Assessing Injuries with Proxies: Implications for Understanding Concurrent Relations and Behavioral Antecedents of Pediatric Injuries

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Objective   To examine the implications of using proxies of medically attended injuries (minor injuries and close calls) for understanding concurrent relations among—and behavioral antecedents of—pediatric injuries. **Methods**   Participants were 812 children from the NICHD Study of Early Child Care. Measures of externalizing behavior, maternal depression, SES, and the home environment were examined as prospective predictors of minor injuries, close calls, and medically attended injuries.   **Results**   Minor injuries and close calls were associated with medically attended injuries concurrently. Regression equations revealed different prospective predictors across the three outcome variables.   **Conclusions**   This study was the first to examine concurrent associations among minor injuries, close calls, and medically attended injuries. Prospective antecedents of each injury assessment were also examined. The present findings signify the importance of distinguishing between these different methods of assessing pediatric injury. The study also illustrated that different analytic strategies were needed to represent observed data of each outcome variable.

Key words   injury; injury proxies; count outcomes.

Injuries pose a significant threat to the health of children (Peterson & Brown, 1994; U.S. Department of Health and Human Services, 2000), accounting for more deaths in the United States than any other cause (e.g., Martin et al., 2008). Injuries are difficult to study on the individual level because of a variety of methodological and ethical issues with observing injury risk behavior (Peterson & Brown, 1994; Peterson, Saldana, & Heiblum, 1996). Therefore, many researchers utilize proxies of severe injuries, such as minor injuries or ''close calls'' (e.g., Damashek et al., 2005; Morrongiello, 1997). However, the extent to which assessments of medically attended injuries and various proxies can be used interchangeably is not well established. The purpose of the present study was to examine the extent to which children's minor injuries and close calls are related with medically attended injuries. Antecedents of each injury variable were also examined. An additional overarching goal of the current study was to explore statistical methodologies appropriate for count outcomes with different distributions (Karazsia & van Dulmen, 2008).

Methodological ''Problems'' with Injury Outcomes

For decades, scholars stressed the importance of identifying behavioral antecedents of children's injuries (Peterson et al., 1996; Scheidt, 1988), though doing so is difficult for several reasons. Childhood injuries are highly reactive (Peterson et al., 1996). That is, they occur less often in the context of supervision (Schwebel, 2006), which makes them difficult to observe directly. Even if injuries could be observed in natural environments, there are obvious ethical problems with doing so without implementing prevention efforts (e.g., Peterson et al., 1996).

Furthermore, injury data present a host of ''problems'' from a statistical standpoint. The most common approach to measuring injury risk is to sum the number of injury events that occur during a specified time period. At the individual level, severe injurious experiences are a low base rate phenomenon (Peterson et al., 1996), which leads to low variability and highly skewed distributions (Karazsia & van Dulmen, 2008). These characteristics present problems because (a) variability is necessary to demonstrate meaningful relations among variables (Cohen, Cohen,

West, & Aiken, 2003) and (b) highly skewed distributions violate assumptions of common statistical techniques, which often leads to inaccurate results (Hammer & Landau, 1981; Gardner, Mulvey, & Shaw, 1995).

Common analytic methods to overcome these problems include dichotomizing data into two groups (i.e., those injured versus not injured) or transforming the data (e.g., Johnson & Wichern, 1998), although it may be more appropriate to use regression techniques designed specifically for count outcomes. In an analysis of medically attended injuries that occurred when children were in the second through sixth grades, Karazsia and van Dulmen (2008) demonstrated that a zero-inflated Poisson (ZIP) model provided the best fit of observed injury data, compared to Ordinary Least Squares, Poisson, negative binomial, and zero-inflated negative binomial models (ZINB).[1]

Injury Proxies

Injury researchers also rely on alternative assessment methods, or proxies, to overcome the aforementioned problems. When proxies are utilized, it is assumed that they adequately represent the phenomenon of interest, in this case severe injury (e.g., Damashek et al., 2005). Multiple proxies of medically attended injuries exist in the literature, including counting the number of minor injuries and close calls. An attractive feature of these proxies is that they occur at a higher frequency than severe injuries. Therefore, different analytic strategies may be required to model the different distributions appropriately. To our knowledge, this issue has never been explored empirically, and thus one goal of this paper was to explore statistical techniques that may be useful for these outcomes.

Assessing minor injuries is a common practice established by Peterson and colleagues (Peterson & Brown, 1994; Peterson et al., 1996). Minor injuries are an attractive proxy of medically attended injuries because they have higher base rates, although research on the extent to which they are related with medically attended injuries is mixed. For example, Morrongiello, Ondejko, and Littlejohn (2004) reported that minor injuries correlated positively with retrospective reports of more severe injuries, while Schwebel, Binder, and Plumert (2002) reported no significant relationship between minor injuries and retrospective reports of medically attended injuries. To our knowledge, no studies have investigated the

extent to which minor injuries are associated concurrently with medically attended injuries.

