A case-control study of risk factors for playground injuries among children in Kingston and area

David L Mowat, Feng Wang, William Pickett, Robert J Brison

Abstract

***Objective*—To determine the risk for injury associated with environmental hazards in public playgrounds.**

***Setting*—One hundred and seventeen playgrounds operated by municipalities or school boards in and around Kingston, Ontario, Canada.**

***Methods*—A regional surveillance database was used to identify children presenting to emergency departments who were injured on public playgrounds; each case was individually matched (by sex, age, and month of occurrence) with two controls—one non-playground injury control, and one child seen for non-injury emergency medical care. Exposure data were obtained from an audit of playgrounds conducted using Canadian and US safety guidelines. Exposure variables included the nature of playground hazards, number of hazards, frequency of play, and total family income. No difference in odds ratios (ORs) were found using the two sets of controls, which were therefore combined for subsequent analysis.**

***Results*—Multivariate analysis showed strong associations between injuries and the use of inappropriate surface materials under and around equipment (OR 21.0, 95% confidence interval (CI) 3.4 to 128.1), appropriate materials with insufficient depth (OR 18.2, 95% CI 3.3 to 99.9), and inadequate handrails or guardrails (OR 6.7, 95% CI 2.6 to 17.5).**

***Conclusion*—This study confirms the validity of guidelines for playground safety relating to the type and depth of surface materials and the provision of handrails and guardrails. Compliance with these guidelines is an important means of preventing injury in childhood.**

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Kingston, Frontenac and Lennox and Addington Health Unit and Department of Community Health and Epidemiology, Queen's University, Kingston, Ontario, Canada
D L Mowat
F Wang

Kingston, Frontenac and Lennox and Addington Health Unit and Department of Community Health and Epidemiology and Department of Emergency Medicine, Queen's University
W Pickett
R J Brison

Correspondence to:
Dr David Mowat, Kingston, Frontenac and Lennox and Addington Health Unit, 221 Portsmouth Avenue, Kingston, Ontario K7M 1V5, Canada.

Outdoor playgrounds are widely recognized as providing important opportunities for cognitive and motor development and the enhancement of communication and social skills. Children are safer playing in a playground than in many other settings, yet there is also evidence that playground equipment can be an important cause of childhood injury. Playground injuries account for only a small proportion of injuries to children. Yet they are important because they result in a greater proportion of fractures and hospital admissions than many other types of injury, and there are practical interventions available for their prevention.[1 2]

Risk factors for playground injuries include age less than 9 years,[2–4] and male sex,[5 6] though the relative contributions of susceptibility and exposure are not well understood. As might be expected, a higher incidence of playground injuries has been observed in warm weather seasons, and during daylight hours and wee kdays.[2 7–9]

Studies have suggested positive associations between factors such as aggressive behaviour, overactivity, and the occurrence of playground injuries.[5 10–13] In addition, low socioeconomic status and some social and family factors have been associated with the occurrence of childhood injuries in general.[14–16] It has also been demonstrated that adult supervision may be important in the prevention of injuries in playgrounds and other settings.[5 17]

Falls, onto the ground or other equipment, account for three quarters of playground injuries that receive medical attention.[2 4] Other mechanisms of injury include collisions with moving equipment or other children; contact with protruding bolts, pinch points, or sharp edges; and entrapment of the head or other body parts in equipment.[2]

In 1990, the Canadian Standards Association (CSA) developed guidelines for public playgrounds that include recommendations about the safe design, installation, and maintenance of playgrounds and equipment.[18] Some of the more important guidelines address the type of impact absorbing surfaces that surround equipment; handrails, or panel style barriers on steps and high platforms; entrapment hazards; accessible sharp edges; points or projections; and non-encroachment zones. The type and depth of the surfacing materials have been shown to have an effect on the severity of injuries resulting from falls.[19–21] While the CSA guidelines do not give requirements for the depth of surfacing materials, the US Consumer Product Safety Commission (CPSC) does recommend depths for surfacing materials beneath play equipment, depending upon the height of the equipment.[22]

A 1994 study in Kingston, Ontario showed that only 15.4% of 117 public playgrounds conformed to all CSA guidelines, and only 10.3% were in compliance both with all CSA guidelines and the CPSC standards for surfaces.[2] Similar results have been found in audits of public playgrounds in Boston, Atlanta, and Montreal.[19 23 24]

Our initial study had shown that there was a significant incidence of playground injuries in the Kingston area,[2] and of those that reached

emergency medical attention, 40% required follow up treatment or hospital admission. We therefore conducted a second study, the purpose of which was to explore associations between some environmental playground hazards and the occurrence of childhood injury.

