



Original Research

Age in months and birth order in infant nonfatal injuries: A retrospective cohort study

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ABSTRACT

Objective: To examine the age in months at which infants visited outpatient clinics or emergency rooms for the first time for nonfatal injuries and to identify risk factors for the occurrence of these injuries.

Study design: Retrospective cohort study.

Methods: We used a health insurance claims database in Japan. Infants born between April 2012 and December 2014 were identified and followed until 12 months of age. We identified their first visit to outpatient clinics or emergency rooms because of nonfatal injuries (wounds/fractures, foreign bodies, and burns). Cox regression analysis was used to examine the association of nonfatal injuries with infants' sex, birth order, and parental age.

Results: We identified 46,431 eligible infants. Of these, 7606 (16.4%) were brought to an outpatient clinic or emergency room for nonfatal injuries within 12 months of birth. Of the 7,606, 21.7% were aged ≤ 4 months and 44.7% ≤ 7 months. First-born infants were more likely to have wounds/fractures and burns.

Conclusion: One-fifth of first nonfatal infant injuries occurred within 4 months of age. Healthcare providers should provide early education about injury prevention, especially to caregivers of first-born infants.

1. Introduction

Unintentional injury is a major cause of death and disability in children and has been perceived as a global public health problem [1]. In Japan, unintentional injury has been one of the most frequent causes of deaths among children [2]. The majority of fatal injuries to infants (<12 months old), excluding traffic accidents, occurred at home [3], and most were reported to have been preventable had caregivers taken greater precautions [4]. Similar results were also reported in the United States [5].

Cross-sectional studies of the estimated prevalence, cause, and outcome of injuries among infants treated in emergency departments have been conducted. One described the causes of injuries and estimated the population-based prevalence of injury hospitalization or death, categorizing age into 3-month groups [6]. Another study on fatal and nonfatal injuries of infants in emergency departments showed that causes of injury were related to outcomes; for example, suffocations were fatal, and falls were common but rarely fatal [7]. Additionally, a study of

products related to injuries in infants of different months of age has been reported [8].

As shown by the child *injury pyramid*, a knowledge of mild injuries is essential to understand and prevent both fatal and nonfatal injuries [1]. However, most previous studies have focused on serious injuries treated in hospital emergency departments, while few have covered minor nonfatal injuries. Moreover, the timing of infants' injuries should be described in short periods because infants' development is very rapid. Additionally, few studies have examined the association between the occurrence of injury and factors that could potentially affect a caregiver's consultation behavior (including birth order and parental age).

We conducted a retrospective cohort study to describe the age in months at which infants visited outpatient clinics or emergency rooms for the first time because of nonfatal injuries. We also examined the association of the occurrence of nonfatal injuries with various infant and caregiver factors.

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2. Methods

2.1. Data source

In Japan, there is universal health coverage through mandatory social health insurance [9]. Although there are multiple insurers, the services covered and the fees for them are uniformly set by the Ministry of Health, Labour, and Welfare. This compulsory insurance covers most medical services, including visits to clinics or emergency rooms for mild injuries. We used a health insurance claims database constructed by JMDC Inc. (Tokyo, Japan). The JMDC Claims Database includes anonymized health insurance claims data for approximately 1.5 million insured individuals in 2013. The majority of the insured individuals in the database are employees of Japanese companies and their families. The database includes the following information: sex, year and month of birth, year and month of joining the insurance, diagnoses, and claims data for drugs and procedures. Diagnoses are recorded based on International Classification of Diseases 10th revision (ICD-10) codes. The database also includes anonymized personal identifier, family identifier, and relationships between individuals and the main insured person (for example, spouse, child, and grandchild).

This study was approved at the institution of the first author. Because of the anonymous nature of the data, the need for informed consent was waived.

2.2. Participants

We first identified infants who were born between April 2012 and December 2014. We then identified their father and mother using family identifiers. Because parenting multiples differs from singleton parenthood [10], we excluded multiples and focused on singletons. We also excluded infants who were withdrawn from insurance within 12 months of birth, including the deceased.