Another common practice is to assess injury-related outcomes, such as close calls. These events are usually operationalized as situations during which the threat of injury was evident, but the injury vector did not contact the individual. In other words, during a close call event, a child could have been injured but was not. Close calls, like minor injuries, are also assumed to be a useful proxy of more serious injury events (e.g., Cobb, Cairns, Miles, & Cairns, 1995; Morrongiello, 1997), though to our knowledge there is no empirical data to support this notion.

Potential Problems with Injury Proxies

Conceptually, it has been argued that medically attended or severe injuries may not measure the same underlying phenomena as various proxies for two reasons (Peterson & Brown, 1994; Peterson et al., 1996). First, while injuries tend to occur to children who are exposed repeatedly to increasing risk (e.g., Speltz, Gonzales, Sulzbacher, & Quan, 1990), many injuries are isolated events that occur to children who are not typically exposed to risky situations. Peterson and Brown (1994) illustrated this point with an example: a child who never swims in a family pool alone drowns during an infrequent lapse in supervision while the caregiver answers the front door. Isolated events such as these likely have different antecedents than injuries resulting from gradually escalating patterns of risk (Peterson & Brown, 1994).

A second potential problem with injury proxies is the ''positive feedback loop'' (Peterson & Brown, 1994, p. 309). Injury risk behaviors resulting in either no injury or a minor injury produce little pain or anxiety relative to severe injuries. Given that injury severity is related to children's intentions to engage in future risk-taking behaviors (Morrongiello, 1997), minor injury occurrences may actually lead to increases in future risky behaviors. Therefore, unique patterns of antecedents and consequences may operate across severe injuries and proxies, thus calling to question the adequacy of injury proxies in research that seeks to identify underlying processes of severe injury outcomes.

To date, there is little information concerning the extent to which different injury assessments can be used interchangeably because few studies have considered multiple indices of injury in the same study. When they have, differences across dependent variables typically emerged. For example, in a prospective examination of adolescent injuries, different predictors emerged for medically attended injuries (i.e., aggression and child sex) versus close calls (i.e., aggression and race;

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[1]For a thorough description of these and other regression models, including mathematical equations, please consult Long and Freese (2006).

Cobb et al., 1995). Similarly, Morrongiello (1997) assessed minor injuries and close calls among children aged 6, 8, and 10 years. Several differences across each proxy emerged, including differences with respect to bystanders of the event, type of injury that resulted (or could have resulted), the extent to which children learned from the experiences, and the extent to which boys reported the event to parents (Morrongiello, 1997). In other areas of research, differences across injury proxies are also found consistently (e.g., Deffenbacher, Richards, Filetti, & Lynch, 2005; Rizzo, Reinach, McGehee, & Dawson, 1997), which has led some researchers to conclude that each outcome variable may possess ''unique antecedents and thus may require different explanations'' (Morrow & Crum, 2004; p. 66).

The Present Study

The purpose of the present study was to examine the concurrent associations between children's medically attended injuries and two proxies, minor injuries and close calls, which occurred when children were in the fourth through sixth grades (middle to late childhood). Given the documented relationships among injury proxies and retrospective reports of medically attended injuries (e.g., Morrongiello, 1997), we hypothesized that minor injuries and close calls would each have positive concurrent relations with the number of medically attended injuries that children experienced. We also hypothesized that the relationship between close calls and minor injuries would be positive, such that children who experienced greater numbers of close calls would also experience more minor injuries. Second, using a prospective design, we examined the influence of various injury risk factors on minor injuries, close calls, and medically attended injuries (see hypothesized model below). Based on previous research that reported differences between proxies and medically attended injuries (e.g., Cobb et al., 1995; Morrongiello, 1997), we expected differences across injury assessments to emerge. However, due to the lack of previous research that examined antecedents of multiple injury assessments, no specific hypotheses were made in this regard. We also explored different analytic strategies for each count outcome (Karazsia & van Dulmen, 2008).

Hypothesized Model

Selection of independent variables was based on well-accepted conceptual models that consider various child, caregiver, and contextual risk factors of children's injuries (Morrongiello, 2005; Peterson & Brown, 1994; Schwebel & Brezausek, 2007). Among child-based variables, child sex and child behavior were hypothesized to predict injury outcomes prospectively, as both of these variables have received substantial support as risk factors of injuries. Boys experience up to four times as many non-fatal injuries than their female counterparts (e.g., Morrongiello & Hogg, 2004). In terms of child behavior patterns, children who display more frequent externalizing behavior problems are at an increased risk of injury (e.g., Schwebel & Gaines, 2007). Conceptual paradigms suggest that many caregiver variables are interrelated and exert similar influences through decreases in quality and quantity of supervision and discipline practices (cf. Peterson & Brown, 1994). In the present study, mothers' age at the time of birth (Peterson & Brown, 1994) and maternal depression (e.g., Schwebel & Brezausek, 2008) were examined. We hypothesized that children of mothers who were younger at the time of birth and who reported more symptoms of depression would be at an increased risk of injury. An estimate of socioeconomic status (SES) and an assessment of the safety of children's home environments were also included in this examination (e.g., Schwebel & Brezausek, 2007). It was hypothesized that children in families with lower SES backgrounds and in less safe home environments would incur more injuries.

