Family size, birth interval, and the risk of serious unintentional injury to the youngest child

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Abstract

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Objective: To evaluate the association between family size/spacing and risk of fatal and serious non-fatal unintentional injury to children younger than 15 months of age. We also sought to determine whether the magnitude of this association depends on the injury mechanism.

Methods: A population-based case control study was conducted using linked hospital discharge and vital records data from Washington State. All children born in Washington State who were subsequently hospitalized (n=3838) or died (N=342) at <15 months of age as a result of an unintentional injury during 1991-2012 were identified in the hospital discharge and death certificate data. Injuries were classified based on ICD-9 and ICD-10 codes. Controls (n=65,711) were randomly selected from Washington State birth certificates of those without an injury-related hospitalization or death during the same time period. Mantel-Haenszel stratified analysis was conducted using data from birth certificates of cases and controls.

Results: Larger family size was associated with increased risk of serious pediatric injury (odds ratio (OR) 1.80 for parity 3+, 95% confidence interval (CI) 1.61-2.11 compared with parity=0), with a dose-response relationship observed. The magnitude of the increased risk depended on the injury mechanism, with the largest risk for injuries involving drowning/suffocation/foreign body (OR 2.93 for parity 3+, 95% CI 2.33-3.68 compared with parity=0) and being struck by/against an object (OR 3.47 for parity 3+, 95% CI 1.64-7.30 compared with parity=0). Children born <15 months after a sibling had an increased risk of serious injury (OR 1.63, 95% CI 1.38-1.94) compared to those whose sibling was >30 months older.

Conclusion: The results indicate an association between higher parity and increased risk of serious injury to the youngest child, with magnitude of risk depending on injury mechanism. In addition, very close birth interval between the two youngest children is associated with increased risk of serious injury to the younger child. These results suggest priorities for targeting injury prevention interventions.

Introduction

Unintentional injury is the leading preventable cause of pediatric morbidity and mortality in the United States, resulting in over 1,500 deaths and 17,000 hospitalizations annually among children younger than two years of age.[1] Prior studies have identified various sociodemographic factors that may be associated with increased risk of serious or fatal pediatric injury, including young maternal age, low maternal educational attainment, and male sex of the child. Two other factors identified in previous studies, namely maternal parity and birth interval, were the focus of our study.

Previous studies have shown an association between greater maternal parity and serious unintentional injury in children[2-6], possibly due to decreased parental supervision when there are more children to care for. A better understanding of why children with siblings may have increased injury risk, including the spacing between siblings and the relationship between family size/spacing and injury mechanism, may aid in the design of effective injury prevention interventions and help tailor them to the highest risk population.

We analyzed linked birth-hospital discharge registry data from Washington State to examine whether larger family size (as indicated by maternal parity), as well as close birth spacing, is associated with serious or fatal pediatric injury in a younger sibling less than 15 months of age. In addition, we performed an exploratory analysis to determine whether the magnitude of association depends on the injury mechanism.

Methods

We performed a population-based case-control study using Washington State hospital discharge data (Comprehensive Hospital Abstract Reporting System, or CHARS) linked to vital records from the years 1989-2012. Cases included all children younger than 15 months who were hospitalized (n=3838) and/or died (n=342) due to unintentional injury in Washington State from 1991-2012. Fatal and nonfatal injuries were analyzed together as cases.

Injuries were classified based on the *International Classification of Disease* (ICD) codes as indicated on the hospital discharge record or death certificate. Unintentional injuries were defined based on ICD-9 codes E800-869 and E880-929 for all hospitalized cases, and for non-hospitalized fatal cases prior to 1999. Beginning in 1999, WA used ICD-10 codes for underlying cause of death on death

certificates; therefore, our non-hospitalized fatal cases from 1999-2012 are defined based on ICD-10 codes V01-X59.

The primary exposures evaluated included maternal parity as listed on the birth certificate (0, 1, 2, and 3+ previous births) and birth interval as calculated from birth certificate data. Birth interval in months between next-oldest child (when applicable) and the study subject were calculated from the birth month and birth year of the study subject and the birth month and birth year of the mother's previous live birth, as indicated on the study subject's birth certificate. For analysis, the birth interval was converted to a categorical variable (<15 months, 15-30 months, >30 months). Out of 37,790 children with a year of birth available for the mother's last live birth, 2267 (6%), including 2110/65,711 controls and 157/4180 cases, were missing the birth month of the mother's last live birth and were coded as July (7) so they could be included in the analysis. In this manner, a birth interval was calculated that would be within six months of the actual birth interval.

