Pilot case–control study of paediatric falls from windows

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ABSTRACT

Background Unintentional falls from windows are an important cause of paediatric morbidity. There have been no controlled studies to identify modifiable environmental risk factors for window falls in young children. The authors have piloted a case–control study to test procedures for case identification, subject enrolment, and environmental data collection.

Methods Case windows were identified when a child 0–9 years old presented for care after a fall from that window. Control windows were identified (1) from the child's home and (2) from the home of an age- and gender-matched child seeking care for an injury diagnosis not related to a window fall. Study staff visited enrolled homes to collect window measurements and conduct window screen performance tests.

Results The authors enrolled and collected data on 18 case windows, 18 in-home controls, and 14 matched community controls. Six potential community controls were contacted for every one enrolled. Families who completed the home visit viewed study procedures positively. Case windows were more likely than community controls to be horizontal sliders (100% vs 50%), to have deeper sills (6.28 vs 4.31 inches), to be higher above the exterior surface (183 vs 82 inches), and to have screens that failed below a threshold derived from the static pressure of a 3-year-old leaning against the mesh (60.0% vs 16.7%). Case windows varied very little from in-home controls.

Discussion Case–control methodology can be used to study risk factors for paediatric falls from windows. Recruitment of community controls is challenging but essential, because in-home controls tend to be over-matched on important variables. A home visit allows direct measurement of window type, height, sill depth, and screen performance. These variables should all be investigated in subsequent, larger studies covering major housing markets.

INTRODUCTION

Unintentional falls are a major cause of morbidity and mortality for US children and rank as the leading cause of injury hospitalisation in this population.[1] In 2007, unintentional falls by children 0–4 years of age resulted in 60 deaths and almost 1 million hospital and emergency department visits.[2] In 2005, the estimated lifetime costs attributable to hospitalised unintentional fall injuries in children 0–9 years was over US$3.9 billion.[3] Studies from several major metropolitan areas in the USA have identified unintentional window falls as an important source of severe paediatric injury seen in trauma centres.[4–8] The US Consumer Product Safety Commission estimates that nearly 3300 children are treated annually after a window fall.[9]

Despite the magnitude and frequency of this problem, there have been no controlled studies to identify modifiable environmental risk factors for window falls in young children. The only evaluated strategy for the prevention of window falls is the installation of window bars.[10] Other environmental approaches to the prevention of window falls might be possible, as factors such as window size, sill height, opening mechanism, use of screens, and sill depth could potentially affect the risk of a fall of a young child.[5] Planning of prevention strategies for such falls requires a controlled analysis of risk and protective factors.

The goal of this pilot project was to field test procedures for case identification, subject enrolment, and environmental data collection needed to conduct a case–control study of risk factors for window falls among children 0–9 years old. We sought to test the feasibility and efficiency of our recruitment and enrolment procedures as well as protocols for conducting window assessments through home visits. In addition, we sought to estimate the prevalence of potential risk factors in case and control windows as an aid to sample size estimation for future studies.

METHODS

We conducted a prospective case–control study. Incident window falls involving children were identified at two hospitals serving paediatric trauma patients in Seattle, Washington from 1 April 2009 to 30 October 2009.

Cases and controls

Windows, not children, were identified as cases and controls. A case was defined as the window through which an index event occurred. An index event was the unintentional fall of a child under the age of 10 years from a household window for which medical evaluation was sought in a participating hospital emergency department. We required that the fall occurred at a residence in one of three adjacent counties, so field visits to inspect the windows would be feasible. Cases were identified from medical record review among children discharged from emergency departments or admitted for care subsequent to a fall from a window. Since the study was not designed to determine risk factors for injury resulting from falls, but rather to identify risk factors for the fall event, we included patients irrespective of injury. Although there were none, we planned to exclude fatal falls, falls from windows at public facilities, and falls thought to have been intentional in nature. In addition, we excluded case homes where children were in the custody of law enforcement or the State or whose guardians did not speak English or Spanish.