Methods
Participants

This study is based on data from the NICHD Study of Early Child Care (see NICHD Early Child Care Research Network, 2000 for complete study description). Children and their families were recruited at birth from 10 hospitals across the United States, and they were followed through the first 15 years of the target child's life. For the present analyses, variables assessed when the children were in the third grade (Time 1) were examined as predictors of injurious events that occurred from the fourth through sixth grades.

Of the 1,364 families that were originally enrolled in the NICHD study, 812 who had complete data across all assessments utilized in present analyses were retained for the present analyses.[2] Independent samples t-tests across families included versus excluded revealed that the two groups were comparable on variables used in this study, with one exception: mothers in the present analyses were significantly older at birth of the target child ($M = 28.71$,

[2]All results presented in this article are based on the entire subsample. However, given the large sample size, we also split the sample into two random subsamples for purposes of cross-validation. All coefficient confidence intervals from these subsamples overlapped, suggesting that both sets of results were derived from the same distributions.

$SD = 5.52$) than mothers excluded ($M = 26.91$, $SD = 5.73$), $t(1362) = 5.79$, $p < .001$. Ethnic composition of the 812 children included in present analyses was: 83.9% Caucasian, 10.5% African American, and 5.6% other races. Reports of highest levels of maternal educational attainment were as follows: 7.1% had not completed high school, 21.1% completed high school or its equivalent (GED), 32.6% completed some post-secondary training, 23.5% earned a Bachelor's degree, 13.3% earned a Master's degree or completed some graduate work, and 2.3% held an advanced or graduate degree beyond a Master's. This subsample included 410 girls (50.5%) and 402 boys (49.5%).

Measures

Externalizing Behavior Problems

Externalizing behavior problems were assessed using maternal reports on the well-validated Child Behavior Checklist (CBCL; Achenbach, 1991). The CBCL is one of the most widely used screening instruments for tracking the emergence of behavior problems in children, and it is considered the gold standard among behavior rating scales (Myers & Collett, 2006). The global index of externalizing behavior problems, comprised of maternal responses loading on the aggressive, delinquent, and attention subscales, was utilized in the present analyses. This scale has adequate reliability and validity from early childhood through adolescence (Achenbach, 1991), and maternal reports on this measure have demonstrated modest stability across time (e.g., McConaughy, Stanger, & Achenbach, 1992). According to published criteria (Achenbach, 1991), t-scores less than 60 on this measure are considered non-clinical (89.8% of the present sample), 60–63 are considered borderline clinical (4.7% of the present sample), and greater than 63 are considered clinically significant (5.5% of the present sample).

Maternal Depression

Symptoms of maternal depression were assessed with a widely used and validated measure of depressive symptomatology, the Center for Epidemiological Studies Depression Scale (CES-D). Participants were asked to indicate the extent to which they experience 20 symptoms of depression using a four-point Likert-type scale ranging from 0 (Rarely) to 3 (All of the time). This scale has established reliability and validity in nonclinical samples (Radloff, 1977). Total scores greater than or equal to 16 (18.2% of the present samples) are considered to be indicative of severe depression (Anda et al., 1990; McCaffery, Niaura, Swan, & Carmelli, 2003), while scores ranging from 8 to 16 (24.3% of this sample)

represent the presence of moderate depression (McCaffery et al., 2003; Schwebel & Brezausek, 2008).

Home Environment

The seven-item Physical Environment scale from the H.O.M.E. Inventory (Caldwell & Bradley, 1984) was used as an index of the safety of the home environment. Higher scores on this scale reflect an environment that contains no hazards and is thus safe for children. In its entirety, the H.O.M.E. Inventory is comprised of 55 items scored in binary (Yes/No) by trained examiners during a 60–90 min semi-structured interview in children's homes. Caldwell and Bradley (1984) reported that internal consistency of all H.O.M.E. subscales were greater than 0.90, and inter-observer agreement exceeded 90%.

Socioeconomic Status (SES)

NICHD Study of Early Childcare investigators computed an estimate of SES by dividing the total family pre-tax income by the poverty threshold. The household poverty threshold was obtained from the United States Census Bureau, and it was based on the total number of persons residing in the household. Income-to-needs ratios of 1 reflect the poverty line, with values less than one indicating severe poverty (6.4% of the present sample). Families with ratios of 2 or higher are considered to be at or above the middle class (77.5% of this sample).

Injury History

Mothers completed annual interviews when the target child was in the third through sixth grades, during which they reported the number of times the target child experienced three injury outcomes: minor injuries and close calls that occurred during the previous month and medically attended injuries that occurred during the previous six months. When parents reported that an injury requiring medical attention occurred, parents were asked to report additional information about the injuries, such as the type of injury (e.g., broken bone, head injury, burn) and whether or not the child was hospitalized. Empirical research supports the reliability of maternal reports of children's injury history (Pless & Pless, 1995). Minor injuries were operationalized as injuries leaving a visible mark, but not requiring medical attention. Close calls were defined as circumstances during which the child could have been injured, but was not. For the present study, the three outcome variables were the sum of all reported minor injuries, close calls, and medically attended injuries from the fourth through sixth grades. The modal count for all outcome variables was 0 (350, 542, and 601 cases for minor, close calls, and medically attended

