

The role of proximal circumstances and child behaviour in toddlers' risk for minor unintentional injuries

Jennifer Kuhn, Amy Damashek

Department of Psychology,
Western Michigan University,
Kalamazoo, Michigan, USA

Correspondence to

Jennifer Kuhn, Department of Psychology, Western Michigan University, 3700 Wood Hall, Kalamazoo, MI 49008, USA; jennifer.t.kuhn@wmich.edu

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ABSTRACT

Background Much of the research on child injury risk has focused on trait-like factors (eg, hyperactivity, child gender) that influence injury risk rather than state-like factors (eg, environmental circumstances, child behaviour). Additional research is needed to better identify the proximal risk factors for children's risk for unintentional injury.

Objectives The present study examined the antecedents to minor unintentional injury events and whether unusual circumstances and child behaviour predicted injury risk.

Methods The study used archival data that were collected via biweekly in-person interviews with 170 mothers of toddlers (15–36 months) for 6 months. A case crossover design was used to predict children's risk for injury from proximal risk factors.

Results Children were at a higher risk for injury when circumstances were unusual and when they were engaging in an unusual behaviour. When a child was engaging in an unusual behaviour, higher levels of maternal supervision predicted lower injury risk. Children were more likely to be injured in a new environment, in an environment with animals or other people, in an environment with hazards or when engaging in a new activity or in a familiar activity performed in an unfamiliar way.

Conclusions The results indicate that toddlers may be at a greater risk for minor unintentional injury when environmental circumstances are outside of the norm or when a child is engaging in unusual behaviours. The findings also indicate that higher levels of caregiver supervision may be especially beneficial when children are engaging in new or unfamiliar activities.

INTRODUCTION

Unintentional injuries are the leading cause of death for children between the ages of 0 and 19 in the USA and result in 9.2 million emergency room visits yearly.¹ The negative effects of unintentional injuries on children's well-being have led researchers to examine child, family and environmental risk factors for unintentional injuries.^{2–5}

In Haddon's matrix of injury occurrences, there are four contributing factors to an injury event: host factors (eg, child characteristics), the agent of injury (eg, falling down stairs), the physical environment (eg, hazard such as no baby gate on stairs) and the social environment (eg, maternal supervision).⁶ With regards to child characteristics, much of the research on risk for unintentional child injury has focused on trait-like factors (eg, child temperament) that influence injury risk rather than

proximal or state-like factors (eg, child behaviours).^{7–11} Trait-like factors are typically measured through one-time self-report measures, whereas state-like factors are measured immediately prior to an event of interest (eg, an injury). Although examining trait-like factors provides valuable information, it does not explain what specific circumstances or behaviours immediately precede injury events. Research on proximal antecedents to injuries (eg, children's behaviour, environmental circumstances) would allow behavioural scientists to develop focused interventions to address maladaptive behaviours or hazardous circumstances that might increase children's injury risk.

Morrongiello and colleagues¹² published research that helped shed light on the role of proximal child behaviours and environmental circumstances to children's injury risk in farm settings. They examined the interaction between unexpected behaviours (eg, standing on a tractor), unexpected environmental events (eg, barn collapsed) and high-risk or low-risk situations.¹² For children younger than 6, unexpected behaviour was more likely to lead to injury in high-risk environments. In another study investigating the role of supervision in the prevention of unintentional injuries on farms,¹³ Morrongiello and colleagues found that injuries occurred at a high rate even in the presence of adequate adult supervision, suggesting that supervision is not as protective as expected in unusual environments. Limitations of both studies, however, are the retrospective design and the specificity of the environment in which injuries were examined (ie, farms). It is important to examine such child behaviours and events in other environments.

The purpose of the present study was to build on the findings of Morrongiello and colleagues^{12 13} using a case crossover design (which was not used in the studies discussed above) in a non-farm setting. The case crossover design is best used for events with an acute onset in which risk is immediate and transient in nature.^{14 15} In this type of design, an event of interest (eg, an injury) is matched by time to a control condition (eg, a non-injury) for the same participant. This design is an effective way to examine proximal antecedents to injury events because subjects serve as their own control, thereby controlling for between-subject differences.^{14 15}

The present study used proximal measures of child and maternal behaviour and environmental circumstances to determine (1) whether proximal changes in children's environmental circumstances



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and behaviour increased risk for minor unintentional injury, (2) whether maternal supervision interacted with children's environmental circumstances and behaviour to predict injury risk and (3) which unusual environmental circumstances and child behaviours were more common during injury versus non-injury events. Based on previous research, we hypothesised that injury risk would increase following unusual environmental circumstances and child behaviours and that supervision would be less protective for children in unusual environments and when children engaged in unusual behaviours.