Methods

SETTING

The Kingston, Frontenac and Lennox and Addington Health Unit covers an area of 6660 km^2 in south eastern Ontario and has a population of 166 330, of whom about 26% are aged 0–19 years. Eighty two per cent of the population lives in the urban area, the site of an academic health sciences centre.

STUDY DESIGN

A matched case-control design was employed. Cases were children aged 1–16 years living in the Kingston area of Ontario who were injured on a public playground and presented to either of the two hospital based emergency departments in Kingston during 1995. Cases were identified from the Kingston and Region Injury Surveillance Program (KRISP). KRISP is one site of the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP; Health Canada). Controls were children in the same age range living in Kingston who presented to one of the emergency departments, but who were not injured on public playgrounds. All cases and controls had to have used a public playground in the Kingston area in 1995 to be eligible.

Controls were of two types: the first consisted of children who presented for treatment of an injury that had not occurred on a playground; the second included children who presented for any type of non-injury emergency medical care. Injury controls were selected using KRISP data: of all injured children of matching age and sex presenting on the same day as a case (or, if none, the closest day), one was randomly selected. Non-injury controls were selected from logs of emergency records kept at the two hospitals. Each case was individually matched by age, sex, and day seen in the emergency department to one of each type of control. Two types of controls were employed because of the possibility that current playground injuries and other injuries were caused by the behavioural characteristics of some children. If this were true, different risk estimates might be obtained, depending upon which type of control was used.

Data concerning specific playground hazards were obtained from a complete safety audit of all playgrounds in public parks and schools in Kingston and two neighbouring townships conducted in the summer of 1995. This audit was conducted independently from the present case-control study. One hundred and seventeen playgrounds, 76 (65.0%) owned by municipalities and 41 (35.0%) by school boards, were inspected and compared with the CSA and CPSC standards. The audit results have been previously reported.[2]

A total of 85 potential cases were identified by KRISP, of which 59 were asked to participate in this study. Five cases were excluded because they did not provide permission to be contacted for research purposes on the KRISP form filled out in the emergency department, and 21 lived outside the audited area. Of the 59 that remained, 45 cases were recruited for study and were individually matched with one of each type of control.

Demographic variables for both cases and controls, and the time of injury for cases, were obtained from hospital charts. The primary exposure variables that were assessed in this study were environmental hazards on playgrounds, and these were identified from the safety audit. The identification of the playgrounds where the injury occurred (cases), or where the child usually played during the month they presented to the emergency department (controls), and family income were collected by means of a telephone interview conducted with a parent or guardian of each child.

Where a child used more than one playground, the playground in which the injury occurred was used for cases and the playground used most often for controls.

Data from the telephone questionnaire and the playground audits were coded and entered into a computerized database. Individual playground and equipment hazards from the playground audit were linked to each child in this database.

STATISTICAL ANALYSIS

Bivariate analyses were performed to quantify the strength and statistical significance of associations between each of the independent variables (potential environmental playground hazards) and case-control status. Conditional logistic regression was used to calculate the odds ratio (OR) and associated 95% confidence interval (CI) for cases relative to each control type separately. The two series of ORs were then compared and there were no substantial differences found in the size or direction of any of the risk estimates. The two control groups were therefore combined during subsequent analyses.

We used an exploratory approach to the conduct of our multivariate analysis. The intent of this modelling process was to explore and possibly rank the importance of potential environment risk factors for playground injuries. We considered variables for inclusion in our multivariate model if: (a) they were hypothesized, *a priori*, to be potential etiological factors; and (b) they were found to be statistically associated with the occurrence of playground injuries in bivariate analyses, using a conservative cut off value of $p<0.10$. Conditional logistic regression with forward, stepwise selection was employed. Variables were included in the final model if they were significantly ($p<0.05$) associated with the study outcome after simultaneously controlling for other risk factors considered in the modelling process.