Table I. Means, Standard Deviations, and Intercorrelations among Independent Variables ($N = 812$)

Variables	M	SD	Range		1	2	3	4	5
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1. Sex of child	–	–	–	–	1				
2. Child behavior	47.23	9.70	30.00	78.00	−0.05	1			
3. Age of mother	28.71	5.52	18.00	46.00	−0.06	−0.18***	1		
4. Maternal depression	8.69	8.04	0.00	55.00	−0.04	.30***	−0.14***	1	
5. Home environment	7.43	1.14	1.00	8.00	−0.05	−0.14***	.29***	−0.18***	1
6. SES	4.10	2.86	0.09	26.64	−0.02	−0.17***	.39***	−0.25***	0.30***
7. Medically attended injuries	0.34	0.65	0.00	4.00	–	–	–	–	–
8. Minor injuries	2.14	4.12	0.00	72.00	–	–	–	–	–
9. Close calls	0.78	1.47	0.00	9.00	–	–	–	–	–

Note. Maternal age reflects age of mother when the target child was born, and values were rounded down to reflect years in integers. Sex of child was coded as follows: Female = 0, Male = 1. Bivariate relations with and among injury variables are not reported because of non-normal distributions of these variables, and the correlations between any two variables are underestimated when their distributions are dissimilar (Cohen et al., 2003).
*$p < .05$, **$p < .01$, ***$p < .001$.

injuries, respectively), followed by 1 (142, 114, and 165 cases, respectively), 2 (98, 65, and 32 cases, respectively), 3 (71, 35, and 12 cases, respectively), and 4 (33, 26, 2 cases, respectively). A total of 118 children experienced between 5 and 72 minor injuries, and 30 children incurred between five and nine close calls.

Results

Consistent with the stated aims of this study, results are presented in the following order: 1—determination of appropriate statistical methodology for each dependent variable, 2—concurrent relations of injury proxies with medically attended injuries, and 3—examination of prospective predictors of each outcome variable. Preliminary analyses used to determine appropriate regression techniques were conducted in Stata version 8.0 (StataCorp., 2003). All other analyses were conducted in Mplus 5.1 (Muthén & Muthén, 2007). Preliminary analyses that are mentioned but not reported are available upon request from the first author. Means, standard deviations, and intercorrelations among Time 1 predictor variables are presented in Table I. According to Cohen's (1988) conventions, effect sizes of all correlation coefficients are small, with one exception. The correlation between maternal age and income-to-needs ratio is in the medium range.

Selection of Analytic Methods

All injury outcomes had a high preponderance of zeros (non-occurrence). We conducted preliminary analyses to investigate which modeling strategy (Poisson, negative binomial, zero-inflated Poisson, zero-inflated negative binomial) provided the "best" fit with distributions of each outcome variable (Karazsia & van Dulmen, 2008;

Long & Freese, 2006). Two tests are useful for choosing among these modeling strategies. A likelihood-ratio (LR) test can be used to compare nested estimation methods (i.e., Poisson versus negative binomial, ZIP versus ZINB). A statistically significant LR test indicates that the negative binomial provides a better fit with observed data. The Vuong test (Vuong, 1989) can be used to compare non-nested estimation methods (i.e., Poisson versus ZIP, negative binomial versus ZINB). When the resulting z-value is positive and statistically significant, then a zero-inflated model is favored. Alternatively, the Poisson or negative binomial model is preferred when the resulting z-value is negative and statistically significant. Long and Freese (2006) also suggest plotting residuals of each method to provide a graphical depiction of model accuracy for different outcomes.[3]

Preliminary analyses revealed that a zero-inflated Poisson model (ZIP) was appropriate for handling the preponderance of zeros on the injury count variable, whereas negative binomial and zero-inflated negative binomial model (ZINB) models were appropriate for analyzing minor injuries and close calls, respectively. These differences are due to the differences in observed distributions of each count outcome.

Zero-inflated estimation methods generate two coefficients for each variable: a dichotomous and continuous outcome. These coefficients are used to examine two latent (unobserved) groups: an "always zero group" (e.g., individuals who are not likely to be injured) and a "not

[3]Details of these preliminary analyses are presented by Long and Freese (2006). Karazsia and van Dulmen (2008) provided an illustration of this decision-making process (including a graphical comparison across models) using data on medically attended injuries.

always zero group'' (e.g., individuals who are more likely to be injured). Importantly, children in the ''not always zero group'' can still have zeros, but the reason they have a zero count differs from children in the ''always zero group'' (see Long & Freese, 2006).

Concurrent Relations

As can be seen in Table II, the hypothesis that injury proxies would predict medically attended injuries concurrently received partial support. Maternal reports of minor injuries and close calls were significantly associated with the number of reported medically attended injuries. An individual's chance of experiencing more medically attended injuries increased by a factor of 1.13 and 1.04

with every additional reported close call and minor injury, respectively. Neither minor injuries nor close calls predicted the dichotomous outcome of medically attended injuries. Maternal reports of injury close calls were significantly related with the number of reported minor injuries ($B = 0.24$, $SE\ B = 0.04$, $p < .001$). The chance of children in this sample experiencing more minor injuries increased by a factor of 1.27 with every additional close call.