2.3. Variables

We extracted data on infant sex, birth order, and age in months. Birth order was categorized into first, second, and third or later. For parental variables, we extracted data on maternal age at the infant's birth and categorized them into ≤ 24 , 25–29, 30–34, 35–39, and ≥ 40 years following the category in the Japanese Vital Statistics.

2.4. Outcomes

We grouped nonfatal injuries into three categories: wounds/fractures, foreign bodies, and burns. These were reported as leading causes of nonfatal injuries among infants treated in hospital emergency departments in the United States [7,11] and Canada [12]. We identified these injuries using diagnoses recorded with the following ICD-10 codes: wounds/fractures, S00–S99 and T00–T14; foreign bodies, T15–19; and burns, T20–32. The month when each diagnosis first appeared in the claims data was regarded as the month of the first visit to an outpatient clinic or emergency room because of injury.

We used claim records of treatment as a marker of the severity of injury. In the Japanese reimbursement system, wound treatments by bandages and burn treatments are reimbursed according to the treated area. Wounds that do not require bandages and first-degree burns less than ≤ 100 cm² are not covered by these reimbursements. We used these reimbursement records to identify wound and burn requiring treatments.

2.5. Statistical analysis

We described age in months of infants who visited outpatient clinics or emergency rooms for the first time because of wounds/fractures, foreign bodies, or burns. Treatments for wounds and burns were compared across birth order and sex using the chi-squared test.

We also conducted Cox regression analyses for the occurrence of each nonfatal injury until 12 months of age using the infant's sex, birth order, and mother's age group as covariates to compare the incidence of first hospital visits from each type of injury (wound/fracture, foreign body, and burn). Infants withdrawn from insurance within 1 year were included in these analyses and treated as censored.

To further examine the association between birth order and infant nonfatal injury, we identified families with first and second children born during the observation period, and performed a within-family matching of the siblings. We performed another Cox regression analysis for the occurrence of any nonfatal injury, using infant's sex and birth order as covariates.

Statistical analyses were conducted using Stata/SE version 15.0 software (StataCorp, College Station, TX, USA). Clustered standard error was used to account for clustering within families. A two-sided p value of < 0.05 was considered significant.

3. Results

We identified 84,911 children who were born between April 2012 and December 2014. Of these, 49,326 had a father and mother living in the same insured household. We then excluded multiples ($n = 1113$) and those withdrawn from insurance during the first 12 months ($n = 1,782$, including 42 infants who died), leaving 46,431 infants for our analysis.

Baseline characteristics are shown in Table 1. The proportion of boys was 51.6%. First-born infants accounted for 41.4%, 42.4% were second-born infants, and 16.2% were third-born or later. The average age of fathers was 34.5 years (standard deviation, 5.6 years), and 62.7% of fathers were in their 30s. The average age of mothers was 32.9 years (standard deviation, 4.9 years), and 65.6% of mothers were in their 30s. A total of 7606 infants (16.4%) first visited outpatient clinics or emergency rooms because of wounds/fractures, burns, or foreign bodies during their first year of life. The numbers (proportions) of wounds/fractures, foreign bodies, and burns were 5824 (12.5%), 1170 (2.5%), and 1034 (2.2%), respectively.

Table 2 shows the age in months of infants with each type of nonfatal injury. Overall, 21.7% of infants were aged ≤ 4 months when their first nonfatal injury requiring a hospital visit occurred. Among those with wounds/fractures, foreign bodies, and burns, the proportions of infants aged ≤ 4 months were 25.8%, 7.3%, and 6.9% respectively, and the proportions of infants aged ≤ 7 months were 50.1%, 20.1%, and 28.8%, respectively.

Table 3 details the characteristics of infants who received wound treatments. Second-born and third-born and later infants received wound treatments more often than first-born infants, and boys received wound treatments more often than girls.

Table 4 details the characteristics of infants who received burn treatments. Third-born and later infants received burn treatments more often than first and second-born infants. There was no significant difference in boys and girls with respect to burn treatments.