Control households were selected by identifying an age- and gender-matched patient who did not fall through a window but was treated for a burn or injury in one of our clinical sites within 2 weeks of the incident fall. If there were several potential controls, the child who presented closest in time to the case was selected for recruitment. If the parents of a potential control child declined to participate, we contacted parents for the child presenting next closest in time until a matching control household was found.

Case windows were described according to the specific function of the room they served (eg, child's bedroom, dining room). Rooms were also assigned to clusters of living space with similar functions (eg, bedrooms, living areas) such that each window could be matched according to its specific room or to a more general cluster of similarly used rooms. We sought to identify two different types of control window.

1. In-home control. The in-home control window was a randomly selected window in the same household as the case window. The control was chosen so the child victim would have had normal access. Operable windows in the same room as the case window were enumerated. If there were no other windows in the same room, windows in the same cluster were listed. A table of random numbers was used to select one in-home control window from the same room or from the same cluster as the case window.
2. Community control. The community control window was randomly selected in a 'control' household serving a functionally equivalent room. Operable windows in the same room as the matched case window were enumerated. If there were no windows in the same room, or if the control child did not normally have access to that room, windows in the same cluster were listed. A table of random numbers was used to select one community control window from the same room or the same cluster as the case window.

Recruitment

Incident falls from windows were identified by clinical staff at participating emergency departments through daily review of visit logs. When a case was identified, a letter was mailed to the child's legal guardian explaining the study and offering an opportunity to 'opt out' of a research recruitment phone call. Research staff attempted to contact each identified family by telephone up to three times. When a family was enrolled, research staff sought to identify a suitable control using the criteria specified above and followed a similar procedure for mail and telephone approach. All families were offered a US$25 gift card for participation.

After enrolment, a self-report questionnaire was mailed to case participants. Parents were asked to describe key attributes and dimensions of the case window. Research staff then scheduled home visits with participating case and control households.

Exposures

Home visits focused on documenting aspects of window design and maintenance that might be associated with risk of a window fall. These included window type, presence of locks, guards or other safety devices (at the time of the window fall), and presence of a screen (at the time of the window fall). Direct measurements included maximum opening dimension of the window, the dimensions of the window, height of sill from floor and height of sill from any object under the window (functional sill height), sill depth, and exterior height of window above grade (the finished ground level adjacent to the window opening). The exterior height of the window above a roof, carport, awning, or other structure was also measured (functional exterior height).

Because many children fall through screened windows when the frame of the screen separates from the window, we also measured the static pressure at which screens in case and control windows failed in this manner. We used a device with two pads simulating the hands of a 3-year-old toddler (figure 1). These were connected to a handle through a load transducer. Continuous recording of the load during application of the test device to a screen allowed us to record the force (in Newtons) at which the screen frame could be pushed out of the window opening.

As this was a pilot study focused on research procedures, we asked all case families to complete a confidential survey after the home visit. Families described their understanding of the purpose of the study and their comfort in participating.

Sample size

The primary aim of this study was to test the feasibility of study procedures and to estimate associations between exposures and outcomes for use in the design of subsequent studies. Therefore we did not conduct formal sample size calculations.

Analysis

For all exposures we report univariate statistics comparing the measured value in two separate comparisons: (1) the case window compared with an in-home control; (2) the case window compared with a matched community control window. Because not all case windows were successfully matched to community controls, we only report data in the second comparison from matched case windows.

We sought to describe screen failure results according to a clinically meaningful threshold. We calculated that a typical 3-year-old (96.5 cm tall, 17.2 kg, and centre of gravity 57 cm above ground) would generate up to 22 N of static pressure when leaning against a window screen with two hands from 25 cm away. Therefore we dichotomised screen test load results according to whether dislodgement of the screen required forces >22 N versus ≤22 N.

Figure 1 Testing screen failure threshold with static load.