Behavioral Antecedents of Injuries and Injury Proxies

As hypothesized, different patterns of predictors emerged across each injury outcome. As can be seen in Table III, only maternal depression ($CI_{95\%} = 0.017–0.057$) emerged as a significant predictor of the continuous outcome of medically attended injuries. Holding all other variables constant, children's risk of incurring an additional medically attended injury from the fourth through sixth grade increased by a factor of 1.04 for every unit increase in maternal depression. In other words, risk of sustaining an additional injury increased 32.16% with each standard deviation increase in maternal depression.

Two different variables emerged as prospective predictors of minor injuries, child sex ($CI_{95\%} = 0.20–0.64$) and child externalizing behavior problems ($CI_{95\%} = 0.014–0.037$). Holding all other variables constant, the risk of experiencing more minor injuries increased by a factor of 1.52 among males, relative to females. With every unit increase in the measure of children's externalizing behavior problems, children's risk

Table II. Concurrent Relations of Injury Proxies with Medically Attended Injuries ($N = 812$)

Variable	B	SE B	e^b	CI$_{95\%}$ Lower Bound	Upper Bound
Continuous outcome					
Minor injuries	0.04	0.019	1.04*	0.003	0.08
Close calls	0.14	0.06	1.15**	0.04	0.24
Dichotomous outcome					
Minor injuries	0.03	0.15	1.03	−0.03	0.08
Close calls	0.16	0.13	1.17	−0.07	0.38

Note. e^b = factor change (Long & Freese, 2006), and interpretation of this value is similar to that of odds ratios (i.e., for a unit change in variable x, the expected count in variable y changes by a factor of e^b); CI: confidence interval; dependent variable (y) is number of medically attended injuries.
*$p < .05$, **$p < .01$.

Table III. Regression Results across Injury Assessment Methods ($N = 812$)

Variable	Medically attended injuries B	SE B	e^b	Minor injuries B	SE B	e^b	Close calls B	SE B	e^b
Continuous outcome									
Child sex	0.19	0.22	1.20	0.42	0.11	1.52***	0.28	0.16	1.32
Child behavior	−0.01	0.01	0.99	0.03	0.01	1.03***	0.02	0.01	1.02*
Age of mother	0.04	0.03	1.04	0.01	0.01	1.01	−0.03	0.02	0.97
Maternal depression	0.04	0.01	1.04***	0.01	0.01	1.01	0.01	0.01	1.01
SES	0.02	0.05	1.02	−0.02	0.02	0.98	−0.01	0.03	1.00
Home environment	0.00	0.13	1.00	0.03	0.05	1.03	0.01	0.08	1.01
Dichotomous outcome									
Child sex	0.09	0.67	1.09	–	–	–	−0.23	0.26	0.80
Child behavior	−0.10	0.06	0.91	–	–	–	−0.02	0.01	0.98
Age of mother	0.08	0.09	1.08	–	–	–	−0.00	0.03	1.00
Maternal depression	0.06	0.03	1.06	–	–	–	−0.01	0.02	0.99
SES	−0.08	0.17	0.93	–	–	–	−0.03	0.05	0.97
Home environment	−0.22	0.30	0.80	–	–	–	−0.13	0.11	.88

Note. ZIP regression was used for medically attended injuries, negative binomial for minor injuries, and ZINB for close calls. e^b = factor change (Long & Freese, 2006), and interpretation of this value is similar to that of odds ratios (i.e., for a unit change in variable x, the expected count changes by a factor of e^b).
*$p < .05$, **$p < .01$, ***$p < .001$.

of experiencing more minor injuries increased by a factor of 1.03 (i.e., 29.10% for every standard deviation increase in behavior problems). The only statistically significant predictor of close calls in this study was child behavior ($CI_{95\%} = 0.004$–0.035). On average, children's risk of experiencing more close calls increased by a factor of 1.02 with every increase in units on maternal report of children's externalizing behavior problems (i.e., 19.40% for every standard deviation increase in behavior problems).

Discussion

In the present study, associations among and antecedents of minor injuries, close calls, and medically attended injuries were examined. Results partially supported our hypothesis that minor injuries and close calls would predict medically attended injuries concurrently. Children who experienced more minor injuries and close calls from the fourth through sixth grades were more likely to experience more medically attended injuries. However, the number of reported minor injuries and close calls did not differentiate between children who did and did not incur an injury that resulted in medical attention. To our knowledge, this study was the first to demonstrate concurrent relations among injury proxies and medically attended injuries, and these findings offer additional insight into previous mixed findings on the relationship between minor injuries and medically attended injuries (e.g., Morrongiello et al., 2004; Schwebel, Speltz, Jones, & Bardina., 2002). This study was also the first to document a concurrent relationship between minor injuries and close calls.

