cohort which demonstrated

Table 2. Summary statistics for emergency department visit and admission

	Balconies (N=13)	Windows (N=89)	All children (N=102)
ED visit			
Mode of arrival, N=102	n=13	n=89	n=102
EMS, n (%)	9 (69.2%)	66 (74.2%)	75 (73.5%)
Air ambulance, n (%)	1 (7.7%)	1 (1.1%)	2 (2.0%)
Private vehicle, n (%)	3 (23.1%)	6 (6.7%)s	25 (24.5%)
Arrival from, N=102	n=13	n=89	n=102
Edmonton and region, n (%)	8 (61.5%)	74(83.1)	82(80.4%)
Outside region, n (%)	5(38.5%)	15(16.9)	20(19.6%)
CTAS, N=102	n=13	n=89	n=102
1-Resuscitation, n (%)	0 (0%)	8 (9.0%)	8 (7.8%)
2-Emergency, n (%)	9 (69.2%)	63 (70.8%)	72 (70.6%)
3-Urgent, n (%)	3 (23.1%)	14 (15.7%)	17 (16.7%)
4-Semi-urgent, n (%)	1 (7.7%)	3 (3.4%)	4 (3.9%)
5-Non-urgent, n (%)	0 (0%)	1 (1.1%)	1 (1.0%)
Time of day, N=30	n=4	n=26	n=30
Day (08:01–16:00)	2 (50%)	5 (19.3%)	7 (23.3%)
Evening (16:01–00:00)	2 (50%)	21 (80.8%)	23 (76.7%)
Overnight (00:01–08:00)	0 (0%)	0 (0%)	0 (0%)
CAPS or social work involvement, N=38	n=6	n=32	n=38
Yes, n (%)	2 (33.3%)	12 (37.5%)	14 (36.8%)
ED length of stay (hours), N=30	n=4	n=26	n=30
Median (IQR)	3.3 (1.7–5.6)	3.2 (2.3–6.3)	3.3 (2.1–6.3)
Injury severity, N=101	n=13	n=88	n=101
Severe, n (%)	8 (61.5%)	51 (58.0%)	59 (58.4%)
Minor, n (%)	5 (38.5%)	32 (36.4%)	37 (36.6%)
None, n (%)	0 (0%)	5 (5.7%)	5 (5.0%)
Discharge disposition, N=102	n=13	n=89	n=102
Discharged home, n (%)	9 (69.2%)	61 (68.5%)	70 (68.6%)
Admitted, n (%)	4 (30.8%)	27(30.3%)	31 (30.4%)
Left without being seen, n (%)	0 (0%)	1 (1.1%)	1 (1.0%)
Admission			
Age (years), N=31	n=4	n=27	n=31
Median (IQR)	7.1 (2.33–12.42)	4.5 (3.33–5.33)	4.5 (3.3–6.8)
Sex, N=31	n=4	n=27	n=31
Males, n (%)	2 (50%)	17 (63.0%)	19 (61.3%)
Surgery, N=31	n=4	n=27	n=31
Yes, n (%)	2 (50%)	13 (48.1%)	15 (48.4%)
Length of admission (hours), N=31	n=4	n=27	n=31
Median (IQR)	44 (30.5–60)	46 (24–70)	46 (24–70)

ED Emergency Department; EMS Emergency Medical Services; CAPS Child and Adolescent Protection Centre; CTAS Canadian Triage Assessment Score; IQR Interquartile range.

a 1.75:1 ratio. The Centers for Disease Control and Prevention has reported that boys have generally higher injury rates than girls, across several different injury mechanisms including falls (20). In their study, for children less than 10 years, 65.9% were male; however, in those over 10 years, the sex ratio was almost

equal with only 52.9% being male. Our overall annual incidence of 5.4/100,000 is similar to Istre's of 6.2/100,000 in the 0 to 14 year age range (21).

Over 95% of windows had a screen in place at the time of the fall. Window screens are designed primarily to keep

insects out, rather than to keep children in. However, screens might offer a false sense of security due to the misconception that they are strong enough to hold the weight of a child and prevent them from falling out (5,6,21). Safety features that may actually assist in the prevention of window-related falls include operable window guards and window stops (7,8). Window guards consist of metal bars that attach onto the window frame, whereas window stops prevent windows from opening past a certain height or opening too far out. In 1976, the New York City Board of Health passed a law requiring the owners of multi-storey dwellings to provide window guards in apartments which housed children 10 years and younger. The law was passed after the pilot project demonstrated the effectiveness of this strategy. There was a 50% reduction in incidents, and no child fell from a window that was equipped with a window guard (7).

Another potential risk factor was the presence of furniture or other objects by the window, which the child climbed onto to gain access to the window opening (90% of prospectively enrolled cases). The American Academy of Pediatrics recommends both modification of the environment as well as parental counselling as key strategies in prevention of window related falls (4,5).

Limitations

This is a single centre study and thus had a limited number of cases and generalizability. Retrospective data collection was reliant on documentation in the patient's medical chart which led to a high variability in denominators due to missing data. Site visits were not conducted. Thus, fall height and circumstances data were verbally reported and therefore estimated by either parents or witnesses. Information regarding the fall surface was not collected.

CONCLUSIONS AND FUTURE DIRECTIONS

While largely preventable, paediatric falls from windows and balconies have continued to occur in Alberta over the last decade. Environment can be modified such as ensuring that climbable furniture is not placed under a window and that window design for those in second floors or higher meet standards that reduce the risk of children falling out. In Alberta, efforts are underway to amend the Canadian National Building Code to ensure safer windows at heights. If approved, these proposed changes would be implemented for new buildings in Alberta, starting in December 2021 (22). Efforts such as these may lead to improved outcomes, but will not change the risk of falls from balconies. Direct supervision of children near any dangerous height is always going to be key in protecting them from serious falls.

SUPPLEMENTARY DATA

Supplementary data are available at *Paediatrics & Child Health* Online.

Informed Consent: Consent was obtained from prospectively enrolled families and was waived for the retrospective chart review.

Funding: This study was funded, in part, by the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) (Edmonton, Alberta), and the Women and Children's Health Research Institute (WCHRI) (Edmonton, Alberta) through the Research Capacity Building Program.

Potential Conflicts of Interest: All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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