METHODS

Participants

Data for the present study were taken from a larger study investigating minor unintentional childhood injuries.¹⁶ Participants included 170 mothers with singleton toddlers who were recruited in a mid-sized Midwestern community through flyers, advertisements and phone calls. Families were not eligible to participate if they had more than one child at home to ensure that mothers' injury prevention practices did not differ based on their child's birth order. Families were also excluded if their child had a developmental disability or had been hospitalised overnight because these factors may have influenced mothers' safety behaviours. Lastly, families were excluded if English was not the mother's primary language to ensure that the mothers could easily participate in the interviews. Child participants were 54% boys and 46% girls between the ages of 15 and 36 months ($M=24$, $SD=7$). Mothers were primarily Caucasian (91%), in their mid-to-late twenties ($M=28.8$, $SD=4.43$), married (83%), college educated (80%) and earned more than \$30 000 annually (78%).

Procedure

The study was approved by the university's Institutional Review Board. Mothers collected data on their children's minor unintentional injuries by monitoring and recording information regarding the antecedents (eg, child behaviour, environment, maternal supervision) and consequences (eg, injury severity) of their child's injuries as they occurred. Mothers were interviewed by trained bachelor-level research assistants biweekly over a 6-month period using a 2 h structured interview and reported the injury events that occurred over the 2-week period. Mothers reported on all injury and control events. If they were not the supervisor at the time of the injury or control events, they gathered detailed information from the person supervising their child during injury or control condition times. Mothers were supervisors in the majority of cases (71.4%). Fathers were supervisors in 14.5% of cases, daycare providers, babysitters or teachers were supervisors in 7.6% of cases and others supervised (eg, sibling, adult male relation) in 6.5% of cases. Unintentional injuries were defined as injuries that occurred after an unintentional event that left a mark (eg, cut) or caused pain or discomfort (eg, muscle strain) for at least 24 h. The study focused on minor injuries because severe injuries are a low base rate event. Moreover, minor injuries have been found to predict children's risk for medically attended injuries.¹⁷

A case crossover design was used. In this design, a within-subjects method is used and event and control conditions are collected for each participant.^{14 15} For control conditions, mothers were asked to record their and their child's activities preceding predetermined non-injury events. These times were determined by matching them to a day and time during which a previous injury had occurred. For example, if a child had an injury on Monday at 10:00, the mother would record the child's activity

and the surrounding circumstances the next Monday at 10:00. This design allowed us to compare antecedents to injury and non-injury events and examine proximal risk factors for injury.

Measures

Caregiver supervision levels

For each injury and non-injury event, mothers were asked to describe what the caregiver was doing at the time of the injury or control event, whether or not the caregiver was engaged in an activity with the child and the distance the caregiver was from the child. Supervision level was then coded on a seven-point Likert scale in which '7' was the highest and '1' was the lowest level of supervision (see [box 1](#)). Average pairwise coding reliability for coders was high ($r=0.9$).

Environmental circumstances

To examine the child's environment prior to an injury or during a control condition (ie, non-injury), mothers were asked the following question, 'Was the situation or were the circumstances unusual or pretty typical for your child?' If mothers responded that the circumstances were unusual, they were then asked, 'What made the circumstances unusual?' These answers were then coded into six categories by trained coders (see [table 1](#)).

For the question regarding whether or not the circumstances were unusual, average reliability for the two coders was acceptable ($\kappa=0.80$, $n=104$). For the question regarding what made the circumstances unusual, κ was 1.0. However, the sample size for these reliability analyses was very small ($n=12$).

Child behaviour

Mothers reported on their child's behaviour at the time of the injury or control condition. Mothers were asked the following question, 'Was your child's behaviour unusual or pretty typical of your child?' If they indicated that their child's behaviour was unusual, they were asked, 'What made the behaviour unusual?' Answers to this question were coded by trained research assistants (see [table 1](#)). For the item regarding whether or not the behaviour was unusual, average κ was 0.78 ($n=104$).