Consistent with our expectations, antecedents that emerged as statistically significant predictors varied across the three count outcomes. Interestingly, only maternal depression predicted the number of medically attended injuries children experienced prospectively. This finding is consistent with a recent study that demonstrated children in early childhood were at an increased risk of injury when their mothers experienced chronic depression (Schwebel & Brezausek, 2008). The present results extend those of Schwebel and Brezausek (2008) to middle childhood. With respect to proxies of medically attended injuries, only child sex and reports of children's externalizing behavior problems emerged as prospective predictors of children's minor injuries. Only one variable, child behavior, emerged as a predictor of close calls.

Taken together, the present results are largely consistent with previous research. Across all injury assessments, maternal depression (e.g., Schwebel & Brezausek, 2008),

children's externalizing behavior problems (e.g., Schwebel et al., 2002), and child sex (e.g., Morrongiello & Hogg, 2004) predicted children's risk for injury prospectively. This study failed to support previous research that suggests children of younger parents are at increased risk for injury (e.g., McCormick, Shapiro, & Starfield, 1981). Furthermore, two contextual variables, an SES aggregate and an assessment of the home environment, did not predict children's injuries prospectively. These findings were surprising given the substantial support of the importance of these predictors of children's injury risk (Grossman, 2000). It is possible that the present results were due to restricted ranges across these variables. Only mothers 18 years of age and older were recruited in the NICHD study, and only a small proportion of families in this study were below the poverty level.

It is also important to note that child sex did not predict medically attended injuries or close calls prospectively. This finding was particularly surprising because previous research suggests that child sex is one of the most robust predicts of children's risk of injury (e.g., Morrongiello & Hogg, 2004; Schwebel & Gaines, 2007). However, an important difference between the present and many previous analyses concerns the statistical modeling strategies that were employed. In a recent prospective study, Karazsia and van Dulmen (2008) demonstrated that the importance of child sex diminished substantially in the context of other predictors. Importantly, this pattern of results emerged only when data were modeled appropriately (Karazsia & van Dulmen, 2008). The present results support the notion that other variables may account for the previously demonstrated associations between child sex and children's risk for injury. Clearly, future research is necessary to explore this possibility further.

This study offered important insights into the use of analytical methods for count outcomes. The usefulness of choosing between various modeling strategies of count outcomes was demonstrated in several recent works (Atkins & Gallop, 2007; Karazsia & van Dulmen, 2008; Long & Freese, 2006). This article extends these previous methodological demonstrations by illustrating how different models are appropriate for representing observed data of different outcome variables. Our analyses revealed that three different modeling strategies were necessary to model data of the three different injury assessment methods. It is our hope that this illustration encourages researchers to consider comparisons among these methods in research that utilizes count outcomes (e.g., Atkins & Gallop, 2007; Long & Freese, 2006).

To our knowledge, this study was the first to include three measures of child injury risk in one prospective

study. Therefore, findings from this study offer important insights into the extent to which commonly used proxies of severe pediatric injuries can be used interchangeably with assessments of medically attended injuries. Concerning interrelationships among various assessment methods, close calls and minor injuries predicted medically attended injuries concurrently. However, neither close calls nor minor injuries shared similar antecedents with medically attended injuries. Therefore, our conclusions about antecedents of medically attended injuries may have been inaccurate if assessment of close calls or minor injuries substituted assessment of medically attended injuries. While these results bring to question the extent to which knowledge based on studies that assess injury proxies can be extended to the empirical knowledge base of medically attended injuries, they do not preclude use of these proxies in research. Clearly, the field of injury research and prevention has benefited from the development and utilization of proxies to assess pediatric injury risk. Furthermore, the study of minor injuries and close calls is an important endeavor in its own right (Peterson et al., 1996), particularly as injury mortality continues its downward trend (Grossman, 2000).

Findings from this study offer important advances for injury research that are consistent with recent emphases on empirically-based assessment in clinical child and pediatric psychology (Cohen et al., 2008; Mash & Hunsley, 2005). Pediatric injury researchers frequently assess minor injuries or close calls and assume that these phenomena serve as proxies of more severe injuries. As noted previously, we are unaware of any empirical research that has examined this assumption with concurrent assessments of these variables. Therefore, this study was the first to examine the concurrent validity of proxies of medically attended injuries. Falling under the umbrella of criterion validity (i.e., the extent to which a given assessment is associated with relevant criteria), the establishment of concurrent validity concerns the degree to which a particular assessment technique is associated with a criterion that occurs during the same time period (Rosenthal & Rosnow, 2008). A logical next step is to examine the extent to which minor injuries and close calls predict medically attended injuries prospectively (i.e., predictive validity).

Although the present analyses were based on prospective data from a large sample, the dataset was preexisting, which limited variables that could be included in our model. Several main variables in this study were collected from a single informant, so relations among variables may be inflated due to shared method variance (Burt et al., 2005). Several limitations concerning the assessment of injury events are also noteworthy. Although we

incorporated three different methods of injury assessment, generalizability of these findings are limited by the definitions of injuries used in this study. Namely, there was no assessment of injury severity, so it cannot be assumed that all minor injuries were less severe than medically attended injuries (Peterson, DiLillo, Lewis, & Sher, 2002). Additionally, minor injuries and close calls were assessed over a one month period when children were in the fall semester of grades four through six. Data on injuries that occurred at other times throughout the year were not available. The validity of parental recall information about minor injury and close call occurrences over this period of time is not well established, and some researchers have advocated for more frequent telephone interviews (e.g., Morrongiello, 1997; Peterson, Bartelstone, Kern, & Gillies, 1995) or the use of daily diaries (e.g., Schwebel et al., 2002). However, it should be noted that participants in the NICHD Study of Early Child Care reported information on these outcomes during regular interviews since the target child was 3 months of age. Therefore, it is plausible that mothers were primed to pay attention to and recall information on these behavioral outcomes. In light of these limitations, findings from this study will help establish a foundation for empirically based assessment practices in the pediatric injury literature.