Controls (n=65,711) were randomly selected from remaining birth certificates 1989-2012 without an unintentional injury resulting in hospitalization or death. The ratio of controls to cases was > 14:1.

The risk of unintentional injury leading to hospitalization or death was estimated by stratified analysis using Mantel-Haenszel odds ratio (OR) estimates and test-based 95% confidence intervals (CI). Because the incidence of serious or fatal unintentional injury is relatively low, estimated at 372 per 100,000 in US children less than age 3 years in 2010 [1], the OR approximates the relative risk (RR) of serious or fatal injury in this analysis.

Variables from the birth record considered as potential confounders included: maternal age (<20, 20-29, 30-39, 40+ years), marital status, maternal education (<12 years, 12-15 years, 16+ years), maternal race/ethnicity group, sex of the child, and socioeconomic status (SES), using primary payer of birth expenses to indicate low SES. When evaluating potential confounders, we adjusted for variables that 1) have a plausible association with both exposure and outcome, and 2) change the crude OR by at least 10%, after adjustment for other confounders that change the OR by a larger percentage. Potential effect modification by maternal age, maternal education, and child sex were evaluated by reviewing stratum-specific OR for large differences and Breslow-Day tests for homogeneity.

In the exploratory analysis, categories of injury mechanism (as indicated on the hospital discharge record or death certificate) included the most common types of unintentional injury resulting in hospitalization in children <2 years, as defined by the CDC, falls, poisoning, fire/burn, drowning/suffocation/foreign body, and struck by/against.[7] All remaining cases were categorized as "other."

Results

Between 1991-2012, 4180 Washington State children younger than 15 months were hospitalized or died due to unintentional injury (Table 1). Cases were more likely than controls to be male and to have more siblings. Mothers of cases tended to be younger, poorer, and less educated than mothers of controls. Mothers of controls were more likely to be white and married. Although all of these factors differed between the two groups, maternal age was the only variable that met the criteria for a confounder. All results were adjusted for maternal age, as well as for child year of birth for reasons discussed previously.

Table 1. Selected maternal and infant characteristics of women whose child aged <15 months had an unintentional injury resulting in hospitalization or death in Washington State in 1991-2012, versus controls with no injury (n=69891).

	Serious Injury N[a]=4180		No Serious Injury N[a]=65711	
Characteristic	**N**	**%**	**N**	**%**
Child characteristics				
Male sex	2345	56.1	33152	50.5
Mother characteristics				
Age (years)				
<20	589	14.1	6487	9.9
20-29	2276	54.5	34640	52.8
30+	1314	31.4	24545	37.4
Parity				
0	1506	36.8	27112	42.1
1	1319	32.2	20861	32.4
2	719	17.6	9816	15.3
3+	551	13.5	6597	10.3
Unmarried	1766	42.4	18852	28.8
Race				
White	2859	70.1	47966	74.9
Black	226	5.5	2430	3.8
Native American	188	4.6	1438	2.3
Asian/Pacific Islander	316	7.8	5101	8.0
Hispanic	490	12.0	7078	11.1
Education [b]				
<12 years	960	25.4	10236	18.7
HS graduate	2165	57.3	30895	56.4
College graduate	656	17.4	13694	25.0
Low SES[c]	1997	49.3	23472	35.7
Rural residence	827	25.1	14098	24.1

[a] Numbers may not add to totals due to missing data.
[b] Education level of mother for cases and controls available only for birth years 1992-2012.
[c] Low socioeconomic status (SES) estimated from primary payer of birth expenses.

The presence of older siblings in the family was associated with increased risk of serious or fatal unintentional injury in the younger sibling (OR 1.80, 95% CI 1.61-2.11 for parity 3+ compared to parity=0), with a clear dose-response gradient observed (Table 2).