Table 5 presents the results of Cox regression analyses for each injury. Birth order was associated with wounds/fractures and foreign bodies, with first-born status being significantly associated with increased hazard of first visit in the first year of life. Although not significant, being the second-born was associated with a decreased hazard of a first hospital visit because of burns compared with the first-born. Infants' sex was not associated with the risk of wounds/fractures, foreign bodies, or burns. Differences according to mother's age were only associated with burns.

Matching within families yielded 1161 pairs of first- and second-born infants. The results of Cox regression analysis in the siblings are shown in Table 6.

First-born infants experienced wounds/fractures and burns significantly earlier than second-born infants, although there was no significant difference in foreign bodies. Boys tended to experience burns earlier than girls, but the difference was not significant. There was also no significant association between infant's sex and the occurrence of wounds/fractures or foreign body injuries.

Table 1
Baseline characteristics of all infants and those with nonfatal injuries from birth to 12 months.

	Total (n = 46,431)		Wounds/fractures (n = 5824)		Foreign bodies (n = 1170)		Burns (n = 1034)	
	n	(%)	n	(%)	n	(%)	n	(%)
Sex								
Boy	23946	(51.6)	3071	(52.7)	628	(53.7)	561	(54.3)
Girl	22485	(48.4)	2753	(47.3)	542	(46.3)	473	(45.7)
Birth order								
First	19216	(41.4)	3018	(51.8)	554	(47.4)	462	(44.7)
Second	19689	(42.4)	2125	(36.5)	475	(40.6)	394	(38.1)
Third and later	7256	(16.2)	681	(11.7)	141	(12.1)	178	(17.2)
Age of father, years								
≤24	1241	(2.7)	183	(3.1)	45	(3.8)	47	(4.5)
25–29	7406	(16.0)	1039	(17.8)	204	(17.4)	182	(17.6)
30–34	15790	(34.0)	2011	(34.5)	409	(35.0)	367	(35.5)
35–39	13325	(28.7)	1561	(26.8)	303	(25.9)	241	(23.3)
≥40	8669	(18.7)	1030	(17.7)	209	(17.9)	197	(19.1)
Age of mother, years								
≤24	2001	(4.3)	278	(4.8)	69	(5.9)	67	(6.5)
25–29	9686	(20.9)	1364	(23.4)	260	(22.2)	234	(22.6)
30–34	17549	(37.8)	2149	(36.9)	423	(36.2)	389	(37.6)
35–39	12921	(27.8)	1535	(26.4)	301	(25.7)	242	(23.4)
≥40	4274	(9.2)	498	(8.6)	117	(10.0)	102	(9.9)

Table 2
Age in months of infants with nonfatal injuries from birth to 12 months (n = 46,431).

Age (months)	Wounds/Fractures			Foreign bodies			Burns			Any injuries		
	n	(%) ^a	(%) ^b	n	(%) ^a	(%) ^b	n	(%) ^a	(%) ^b	n	(%) ^a	(%) ^b
0	140	0.3	2.4	23 ^c	0.0	2.4	12 ^c	0.0	1.3	146	0.3	1.9
1	253	0.8	6.7							281	0.9	5.6
2	339	1.6	12.6	19	0.1	3.6	18	0.0	2.9	375	1.7	10.5
3	352	2.3	18.6	24	0.1	5.6	22	0.1	5.0	395	2.6	15.7
4	420	3.2	25.8	19	0.2	7.3	19	0.1	6.9	456	3.6	21.7
5	458	4.2	33.7	25	0.2	9.4	45	0.2	11.2	522	4.7	28.6
6	433	5.2	41.1	40	0.3	12.8	71	0.4	18.1	527	5.8	35.5
7	520	6.3	50.1	85	0.5	20.1	111	0.6	28.8	695	7.3	44.7
8	533	7.4	59.2	136	0.8	31.7	133	0.9	41.7	761	9.0	54.7
9	583	8.7	69.2	186	1.2	47.6	133	1.2	54.6	844	10.8	65.8
10	577	9.9	79.1	240	1.7	68.1	153	1.5	69.4	893	12.7	77.5
11	596	11.2	89.4	196	2.1	84.9	154	1.9	84.2	850	14.5	88.7
12	620	12.5	100	177	2.5	100	163	2.2	100	861	16.4	100

^a Cumulative proportion among all participants.