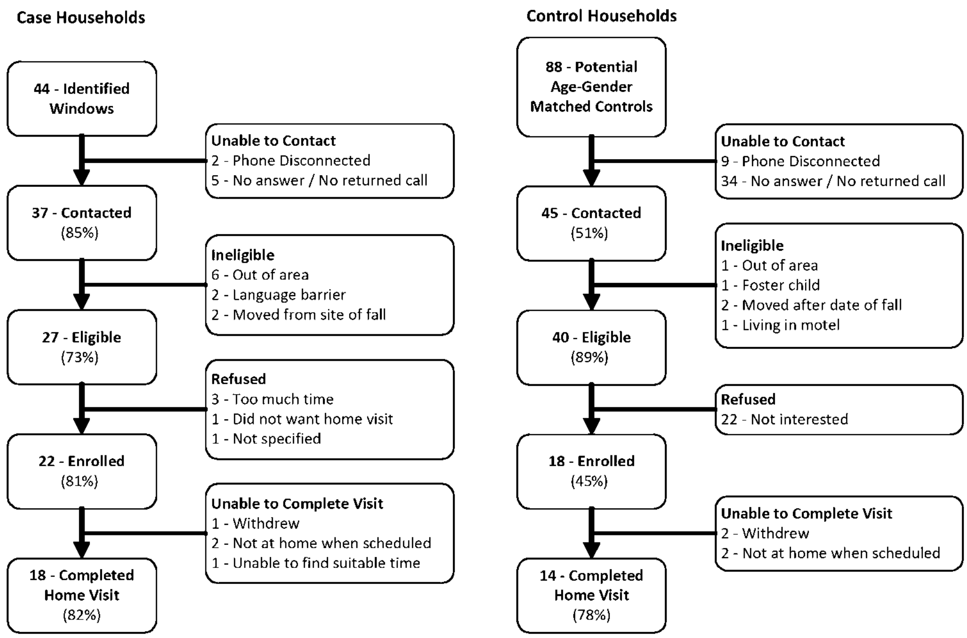

Figure 2 Flow diagram of identification, recruitment, and enrolment to case and control arms.

Analyses were conducted in Stata SE 8.0. All study procedures were reviewed and approved by the institutional review board at Seattle Children's Hospital.

RESULTS

We identified 45 incident window falls involving 44 case windows (in one event, two children fell from the same window at the same time). Of the 27 contacted and eligible families, 22 were enrolled, and 18 completed a home visit for exposure measurement (figure 2). Attempting to match a control household to each enrolled case, we identified 88 children who were age and gender matched. Of the 45 families whom we were able to contact, 18 were enrolled and 14 completed home visits (figure 2). We thus required 6.2 control referrals per enrolled control household.

Demographic characteristics of the children who sustained window falls and those enrolled as age- and gender-matched controls are shown in table 1. We did not match on home ownership; as a result, 50% of matched case homes were rental units, whereas only 39% of the community controls were rented. In addition, control families had, on average, a longer tenure in their current location.

Case windows were typically located in the index child's bedroom (22.2%) or in another bedroom (61.1%). Window characteristics are detailed in table 2. Case windows were almost uniformly of the horizontal slider type. This difference was statistically significant when compared with community controls, which evidenced a broader ranger of window designs. All windows had a lock, latch, window opening control device (WOCD), or other safety mechanism in place. None was equipped with window guards, although one family had used a stair gate for this purpose.

Most windows were fitted with a screen. Although case windows (94.4%) were more likely than in-home (83.3%) or community controls (85.7%) to have a screen in place, this difference was not significant.

Direct window measurements are reported in table 3. There was no difference in the mean maximum opening of case and control windows, nor in mean maximum opening when WOCDs were applied. Similarly, case and control windows showed no differences in mean sill height or functional sill height. However, case windows had deeper sills than matched community controls. Case windows also had, on average,

Table 1 Demographic characteristics of index case children, case children with matched controls, and community control children

	All cases (n=18)	Matched cases (n=14)	Matched controls (n=14)
Mean (SD) age (years)	4.04 (1.97)	3.92 (1.38)	3.97 (1.40)
Gender			
Female (%)	27.8	14.3	14.3
Male (%)	72.2	85.7	85.7
Home ownership			
Rent (%)	50.0	50.0	38.5
Own (%)	50.0	50.0	61.5
Mean (SD) years in current home	2.31 (1.80)	2.50 (1.96)	4.27 (4.72)