Table 2. Association between parity and risk of serious unintentional injury to the youngest child, in WA 1991-2012, adjusted for maternal age and child year of birth

Parity	N	%	OR	95%CI
0	1506	36.8	1.00	Reference
1	1319	32.2	1.32	1.22-1.43
2	719	17.6	1.59	1.44-1.75
3+	551	13.5	1.80	1.61-2.11

The magnitude of association between parity and risk of serious or fatal injury depended on the injury mechanism (Table 3). The risk of falls, which is the most common serious injury type in this age group [8,9], was not substantially increased with the presence of older siblings. However, there was a nearly threefold increase in risk to the youngest child with three or more older siblings for drowning/suffocation/choking when compared with only children (OR 2.93, 95% CI 2.33-3.68). There was also a greater risk of accidentally being struck by or against an object with increasing family size, though the CI were wider due to a smaller number of cases. As with the findings for all injuries combined, there was a gradient of increasing risk with an increasing number of children in the family within most of the injury categories.

Table 3. Association between parity and risk of serious unintentional injury to the youngest child, by injury mechanism, OR (95% CI) adjusted for maternal age and child birth year

Mechanism*	Parity = 0	Parity = 1	Parity = 2	Parity = 3+
Falls *(n=1381)*	1.00 (Ref)	1.14 (1.00-1.30)	1.23 (1.04-1.45)	1.25 (1.02-1.51)
Poisoning *(n=263)*	1.00 (Ref)	1.54 (1.15-2.07)	1.40 (0.96-2.06)	1.63 (1.04-2.55)
Fire/burn *(n=619)*	1.00 (Ref)	1.36 (1.12-1.66)	1.43 (1.11-1.83)	1.83 (1.40-2.38)
Drown/suff/for body *(n=975)*	1.00 (Ref)	1.68 (1.42-1.99)	2.58 (2.12-3.15)	2.93 (2.33-3.68)
Struck by/against *(n=111)*	1.00 (Ref)	2.31 (1.41-3.79)	2.31 (1.21-4.41)	3.47 (1.64-7.30)
Other *(n=831)*	1.00 (Ref)	1.11 (0.93-1.33)	1.51 (1.22-1.86)	1.83 (1.44-2.32)

*See Appendix 1 for ICD-9 and ICD-10 codes included in each mechanism category.

A birth interval of <15 months was associated with an increased risk of serious injury to the younger child (OR=1.42, 95% CI 1.18-1.69) compared with a birth interval of >30 months (Table 4). An exploratory analysis did not provide evidence that the magnitude of association between birth interval and injury risk varies depending on the injury mechanism. Due to small sample sizes in many of the injury mechanism categories for the <15 months birth interval group, large and overlapping confidence intervals interfere with the ability to see significant differences, if any, in ORs among different injury types.

Table 4. Association between birth interval (in months) and risk of serious unintentional injury to the younger child, in WA 1991-2012, adjusted for maternal age and child year of birth

Birth interval	N	%	OR	95%CI
<15	162	6.7	1.42	1.18-1.69
15-30	899	36.9	1.10	1.01-1.20
>30	1373	56.4	1.00	Reference

Discussion

This study provided evidence of a greater risk of serious unintentional pediatric injury in families with multiple children, with a further increase in risk for each additional child. This was consistent with results from prior studies that used data from 20-30 years earlier, and attempted to improve upon some of the limitations of previous research. The magnitude of risk associated with older siblings varied depending on the type of injury. Close birth spacing was also found to be associated with greater injury risk.

Maternal parity and birth interval have been identified in previous studies as possible risk factors for serious or fatal childhood injury. As far back as 1984, a study noted a trend of increased accidental infant deaths with increased parity. [10] In 1994, a paper seeking to identify risk factors for infant injury deaths from 1981-1990 in Washington State (including both intentional and unintentional injuries) found that the relative risk of fatal injury for an infant with ≥2 older siblings was 5 times greater (95% confidence interval (CI) = 3.1 to 8.3) than for an only child; the relative risk for a child with only one older sibling was 2.2 (95% CI = 1.4-3.3) [2]. A 1997 analysis of unintentional and intentional injury deaths in Tennessee children aged 0 to 4 years from 1985-1994 found children with at least 3 older siblings had a relative risk of injury death of 2.97 (95% CI = 2.29-3.85) compared with children with no older siblings [5]. The same researchers obtained a similar result when they looked at U.S. infant injury deaths that occurred from 1985-1991, with a relative risk (RR) of injury death of 1.77 (95% CI = 1.65-1.89) for infants with one older sibling, and 3.15 (95% CI = 2.88-3.45) for infants with ≥3 older siblings [6].