^b Cumulative proportion among infants who experienced injuries by 12 months.

^c Numbers combined to avoid identification of individuals.

Table 3
Infants' characteristics and requirement for wound treatment (n = 5824).

	Total (N = 5824)	Received wound treatment (N = 460)		p
	n	n	(%)	
Sex				<0.001
Boy	3071	276	(9.0)	
Girl	2753	184	(6.7)	
Birth order				<0.001
First	3018	181	(6.0)	
Second	2125	201	(9.5)	
Third and later	681	78	(11.5)	

Table 4
Infants' characteristics and requirement for burns treatment (n = 1034).

Variable	Total (N = 1034)	Received burns treatment (N = 598)		p
	n	n	(%)	
Sex				0.447
Boy	561	326	(58.1)	
Girl	473	272	(57.5)	
Birth order				0.014
First	462	253	(54.8)	
Second	394	225	(57.1)	
Third and later	178	120	(67.4)	

4. Discussion

To the best of our knowledge, this is the first study describing nonfatal injuries by infant age in months in a large-scale longitudinal cohort. We clarified the timings of first visits to outpatient clinics or emergency rooms because of injuries among infants. A total of 46,431 infants were included in the study, corresponding to 1.7% of the total number of live births in Japan during the 33-month period. The proportion of boys/girls, birth order, and the average age of mothers were similar to the results

obtained in the 2013 Vital Statistics of Japan [13]. Therefore, the participants were representative of the general Japanese population. Approximately 16% of the infants first visited a hospital within 1 year after birth because of wounds/fractures, foreign bodies, or burns. One-fifth of these injuries occurred within 4 months after birth, and approximately 45% occurred within 7 months.

A child's injury is closely related to their developmental stage. Four months after birth is one of the milestones, when infants start to hold up their own head and roll over [14]. Therefore, many of the wounds or

Table 5

Cox regression analysis of first hospital visit because of wounds/fractures, foreign bodies, and burns (n = 48,213).

Variable	Wounds/ fractures	Foreign bodies	Burns
	OR (95%CI)	OR (95%CI)	OR (95%CI)
Sex			
Girl	ref	ref	ref
Boy	1.04 (0.99–1.10)	1.10 (0.98–1.23)	1.11 (0.98–1.26)
Birth order			
First-born	ref	ref	ref
Second-born	0.67 (0.63–0.71)	0.85 (0.76–0.96)	0.88 (0.77–1.00)
Third-born and later	0.56 (0.52–0.61)	0.67 (0.56–0.81)	1.08 (0.91–1.29)
Age of mother (years)			
≥24	ref	ref	ref
25–29	1.10 (0.96–1.25)	0.83 (0.64–1.10)	0.73 (0.55–0.95)
30–34	1.02 (0.90–1.20)	0.76 (0.59–0.98)	0.67 (0.51–0.87)
35–39	1.05 (0.91–1.18)	0.76 (0.59–0.99)	0.56 (0.42–0.73)
≥40	1.00 (0.86–1.16)	0.89 (0.66–1.20)	0.72 (0.52–0.98)

OR, odds ratio; CI, confidential interval.

Table 6

Cox regression analysis of first hospital visit because of wounds/fractures, foreign bodies, and burns in sibling comparison (n = 2322).