Table 1 Results of playground audit

CSA standard	Description of standard	Compliance with standard	
		Playgrounds	% complying
	All CSA standards	18	15.4
8.1, 8.2	Surface (CSA only)	69	59.0
8.1, 8.2	Surface (CSA and USCPSC)	63	53.9
8.4	Non-encroachment zones	112	95.7
9.2, 9.3, 9.7	Sharp edges	74	63.2
9.3	Protruding hazards	109	93.2
9.4	Pinch points	103	88.0
9.6	Head entrapment	56	47.9
9.9, 9.12, 9.13	Fall hazards	71	60.7
9.8, 9.14, 9.15	Handrails and guardrails	84	71.8

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Note: n=117, only standards which apply to all playgrounds reported.

Table 2 Mechanism of playground injuries

	No (%)
Fall	36 (80.0)
Contact with rough edge	1 (2.2)
Body part entrapment	2 (4.4)
Collision with moving equipment	1 (2.2)
Hit against equipment	5 (11.1)
Total	45 (100.0)

Results

Children who sustained playground injuries (cases) had a mean (SD) age of 8.3 (2.2) years; 26 were male and 19 female. Nine, 14, 12, and 10 children were injured in the first to fourth quarters of the year, respectively. The more common failures to comply with standards are shown in table 1: it can be seen that there is a considerable risk of a fall onto an unsuitable surface. Table 2 shows that a large majority of the injuries sustained were indeed falls. Fractures were sustained in 35.6% of cases; the anatomical site of injury was the extremities in 55.6% of cases and the head in 31.1%.

Response rates among cases and controls are shown in table 3. Forty five cases were eligible and responded; controls were recruited until 45 of each type were identified and willing to participate. Cases and controls matched perfectly for age (±2 years), sex, and the quarter of the year when they were seen in the emergency department.

Crude (bivariate) and adjusted (multivariate) ORs for all of the exposures measured are shown in table 4. In the bivariate analysis a failure to meet CSA and/or CPSC guidelines was associated with an increased risk of injury. Eight or more hazards, inadequate handrails/guardrails, sharp edges, protrusion hazards, and school board operated playgrounds are also associated with a significantly increased risk of injury in the bivariate analysis. The final multivariate model for playground injuries included two variables: inadequate handrails and guardrails (OR 6.7; 95% CI 2.6 to 7.5), and surfacing materials not of the type recommended by CSA and CPSC (OR 21.0; 95% CI 3.4 to 128.1), or not of the CPSC recommended depth (OR 18.2; 95% CI 3.3 to 99.9). Other variables that were considered in the construction of this model included frequency of play, number of hazards, sharp edge hazards, and protrusion hazards.

Table 3 Response rates among cases and the two control groups; results are number (%)

No approached	Cases (n=59)	Control type 1 (injury) (n=61)	Control type 2 (non-injury) (n=68)
Could not be located	7 (11.9)	10 (16.4)	13 (19.1)
Refused to participate	5 (8.5)	2 (3.3)	2 (2.9)
Did not answer telephone	2 (3.4)	4 (6.6)	7 (10.3)
Did not speak English	0	0	1 (1.5)
Responded	45 (76.7)	45 (73.8)	45 (66.2)

Discussion

The type and depth of surface materials under and around play equipment, and the provision of handrails and guardrails on the high parts of equipment, are ranked as the characteristics most strongly associated with the occurrence of playground injuries. Both are related to the falls that constituted 80% of the injuries in the study. Only 59% of playgrounds met the requirements for the type of surface material, and 54% met requirements for both type and depth. The handrail and guardrail standard was met by 72% of playgrounds. These results are consistent with those from a recent study in New Zealand,[25] which found that falls from heights and inadequate impact absorbing surfaces were important risk factors for injury.

Sharp edges and protrusion hazards were also found to be associated with injuries in the bivariate analysis, but not in the multivariate analysis. Risks were seen in association with other hazards, such as non-encroachment zones and entrapment hazards, but this study lacked the statistical power to identify these associations with statistical significance.