Table 2 Characteristics of case windows, in-home controls, matched case windows, and matched community control windows

	All case windows (n=18)	In-home control windows (n=18)	Matched case windows (n=14)	Matched community control windows (n=14)
Window type				
Single hung (%)	0	11.1	**0**	**21.4**
Double hung (%)	0	0	**0**	**7.1**
Casement (%)	0	0	**0**	**21.4**
Slider (%)	94.4	77.8	**100.0**	**50.0**
Other (%)	5.6	11.1	**0**	**0**
Window safety devices				
Lock or latch (%)	100.0	83.3	100.0	92.9
Stopper/WOCD (%)	27.8	22.2	28.6	14.3
Window guard (%)	0	0	0	0
None (%)	0	0	0	0
Window screen present (%)	94.4	83.3	100.0	85.7

Bold type indicates that differences between matched case windows and matched community control windows are significant at $p<0.05$.
WOCD, window opening control device.

Table 3 Measured dimensions and performance test for case windows, in-home controls, matched case windows, and matched community control windows

	All case windows (n=18)	In-home control windows (n=18)	Matched case windows (n=14)	Matched community control windows (n=14)
Window opening				
Maximum (SD) (inches)	23.86 (7.57)	21.32 (11.42)	24.76 (6.63)	22.84 (8.85)
With safety devices (SD) (inches)	16.81 (11.87)	16.39 (12.96)	15.69 (12.30)	19.19 (11.20)
Window measures—interior				
Window height (SD) (inches)	50.39 (8.12)	49.49 (7.43)	50.21 (8.20)	46.33 (13.17)
Window width (SD) (inches)	57.14 (7.20)	55.57 (12.24)	57.58 (7.66)	53.75 (14.28)
Sill depth (SD) (inches)	6.42 (3.44)	5.32 (1.56)	**6.28 (3.40)**	**4.31 (1.27)**
Floor to sill height (SD) (inches)	29.77 (8.83)	31.69 (6.72)	29.94 (8.93)	33.92 (13.84)
Functional sill height (SD) (inches)	11.35 (15.85)	17.94 (12.92)	12.15 (16.16)	14.54 (14.37)
Window measures—exterior				
Height above grade (SD) (inches)	180.57 (64.59)	186.57 (62.63)	**182.81 (62.65)**	**81.61 (47.94)**
Functional height (SD) (inches)	118.58 (71.47)	125.93 (94.68)	**129.82 (71.57)**	**56.17 (45.06)**
Static screen failure load				
Mean (N)	29.58 (24.05)	24.44 (13.33)	27.80 (26.09)	34.91 (12.92)
Screen failed at <22 N (%)	50.0	54.6	**60.0**	**16.7**

Bold type indicates that differences between matched case windows and matched community control windows are significant at $p<0.05$.

a greater exterior height above grade. These differences were statistically significant when case windows were compared with community matched controls.

Comparing the mean load at which tested screens separated from the window frame revealed no significant difference between case and control windows. However, a much higher proportion (60.0%) of case window screens failed at or below the threshold of 22 N than community matched control window screens (16.7%) (OR 7.5, 95% CI 1.04 to 54.12).

All 18 enrolled and home-visited case families completed a self-report survey. This allowed us to assess the accuracy of these self-reported window observations when compared with measures taken during an in-home visit. Results are shown in table 4. In general, occupants were able to accurately estimate sill height, window height, and window type. The presence of a WOCD was not accurately reported.

We received research experience surveys from 14 of the 18 case households visited. Most participants 'agreed' or 'strongly agreed' that they understood the purpose of the research before the home visit (92.9%), that the study was clearly explained (100%), that they felt comfortable talking about their child's injury (77.0%), and that they felt comfortable having a study team visit their home (100%). One participant found questions about the child's experience to be upsetting (7.1%). Participants disagreed that the study and its procedures took too much time (92.9%) and agreed that the study topic was important (100%).