Plan of analysis

To examine aims 1 and 2, we used conditional logistic regression. This type of analysis is appropriate for analysing data in a case crossover design because it takes into account the matching

Box 1 Scale used to code caregiver supervision

- 7 = caregiver and child are less than 6 feet apart (caregiver not engaged in other activity).
- 6 = caregiver and child are less than 6 feet apart (caregiver engaged in another activity).
- 5 = caregiver and child are greater than 6 feet apart (child has caregiver's full attention).
- 4 = caregiver and child are greater than 6 feet apart (caregiver not paying attention).
- 3 = caregiver and child are greater than 6 feet apart (no visual contact but is auditory contact).
- 2 = no visual or auditory contact (caregiver could reach the child in 30 s).
- 1 = no visual or auditory contact (caregiver could not reach the child in 30 s).

Table 1 Unusual circumstance codes and unusual behaviour codes by injury and no injury

	No injury (n)	Injury (n)
Unusual circumstances		
New environment	18.53% (73)	29.19% (115)
People/animals	8.63% (34)	15.23% (60)
Stationary/mobile environmental hazard	1.27% (5)	8.38% (33)
Weather	3.05% (12)	3.55% (14)
Time of day	3.30% (13)	2.79% (11)
Other (usually adult present but not this time, hazard from something child has on or with him/her)	1.02% (4)	5.08% (20)
Total	35.79% (141)	64.21% (253)
Unusual behaviour		
An unfamiliar activity	18.84% (26)	45.65% (63)
An activity done in an unfamiliar way	5.07% (7)	30.43% (42)
Total	23.91% (33)	76.09% (105)

Table includes unusual behaviours (n=138) and unusual circumstances (n=394) and does not include typical circumstances or behaviours. All information reflects matched injury and non-injury data.

between injury and non-injury events. Since the case crossover design automatically controls for between-subject variability such as age and gender, we did not control for these variables. To examine aim 1, we first tested a model that included the two variables that indicated whether or not the circumstances and the child's behaviour were unusual. Next, to investigate aim 2, we examined one model that included the interaction of unusual circumstances and maternal supervision and another model that examined the interaction of unusual child behaviour and maternal supervision. These models were examined separately because conditional logistic regression analyses may become biased with a large number of predictor variables.¹⁸ Finally, for aim 3, we used χ^2 analyses to examine which behaviours and circumstances were more common during injury events versus non-injury events.

Prior to data analyses, any injuries that were identified by mothers as intentional were deleted from the dataset (4.5% of the total number of injuries). The distribution of the supervision variable was skewed so that it was coded as a '3' or higher in 99% of cases (supervision codes 3 through 7). Thus, cases in which supervision was coded as less than 3 were omitted from the analyses. We excluded events in which the child was sleeping (3.4% of injury and control events). Lastly, we deleted 10 families who were outliers in terms of injury frequency. Following these exclusions, there were 1202 injury events that were matched to 1202 control conditions, resulting in a total of 2404 observations.

RESULTS

Descriptive data

The mean number of minor injuries for all children in the study was 2.4 (SD=1.5, range 0–8.3) per 2-week period. Boys had a slightly higher biweekly injury rate (M=2.6, SD=2.3) than girls (M=2.1, SD=1.8; $t(168)=2.2$, $p=0.03$). Child age was not associated with number of injuries ($r=-0.03$, $p=0.7$). Overall mean caregiver supervision was relatively high (M=5.8, SD=1.29, range 1–7). Mothers indicated that circumstances preceding injury and non-injury events were unusual on 18.5% (n=443) of occasions. Mothers rated behaviours as unusual in 5.8% (n=139) of injury and non-injury events.

Results of a χ^2 analysis indicated that children were more likely to be in an unusual circumstance prior to an injury event versus a non-injury event ($\chi^2(1, n=2399)=46.1$, $p<0.0001$). Moreover, children were more likely to be engaged in an unusual behaviour prior to injury event than a non-injury event ($\chi^2(1, n=2401)=38.1$, $p<0.0001$). Unusual behaviours were slightly more likely to occur during a typical circumstance rather than an unusual circumstance ($\chi^2(1, n=77)=67.2$, $p<0.0001$).

Examination of study aims

Aim 1

Conditional logistic regression analyses were conducted to determine whether unusual circumstances and child behaviour increased children's risk for injury. As seen in table 2, model 1, children were at a higher risk for injury when they were in an unusual circumstance and when they were engaging in an unusual behaviour. Children were nearly two times as likely to be injured when they were in an unusual circumstance and were nearly three times as likely to be injured when they were engaging in an unusual behaviour.