Injuries were more common on school playgrounds than on those owned by municipalities. Though this might be a result of hazardous equipment in school playgrounds, it could also be caused by greater exposure (in terms of hours of play on each occasion) or a greater likelihood of referral for medical care.

No association of injuries with family income was found. The association with socioeconomic status reported in some studies[14 16] concerned childhood injuries in general rather than playground injuries specifically.

The results of this study may only be generalizable to injuries that present at emergency rooms. Differential recall for cases and control was unlikely as parents were asked to report only the name of the playground most frequently used, frequency of play, and total family income, and cases and controls were matched by time of recall. We also expect that changes in playground equipment during the case-control study period were minimal.

Implications for prevention

Because we observed many similarities in the ORs for cases relative to the two control groups, we hypothesize that environmental hazards are more important than behavioural differences in the causation of playground injuries. It is also possible that more active children may be at greater risk on more hazardous equipment.

Another study that explicitly sets out to address this issue is needed to confirm this

Table 4 ORs for injury for selected playground hazards and other risk factors

Variables	Cases (n=45)	Controls (n=90)	Bivariate analysis Crude OR	95% CI	Multivariate analysis† Adjusted OR	95% CI
Surface materials						
Met both CPSC and CSA standards	2	36	1.0*		1.0*	
Met CSA but not CPSC standard	24	33	11.0	2.5 to 48.6	18.2	3.3 to 99.9
Did not meet either standard	19	21	14.9	3.1 to 70.8	21.0	3.4 to 128.1
Inadequate handrails/guardrails						
No	12	66	1.0*		1.0*	
Yes	33	24	4.8	2.3 to 10.0	6.7	2.6 to 17.5
Frequency of play						
1–2 times a month	1	8	1.0*			
1–3 times a week	8	27	2.2	0.2 to 19.6		
4–7 times a week	36	55	4.8	0.6 to 39.1		
No of hazards identified						
0–3	7	34	1.0*			
4–7	15	35	1.9	0.7 to 5.5		
8–11	16	15	4.3	1.4 to 13.3		
12+	9	6	6.7	1.8 to 25.6		
Sharp edges identified						
No	13	47	1.0*			
Yes	32	43	3.0	1.3 to 7.2		
Protrusion hazards identified						
No	36	86	1.0*			
Yes	9	4	5.5	1.5 to 20.7		
Non-encroachment zone met CSA standards						
No	41	87	1.0*			
Yes	4	3	3.4	0.6 to 18.9		
Entrapment hazards						
No	22	52	1.0*			
Yes	23	38	1.4	0.7 to 2.8		
Pinch points identified						
No	40	86	1.0*			
Yes	5	4	2.5	0.7 to 9.3		
Operator of playground						
Municipality	2	37	1.0*			
School board	43	53	12.4	2.9 to 53.3		
Total family income (C$)‡						
0–19 999	11	16	1.0*			
20–39 999	6	27	0.3	0.1 to 1.0		
40–59 999	8	18	0.6	0.2 to 1.7		
60 000	14	18	1.2	0.4 to 3.6		

*Reference category.
†By conditional logistic regression (forward stepwise selection,) controlling for matching factors and considering frequency of play, number of hazards, surface materials, inadequate handrails and guardrails, sharp edges, and protrusions.
‡Six missing values in cases, 10 in controls.

idea, however. The study demonstrates that the number and type of playground hazards are related to the risk of injury. The choice of appropriate materials for the surface under and around equipment, and the provision of handrails and guardrails according to CSA guidelines, will reduce the risk of injury. Validation of other CSA standards will require a larger study. Most importantly, the study indicates the potential value of upgrading playgrounds to CSA guidelines in reducing significant injuries to children and the desirability of adding to the CSA requirements a standard concerning depth of surface material, such as that used by the CPSC in the US.

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PLAYING WITH HORSES.

Horses are very dangerous, but most useful animals. To be kicked by them is almost certain death: and children often play about them and go near their heels without being sensible of their danger. In the engraving we see a little innocent who had been engaged in gathering locks of fresh grass and giving them to her papa's horse. After employing herself in this way for some time, she uncautiously took hold of his tail, unconscious of the danger that she was in, until the horse, by a kick of one leg, laid her lifeless on the ground.

From *The Book of Accidents; Designed for Young Children*, New Haven, 1830.