The present results also offer important insights for future prevention efforts. To our knowledge, this study is the first to support a recent suggestion that child sex, in the context of other child and family attributes, is not an important predictor of medically attended injuries (Karazsia & van Dulmen, 2008). This finding has important implications for injury prevention efforts because it highlights specific mechanisms that may place boys at a higher risk of injury than girls. The present results also support previous research that suggests different determinants exist across multiple injurious outcomes (Morrongiello, 1997; Morrow & Crum, 2004). While future research is needed to examine this issue in more depth, an emerging picture is that injury prevention efforts may need to be tailored to specific injury types. That is, targets of minor injury prevention efforts may differ from those of programs designed to reduce more severe injuries.

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References

Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4-18 and 1991 Profile*. Burlington, VT: University of Vermont.

Anda, R. F., Williamson, D. F., Escobedo, L. G., Mast, E. E., Giovino, G. A., & Remington, P. L. (1990). Depression and the dynamics of smoking: A national perspective. *Journal of the American Medical Association, 264*, 1541–1545.

Atkins, D. C., & Gallop, R. J. (2007). Rethinking how family researchers model infrequent outcomes: A tutorial on count regression and zero-inflated models. *Journal of Family Psychology, 21*, 726–735.

Burt, K. B., van Dulmen, M. H. M., Carlivati, J., Egeland, B., Sroufe, L. A., Forman, D., et al. (2005). Mediating links between maternal depression and offspring psychopathology: The importance of independent data. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 46*, 490–499.

Caldwell, B. M., & Bradley, R. H. (1984). *Home observation for measurement of the environment*. Little Rock, AR: University of Arkansas at Little Rock.

Cobb, B. K., Cairns, B. D., Miles, M. S., & Cairns, R. B. (1995). A longitudinal study of the role of socio-demographic factors and childhood aggression on adolescent injury and ''close calls''. *Journal of Adolescent Health, 17*, 381–388.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied Multiple Regression/Correlation Analyses for the Behavioral Sciences* (3rd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Cohen, L. L., La Greca, A. M., Blount, R. L., Kazak, A. E., Holmbeck, G. N., & Lemanek, K. L. (2008). Introduction to the special issue: Evidence-based assessment in pediatric psychology. *Journal of Pediatric Psychology, 33*, 911–915.

Damashek, A. L., Williams, N. A., Sher, K. J., Peterson, L., Lewis, T., & Schweinle, W. (2005). Risk for minor childhood injury: An investigation of maternal and child factors. *Journal of Pediatric Psychology, 30*, 469–480.

Deffenbacher, J. L., Richards, T. L., Filetti, L. B., & Lynch, R. S. (2005). Angry drivers: A test of state-trait theory. *Violence and Victims, 20*, 455–469.

Gardner, W., Mulvey, E. P., & Shaw, E. C. (1995). Regression analyses of counts and rates: Poisson, overdispersed poisson, and negative binomial models. *Psychological Bulletin, 118*, 392–404.

Grossman, D. C. (2000). The history of injury control and the epidemiology of child and adolescent injuries. *The Future of Children, 10*, 23–51.

Hammer, T. H., & Landau, J. C. (1981). Methodological issues in the use of absence data. *Journal of Applied Psychology, 66*, 574–581.

Johnson, R. A., & Wichern, D. W. (1998). *Applied multivariate statistical analysis*. Englewood Cliffs, NJ: Prentice Hall.

Karazsia, B. T., & van Dulmen, M. H. M. (2008). Regression models for count data: Illustrations using longitudinal predictors of childhood injury. *Journal of Pediatric Psychology, 33*, 1076–1084.

Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata* (2nd ed.). College Station, TX: Stata Press.

Martin, J. A., Hsjang-Ching, K., Mathews, T. J., Hoyert, D., Strobino, D. M., Guyer, B., et al. (2008). Annual summary of vital statistics: 2006. *Pediatrics, 121*, 788–801.

Mash, E. J., & Hunsley, J. (2005). Special section: Developing guidelines for the evidence-based assessment of child and adolescent disorders. *Journal of Clinical Child and Adolescent Psychology, 34*, 362–379.

McCaffery, J. M., Niaura, R., Swan, G. E., & Carmelli, D. (2003). A study of depressive symptoms and smoking behavior in adult male twins from the NHLBI twin study. *Nicotine & Tobacco Research, 5*, 77–83.

McConaughy, S. H., Stanger, C., & Achenbach, T. (1992). Three-year course of behavioral/emotional problems in a national sample of 4- to 16-year-olds: I. Agreement among informants. *Journal of the American Academy of Child & Adolescent Psychiatry, 31*, 932–940.