A study published in 2000 examined unintentional injury hospitalizations and deaths in children <6 years old in Washington State from 1989-1996, and reported an odds ratio (OR) (adjusted for maternal age) of 1.5 (95% CI = 1.37-1.65) for children with at least one older sibling. [3] The OR was slightly greater in children <2 years, those who had >1 older sibling, and when the birth interval between the previous child and the study subject was <2 years. This was the only prior study examining birth interval as an exposure. However, one limitation of their analysis was that it included children through age six. Since the data about other children in the family consisted of the parity number on the birth certificate, only the presence of older siblings is accounted for. The effect of unknown younger siblings cannot be known or

controlled. In order to minimize the likelihood of the presence of subsequent children at the time of the injury, the current analysis limited cases to those <15 months of age.

In a study that analyzed different injury mechanisms separately, the magnitude of the association between greater parity and increased risk for injury death was observed to vary depending on the mechanism, but was still present to some degree for all of the most common mechanisms.[11] An analysis of U.S. infant injury deaths from 1983-1991 found that younger siblings were at increased risk of death by suffocation (OR=3.2, 95% CI = 2.7-3.9), fire-related causes (OR=4.4, 95% CI = 3.2-5.9), drowning (OR=3.8, 95% CI = 2.8-5.2), and choking on food (OR=1.6, 95% CI = 1.2-2.1), compared with only children.[11] Our study included exploratory analyses of whether the magnitude of association between the main exposures (parity and birth interval) and the risk of serious injury depends on injury mechanism, and included as cases injuries resulting in hospitalization in addition to death.

Some prior analyses included both intentional and unintentional injury. We excluded intentional injury cases in order to avoid mixing two causes of childhood morbidity and mortality that may have different mechanisms and means of prevention. The types of public health interventions that would help prevent unintentional injuries, such as parental education about safety equipment and increased adult supervision, may be ineffective in preventing injuries inflicted intentionally.

Most previous studies focused only on deaths. Nonfatal injuries are far more common than fatal injuries.[12] We included both injury deaths and hospitalizations in order to obtain results applicable to all serious unintentional injuries and not only those that result in death. In addition, the data included in the prior studies was from the 1980s through the mid-1990s, which means the most recent cases analyzed are from nearly 20 years ago. We used the most current data available, including injuries from 1991-2012.

Analysis of parity was handled in a variety of ways in the previous literature, from as few as two categories (only children vs. children with any number of siblings), to as many as four. In studies where at least three categories were used for parity, a clear dose-response relationship was observed between maternal parity and relative risk of serious injury to the youngest child [2,5,6,11], therefore we used four parity categories in the current analysis in order to discern a dose-response gradient, if present.

The exact number of children in the family at the time of the injury cannot be known with certainty. It is possible that younger siblings could have been born to the mother prior to the injury event. Therefore, in order to minimize changes in family size that occurred between birth and injury, we limited cases to those <15 months old. The birth of a younger sibling in that timeframe would be unlikely, and this makes the parity number on the birth certificate a reasonable estimate of the number of siblings in the household at the time of the injury.

Population migration into or out of Washington State (WA) also cannot be accounted for in these data, which include cases born and injured in WA; they do not include children born in WA who moved out of state and may have been injured in their new state, or children who migrated from their birth state to WA and were injured. Controls include children born in WA who have no record of dying or being hospitalized in WA due to unintentional injury. However, a small percentage of controls may have moved out of WA and been injured in their new state of residence. According to the U.S. Census Bureau, about 10% of residents in western states migrate to a new state by age 5 (the youngest age interval available) [13]. Because our cases are <15 months old at the time of injury, it is reasonable to assume that we are missing <5% of cases due to out-migration. We can estimate the percentage of controls who would have moved out of state and subsequently been injured in another state by age 15 months at <0.05 percent (<5 per 10,000 controls), which should not have affected the analysis substantially.