Table 4 Comparison of self-reported and directly measured window observations in 18 home-visited case households

	Agreement (%)	Kappa	Correlation	p Value
Window observations				
Single hung	94.1	0.46		0.0031
Double hung	100.0	1.00		0.0000
Horizontal slider	85.3	0.57		0.0004
Any WOCD	35.5	0.02		0.3730
Screen present	75.8	0.34		0.0254
Window measures				
Window height			0.4384	0.0136
Sill height			0.7620	0.0000
Sill depth			0.2419	0.1898
Functional sill height			0.0022	0.9910
Outside window height			0.8480	0.0000

WOCD, window opening control device.

DISCUSSION

We completed a pilot case–control study to identify factors in window design and maintenance associated with paediatric falls from windows. Identification of both case and control windows was feasible, using children treated in the emergency department as index clinical contacts and as age- and gender-matched control contacts. Results of this pilot investigation suggest that window type, exterior height, sill depth, and screen performance may all be associated with the risk of window falls.

Recruitment and enrolment were challenging. Because our emergency department serves as a regional paediatric trauma centre, many potential cases were transferred to the hospital over considerable distances and were therefore excluded as we could not feasibly conduct a home visit.

In-home control windows were easily identified and accessible during home visits to case windows. However, we found little variability in window design between case and in-home control windows, suggesting these controls might be over-matched to the cases. Use of community control windows was thus an important feature of our methodology and should be replicated in subsequent studies. Home visits took less than 60 min and were valued by the families who completed this aspect of the study.

Unfortunately, enrolment of these community control windows was difficult. Many control families did not understand the connection between their child's injury treatment and a study related to window safety. A large proportion never returned calls from our research staff. Among those whom we were able to contact, a substantial number were simply not motivated to participate. As a result, we contacted more than six potential control households for every one we enrolled. The efficiency of recruitment was hampered by ethical review stipulations that limited our research team to three contact attempts.

In our sample, self-report of many variables was accurate. Accuracy could be improved by specifically providing home occupants with a list of window opening control device options. and—perhaps—a digital camera to obtain remote images for quality control. Most of the study could then be conducted

Table 5 Sample size estimates for a study of case windows and unmatched control windows recruited in a 1:2 ratio

Exposure	Prevalence in controls	OR of fall given exposure 1.5 Cases	1.5 Controls	2.0 Cases	2.0 Controls	2.5 Cases	2.5 Controls	3.0 Cases	3.0 Controls
Horizontal slider window	0.47	290	580	103	206	61	122	45	90
Functional sill height <24 inches	0.28	322	644	106	212	60	120	41	82
WOCD present	0.23	326	712	114	228	63	126	43	86
Screen failed at <22 N (static)	0.16	451	902	140	280	75	150	50	100

The prevalence of exposure in control windows is drawn from results of our pilot study.
WOCD, window opening control device.

without a home visit, probably improving recruitment and retention. Unfortunately, screen failure testing cannot be conducted without a site visit.

The efficiency of future studies could also be increased by matching more in-home controls to each case window (in a 1:*n* design), rather than selecting a single in-home control. Similarly, once in a community control home, more than one window could be studied to incrementally increase the power of the design. Community control windows may be easier to find if requirements to match on age and gender were relaxed. In reviewing our results, neither age nor gender of the index child was related to any salient aspects of window design. Matching on these factors adds complexity to recruitment without obvious analytical benefit.

Our data suggest that horizontal slider windows are a risk factor for paediatric falls. Sill depth also appeared to be a risk factor, with deeper sills perhaps promoting sitting or standing in the window frame. That exterior height was a risk factor may simply represent a selection bias insofar as children who fall from lower windows may never present as cases. Alternatively, however, it may be that ground floor windows are kept locked for crime prevention while upper storey windows are open for ventilation.

Finally, although screen presence was not associated with fall risk in this series, the force required to dislodge a screen from the window frame was more likely to be below our paediatric threshold in case windows (and their in-home controls) compared with community control windows. Factors such as screen design, screen maintenance, screen fastener technology, and screen age should all be investigated in subsequent studies.