Aim 2

Conditional logistic regression was used to examine whether supervision interacted with children's proximal circumstances and behaviour to predict injury risk. The supervision variable was centred prior to constructing interaction terms. Results can be seen in table 2 in models 2 and 3. In the model examining the interaction between circumstances and maternal supervision, the interaction term was not significant. There was a main effect for maternal supervision such that children were at a lower risk of injury when supervision was higher. The model examining the interaction between child behaviour and supervision (model 3, table 2) indicated that the interaction was significant. We investigated this interaction by examining the main effect of supervision at both values of the behaviour variable (typical vs unusual). The main effect of supervision for both typical and unusual child behaviour was negative such that higher supervision predicted lower injury risk; however, the effect was

Table 2 Conditional logistic regression model predicting children's injury risk from child behaviour and environmental circumstances

Variable	Model 1 OR (95% CI; n=2398)	Model 2 OR (95% CI; n=2399)	Model 3 OR (95% CI; n=2401)
Unusual circumstances (y/n)	1.9*** (1.5 to 2.4)	2.1*** (1.6 to 2.6)	–
Unusual child behaviour (y/n)	3.0*** (1.9 to 4.5)	–	3.7*** (2.3 to 6.1)
Supervision	–	0.8*** (0.8 to 0.9)	0.8*** (0.8 to 0.9)
Unusual circumstances*supervision	–	0.9 (0.8 to 1.2)	–
Unusual child behaviour*supervision	–	–	0.6* (0.3 to 1.0)

* $p<0.05$. ** $p<0.01$. *** $p<0.001$. For unusual circumstances and unusual child behaviour, 0='no' and 1='yes'. For injury risk, 0=control condition (non-injury event) and 1=injury event. Variables not entered in the model are marked as '–'. The reference category is 0.

stronger when the child's behaviour was unusual (OR=0.5, 95% CI 0.3, 0.9, $p=0.007$) than when the child's behaviour was typical (OR=0.8, 95% CI 0.8, 0.9, $p<0.0001$).

Aim 3

χ^2 analyses were conducted to examine which unusual circumstances and child behaviours occurred more commonly during matched injury versus non-injury events. The percentages are reported in [table 1](#). Results indicated that children were more likely to experience an injury versus a non-injury event (χ^2 (5, $n=394$)=17.8, $p=0.003$) when they were in the following circumstances: a new environment (eg, at a new house), people or animals were in the environment (eg, a party) or stationary or mobile hazards were in the environment (eg, the ground was wet). Results also indicated that children were more likely to experience an injury versus a non-injury event (χ^2 (1, $n=138$)=3.9, $p=0.05$) when they were engaging in the following behaviours: performing an unfamiliar activity (eg, using a new slide, riding a bike for the first time) or performing a familiar activity that was done in an unfamiliar way (eg, sliding off the chair backwards rather than sliding off the chair feet first). Additionally, mothers frequently noted that children's unusual behaviour included having a tantrum or being non-compliant with caregiver directives.

DISCUSSION

Previous studies have examined the effects of trait-like child, caregiver and environmental factors rather than state-like factors in children's risk for unintentional injury.^{7–11} While these studies have proven to be helpful in understanding factors related to children's unintentional injury risk, examining state-like factors that immediately precede an injury is important to finding effective methods of preventing unintentional child injuries. The present study examined the effects of proximal environmental circumstances and child behaviours on children's risk for minor unintentional injuries.

We found that children were at a higher risk for injury when the environmental circumstances and child behaviour was unusual. This is consistent with findings from Morrongiello and colleagues¹² who reported that unusual events and behaviours put younger children at a higher risk of sustaining an injury. Specifically, we found that children were more likely to experience an injury event when they were in a new environment (eg, at a new park), when there were people or animals in the environment or when there were stationary or mobile hazards in the environment (eg, the cement was wet). Children were also more likely to be injured when engaging in a new or unfamiliar behaviour (eg, using a swing for the first time, having a tantrum when this behaviour is unusual for that child).