A 2001 study provided evidence that analysis of child age groups that are too wide (for example "1 to 4 years of age") can mask the true risk of injury to a specific year-of-age group by including children that are developmentally very different within the same group. [14] It is unknown whether this is the case in the current analysis, but it is plausible since the 0 to 15 months age range includes both non-mobile and mobile children.

The results of this study are consistent with prior research in finding evidence for the presence of older siblings, particularly closely spaced siblings, as a risk factor for injury to the younger child. The reasons for this increased risk may include a compromised ability of adults to adequately supervise a larger number of small children. Inadequate adult supervision has previously been associated with injury deaths in young children. [15]

In addition, parental vigilance about household child-proofing and other safety-related practices may decline with the births of subsequent children beyond their firstborn. This may be due to a more relaxed parenting demeanor on the part of experienced parents, such as decreased vigilance at bath time or with sleep practices. Another possible reason for decreased safety could be that the accoutrements of older siblings, such as foods or small toys that are age-appropriate for the older sibling but could be choked on by the younger child, are present in the house and difficult to keep completely separate.

Although future research should be conducted to further specify the characteristics of families at highest risk for unintentional injuries, enough evidence is already available to target injury prevention interventions both to people who already have more than one child and those who are planning to expand their families. Families of multiple children could be encourage by their pediatricians to continue to be as vigilant about safety (such as safe sleeping and bath practices and household child proofing) as they were with their first child. Parents who are planning to have additional children could be advised by physicians that close birth spacing may be associated with more risk to the younger child. Prior studies have found short birth intervals to be associated with increased risk of morbidity [16] and all-cause mortality [17] to both the younger sibling and the parents [18], so the increased risk of injury bolsters what is already known about birth spacing.

Future studies could look more closely at total family size and spacing as factors related to childhood injury, by utilizing multiple birth records longitudinally-linked through the mother to obtain more specific data about each child and the whole family. These data and others have shown that males of all ages are more likely than females to suffer both fatal and nonfatal injuries [19]; it would be interesting to explore whether the magnitude of injury risk associated with the presence of siblings depends on the sex not only of the injured child, but of the siblings. Is having brothers more dangerous than having sisters? Does the risk increase with additional brothers? Does it matter if they are older or younger brothers?

Another advantage of using longitudinally-linked birth records would be to research how the presence of *younger* siblings may impact the injury risk to the *older* children in the family. As discussed earlier, this study and others have been limited to data about older siblings in relation to the injured child (case), as information about younger siblings was unavailable. Availability of more complete information about total family size and spacing, including younger siblings and the sex of all children, may help

pinpoint the reasons behind the apparent increased injury risk among larger families and help to focus potential interventions. For example, if evidence is found that the injury risk associated with older brothers is substantially greater than sisters, this may point to behavior of the siblings themselves as a factor rather than simply the decreased adult-to-child ratio of larger families. Similarly, future studies could explore whether *all* ages of children in the family are at greater risk of unintentional injury, or only younger siblings.

A closer look at specific injury mechanisms beyond what was examined in this study could help clarify targets for intervention. For example, we grouped drowning, suffocation, and choking together and found that children of larger families have a substantially increased risk of such injuries. As a next step, these specific injury types could be analyzed separately to see whether the increased risk is for all three of these equally, or one mechanism stands out from the others; preventive interventions could then be more specifically designed to address the greatest dangers. Educational interventions have been found to be most effective in motivating behavior change when they address specific risks with specific advice about injury prevention.[20,21]

Appendix 1: Injury mechanism categories (ICD-9 and ICD-10 codes included in each category)

Injury mechanism category	ICD-9 codes included	ICD-10 codes included
Falls	E880-E888	W00-W19
Poisoning	E850-E869	X40-X49
Fire/burn	E890-E899 E924	W35-W40 W85-W99 X00-X19
Drowning/suffocation/foreign body	E910-E915	W44 W65-W68 W73 W75-W76 W78-W80 W83-W84
Struck by/against	E916-E917	W20
Other	E812-E828 E830-E849 E900-E909 E918-E923 E925-E929	V01-V09 V40-V59 V80-V99 W54 X30-X31 X59

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