The main purposes of a pilot study are to assess and demonstrate feasibility (of recruitment, enrolment, and measurement protocol) and to obtain estimates of exposure prevalence in a control group. The latter can be used to estimate sample size requirements for a subsequent study by applying the smallest OR that one might want a study to detect.[11] As an example, table 5 presents a range of sample size estimates, assuming power=0.80 and α=0.05, for a study of cases and unmatched controls enrolled in a 1:2 ratio. With 150 case and 300 control windows, potentially modifiable features of window design (sill depth), behaviour around windows (functional sill height), and after-market safety modifications (WOCD and screen reinforcement) could be identified as targets for intervention if associated with an OR of 2.0 or greater.

LIMITATIONS

Our selection methods probably resulted in a sample of windows representative of those in the US Pacific Northwest from which children fall. However, the community control windows, which were more difficult to recruit, may not represent an unbiased sample of all windows to which children in our area are exposed. If the enrolled windows were somehow 'safer' than the typical community window, any differences noted in our analysis would be overstated. There is also regional variability in the age and style of the housing stock. These differences may limit the generalisability of our findings to other communities, although the main focus of this study was on the feasibility of our research procedures. In addition, our screen testing procedure was developed for this study and does not represent an established standard. Subsequent to our study, a standard describing window safety devices, their expected performance thresholds, and methods for measuring these parameters has been published.[12] While this standard suggests that safety screens should withstand forces well in excess of the tests we conducted, it is unreasonable to think the insect screens present in most homes would conform to safety screen specifications. It is also unclear that the testing methods described in the standard could be adapted for field use in a manner acceptable to homeowners.

What is already known on this subject

- Falls from windows are a common cause of paediatric injury morbidity.
- No controlled studies have been conducted to identify modifiable environmental factors associated with fall risk.

What this study adds

- It is feasible to study the design, placement, and maintenance of windows using a case–control design.
- Recruitment of out-of-home control windows is difficult but important to avoid over-matching.
- Risk factor prevalence in control windows can be used to estimate sample size requirements for a definitive study.

CONCLUSION

Falling from windows remains a recalcitrant injury problem in the paediatric population. Our findings suggest that risk factors related to window design and maintenance can be studied using a case–control methodology. Window type, height, sill depth, and screen performance should all be investigated in subsequent, larger studies covering major housing markets.

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Competing interests None.

Ethics approval This study was conducted with the approval of the Seattle Children's Hospital.

Contributors Conception and design: BJ, BE. Acquisition of data: DQ, JS, RP, HR. Analysis and interpretation of data: BJ, DQ, JS, RP. Drafting of the manuscript: BJ. Critical revision for important intellectual content: DQ, JS, RP, HR, BE. Data collection: DQ. HR funding: BE, BJ.

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Infant deaths associated with baby slings

A letter in the *Medical Journal of Australia* (Byard and Gilbert, *MJA* 2011;**195**:321) calls attention to a growing number of infants transported in 'slings' who have died. The letter was prompted by the death of a 2-day-old boy and points out that these devices may be unsafe because of excessive flexion of the neck or obstruction of the mouth and nose. The Australian Competition and Consumer Commission have recently issued warnings. Sixteen deaths attributed to the use of slings occurred in the USA and Canada, resulting in calls for mandatory standards by the USA.

Drunk sues driver

A man who was hit by a truck while 'larking about' in the middle of the road has sued the driver, claiming he (the driver) should have realised he was drunk and slowed down. The victim suffered breaks to both arms and his left leg when a truck reversed over him and dragged him while he was out with friends. Ed note: *Is this a new example of chutzpah?*

It's raining men: beware of balconing

Spanish authorities are warning travellers against the 'balconing' craze—jumping from hotel balconies into swimming pools. This behaviour has resulted in four deaths and left others seriously injured this summer. A report in *The Guardian* states '… hotel owners told the paper that balconing is increasingly popular among drunk guests, who often post videos of their jumps on YouTube and other websites. The number of such incidents is triple that of previous summers. "If you catch them, they say that they have lost their room key, but mostly they are trying to get to a girl's room or think they can jump down into the pool." '