McCormick, M. C., Shapiro, S., & Starfield, B. H. (1981). Injury and its correlates among 1-year-old children. *American Journal of Diseases of Children, 135*, 159–163.

Morrongiello, B. A. (1997). Children's perspectives on injury and close-call experiences: Sex differences in injury-outcome process. *Journal of Pediatric Psychology, 22*, 499–512.

Morrongiello, B. A. (2005). Caregiver supervision and child-injury risk: I. Issues in defining andmeasuring supervision; II. Findings and directions for future research. *Journal of Pediatric Psychology, 30*, 536–552.

Morrongiello, B. A., & Hogg, K. (2004). Mothers' reactions to children misbehaving in ways that can lead to injury: Implications for gender differences in children's risk taking and injuries. *Sex Roles, 50*, 103–118.

Morrongiello, B. A., Ondejko, L., & Littlejohn, A. (2004). Understanding toddlers' in-home injuries: I. Context, correlates, and determinants. *Journal of Pediatric Psychology, 29*, 415–431.

Morrow, P. C., & Crum, M. R. (2004). Antecedents of fatigue, close calls and crashes among commercial motor vehicle drivers. *Journal of Safety Research, 35*, 59–69.

Muthén, L. K., & Muthén, B. O. (2007). *Mplus: Statistical analysis with latent variables. User's guide*. Los Angeles: Authors.

Myers, K., & Collett, B. (2006). Rating scales. In M.K. Dulcan, & J.M. Wiener (Eds.), *Essentials of child and adolescent psychiatry* (pp. 81–98). Washington, DC: American Psychiatric Publishing.

NICHD Early Child Care Research Network (2000). The interaction of child care and family risk in relation to child development at 24 and 36 months. *Applied Developmental Science, 6*, 144–156.

Peterson, L., Bartelstone, J., Kern, T., & Gillies, R. (1995). Parents' socialization of children's injury prevention: Description and some initial parameters. *Child Development, 66*, 224–225.

Peterson, L., & Brown, D. (1994). Integrating child injury and abuse/neglect research: Common histories, etiologies, and solutions. *Psychological Bulletin, 116*, 293–315.

Peterson, L., Saldana, L., & Heiblum, N. (1996). Quantifying tissue damage from childhood injury: The minor injury severity scale. *Journal of Pediatric Psychology, 21*, 251–267.

Peterson, L., DiLillo, D., Lewis, T., & Sher, K. (2002). Improvement in quantity and quality of prevention: Measurement of toddler injuries and parental interventions. *Behavior Therapy, 33*, 271–297.

Pless, C. E., & Pless, I. B. (1995). How well they remember: The accuracy of parent reports. *Archives of Pediatric and Adolescent Medicine, 149*, 553–558.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385–401.

Rizzo, M., Reinach, D., McGehee, D., & Dawson, J. (1997). Simulated car crashes and crash predictors in drivers with Alzheimer's disease. *Archives of Neurology, 54*, 545–551.

Rosenthal, R., & Rosnow, R. L. (2008). Essentials of behavioral research: Methods and data analysis (3rd ed.). New York, NY: McGraw-Hill.

Scheidt, P. C. (1988). Behavioral research toward prevention of childhood injury. *American Journal of Diseases of Children, 142*, 612–616.

Schwebel, D. C. (2006). Safety on the playground: Mechanisms through which adult supervision might prevent child playground injury. *Journal of Clinical Psychology in Medical Settings, 13*, 141–149.

Schwebel, D. C., Binder, S. C., & Plumert, J. M. (2002). Using an injury diary to describe the ecology of children's daily injuries. *Journal of Safety Research, 33*, 301–319.

Schwebel, D. C., & Brezausek, C. M. (2007). The role of context in risk for pediatric injury: Influences from the home and child care environments. *Merrill-Palmer Quarterly, 53*, 105–130.

Schwebel, D. C., & Brezausek, C. M. (2008). Chronic maternal depression and children's injury risk. *Journal of Pediatric Psychology, 33*, 1108–1116.

Schwebel, D. A., & Gaines, J. (2007). Pediatric unintentional injury: Behavioral risk factors and implications for prevention. *Journal of Developmental & Behavioral Pediatrics, 28*, 245–254.

Speltz, M. L., Gonzales, N., Sulzbacher, S., & Quan, L. (1990). Assessment of injury risk in young children: A preliminary study of the injury behavior checklist. *Journal of Pediatric Psychology, 15*, 373–383.

Schwebel, D. C., Speltz, M. L., Jones, K., & Bardina, P. (2002). Unintentional injury in preschool boys with and without early onset of disruptive behavior. *Journal of Pediatric Psychology, 27*, 727–737.

StataCorp. (2003). *Stata Statistical Software: Release 8*. College Station, TX: StataCorp LP.

U.S. Department of Health and Human Services (2000). *Healthy People 2010: Understanding and improving health* (2nd ed.). Washington, DC: U.S. Government Printing Office.

Vuong, Q. (1989). Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica, 57*, 307–334.