Based on previous research,¹³ we hypothesised that supervision would be less effective at preventing injuries when children were engaged in unusual behaviours; however, our results indicated that supervision was more protective when children were engaging in unusual behaviours. Many of the instances in which mothers indicated that their children's behaviour was unusual were instances of defiance or tantrums (eg, not listening to babysitter's instructions, having a tantrum because he or she was tired) or were instances in which children were trying new, developmentally normal activities for the first time (eg, riding a bike for the first time). Our results regarding the role of supervision may have differed from Morrongiello and colleagues' findings based on farm injuries because circumstances on a farm are likely to be more hazardous than in other settings and perhaps

supervision can only be so effective when there are significant hazards in the environment.¹³

The present findings suggest that state-like proximal externalising behaviours may put children at greater risk for injury, even for children who exhibit externalising behaviour on a less frequent basis, and that closer supervision is protective for these less frequent instances. These findings are consistent with literature indicating that children with consistent patterns of disruptive behaviour are at higher risk for injury and that closer supervision can mitigate injury risk for these children.^{9–19} The finding that children were more likely to get injured when they were engaging in new yet developmentally typical activities may suggest that children are at higher risk for injury when they are on the verge of developing a new physical skill. The fact that supervision was protective in these instances highlights a challenge for parents since it is often difficult to predict when children are about to stretch the limits of their physical mobility. Although some have argued that risky play is adaptive,²⁰ parents must balance children's need for exploration with their need for safety; thus, close supervision is particularly important when children are engaging in behaviour that pushes the limits of their physical abilities.

Strengths and limitations

One of the strengths of this study is the use of the case crossover design. This methodology is useful in examining state-like risk factors for acute events, such as injuries. This methodology will be important to use in future studies examining risk for children's unintentional injury. Another strength is the richness of the data about circumstances preceding unintentional child injuries. Such data are difficult to obtain since injuries are a low base-rate phenomena.

There were also some limitations to the study. First, we relied on mothers' self-report of injuries. It is possible that mothers' self-reports may be inflated due to social desirability bias. We did not measure social desirability bias; however, if there were a bias, we would expect that mothers might over-report the level of supervision provided and that the actual effect of mothers' supervision on children's injury risk might be stronger than our ORs currently indicate. Therefore, it will be important in future studies to gather observational data. Second, due to the demographic characteristics of the sample, children in the study were at relatively low risk for injury compared with more ethnically diverse children from lower-income families.^{21–22} It is important to include families that are at a higher risk for injury (eg, single-parent households, lower SES families) in future studies in order to work towards preventing injuries in these at-risk populations. Third, mothers rated few circumstances and behaviours as unusual; thus, our sample size was somewhat limited. A larger sample size in future studies may provide more instances of unusual circumstances or behaviours. Last, the injuries in our sample were mostly minor in severity. It is difficult to collect data surrounding medically attended injuries since they are a low base-rate phenomenon. However, research has shown that minor injuries are a good proxy for studying major injuries.¹⁷

CONCLUSIONS

Our finding that children are more likely to be injured during unusual circumstances or while engaging in unusual behaviours highlights the importance of training parents to be especially vigilant when children are in new environments and while engaging in new behaviours. Furthermore, given that children's unusual behaviours may be somewhat challenging to predict, it may be useful to provide caregiver training that would include

teaching caregivers to closely supervise young children as frequently as possible and to safety proof the home environment. Unfortunately, it is not possible to prevent all childhood unintentional injuries because many injuries occur within the context of normal physical, social and emotional development. Thus, it is important to also train caregivers to understand what is developmentally appropriate, to monitor risk taking and to balance supervision with allowance for children to engage in exploratory activities.

What is already known on the subject?

- ▶ Unintentional injuries are the leading cause of death for children between the ages of 0 and 19 in the USA.
- ▶ Research has examined unintentional injuries in a high-risk environment (eg, farms) and found that unexpected behaviours were more likely to lead to injury and that the role of supervision was not as protective in unusual environments.
- ▶ Several studies have found that maternal supervision protects young children from unintentional injury.

What this study adds?

- ▶ This study found that proximal child behaviour and environmental circumstances play a role in toddlers' risk for minor unintentional injury.
- ▶ Children were more likely to be injured in an unusual circumstance (eg, new environment) or when they were engaged in a new behaviour (eg, sliding down a slide for the first time).
- ▶ Caregiver supervision was found to be particularly protective for children engaging in unusual behaviours, highlighting the importance of parents being especially vigilant during these times.

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Australian football is main hospitalised sports injury

A report from the Australian Institute of Health and Welfare (AIHW) shows that injuries sustained in football (Australian rules variety) comprise the largest proportion (one-third) of sports-related injuries requiring hospitalisation in Australia. Motor and water sports followed. Source: AIHW: Kreisfeld R, Harrison JE, Pointer S. *Australian sports injury hospitalisations* 2011–12. 2014. Injury research and statistics series no. 92. Cat. no. INJCAT 168. Canberra: AIHW.