Variable	Wounds/fractures	Foreign bodies	Burns
	OR (95%CI)	OR (95%CI)	OR (95%CI)
Boys	1.01 (0.79–1.30)	0.96 (0.59–1.55)	1.64 (0.97–2.77)
Second-born	0.65 (0.51–0.83)	1.05 (0.66–1.67)	0.54 (0.32–0.90)

OR = odds ratio, CI = confidential interval.

fractures that occurred within 4 months of birth would be attributable to the care or environmental arrangement provided by caregivers. Previous studies showed that falls from beds, sofas, and caregivers were frequent causes of injury in infants [8,15,16]. Although the reasons for the wounds/fractures in this study cannot be identified, they may include falls which could occur through the behavior of parents or caregivers, such as leaving infants lying on sofas.

Of infants with first visits to hospitals within 12 months because of foreign bodies and burns, 20.1% and 28.8%, respectively, did so within 7 months of age. Foreign bodies and burns are common yet preventable in infants [12]. The risk of foreign bodies and burns are commonly considered to increase after an infant learns to pull to stand, widen their field of view, and grasp objects. These correspond to the developmental stage of around 8–10 months of age [14]. However, 75% of infants can reach for things at around 5 months of age, sit without support at 6 months, and rake raisins in at 7 months [14]. Infants can do more than their caregivers may anticipate and can be surrounded by possible causes of injury. Therefore, foreign bodies and burns that occur within 7 months of birth would likely include those caused by unsafe caregiving.

Compared with the second-born status, we found that being the first-born was significantly associated with an increased hazard of wounds/fractures and burns during the first year of life; these results were also confirmed by our sibling comparison. However, second-born children received treatment for injuries more often in their first hospital visits. Although first-born infants tended to experience outpatient clinics or emergency rooms visits earlier than second-born infants, the extent of injury may have been milder in first-borns.

There are several possible reasons why first-borns visited a hospital for the first time earlier than second-born or later infants. First, parents raising a child for the first time may not have been able to create a safe

environment or take care of their infant safely. Second, parents of first-borns may be highly sensitive to their infant's injuries. Additionally, it may have been easier to take infants to hospital without another child to take care of. In the case of foreign bodies, our sibling comparison result differed from our full-sample analysis in that birth order was not associated with an increased risk of injury. This could be explained by the difficulties experienced by families with other children in providing a safe environment that eliminates dangerously small items. Additionally, there may be increased opportunities for infants to imitate their brothers or sisters. Therefore, the risk of encountering foreign bodies may have increased for second-born infants in this subgroup.

Infants depend almost entirely on their caregivers to conduct daily activities, and the safety of children during the first 12 months depends primarily on safe rearing and environments [12,17]. Indeed, many wounds/fractures, foreign bodies, and burns that occur earlier than expected for the developmental stage are likely preventable by taking adequate safety measures.

In Japan, the infant health check-up at 4 months of age is often the first opportunity to provide parents with information about injury prevention. These checks cover more than 95% of infants in the municipality [18] and often provide information about injury prevention through group education. However, parents may not have received any information about injury prevention until this check-up. A previous study [19] of parents who attended the 4-month check-up revealed that they had insufficient awareness of injury prevention because they believed that "4-month-old infants do not move". The results of the present study suggest that education about injury prevention should be provided to parents earlier than is currently the case. In particular, additional basic knowledge about the child's injury prevention may be warranted for first-time parents.

One possible opportunity for early education is during pregnancy. This is the time when the maternal role is acquired [20,21], and home visit intervention during this period was reported to have a positive effect on parenting practices to prevent childhood injuries [22]. However, individual education can be resource-consuming [23]. Group education is suitable to provide information about injuries that anyone can experience, and feasible under resource constraints. Therefore, group education during pregnancy such as maternity class and couple class may be accessible and cost-effective opportunities for early education.

In light of the results of this study, future education should include the fact that infants who cannot yet roll over do sustain injuries and that infants who cannot move may sustain wounds or burns. Previous studies have identified several effective or promising interventions for prevention of childhood injuries [1], such as stair gates and guards, separation of cooking areas from living areas, child-resistant packaging of medicine and lighters, and safer stoves and kettles. Information about achieving a safer environment and using safer products may be useful for pregnant women preparing to care for a baby. Also, information on injuries caused by childcare products used immediately after childbirth, such as head trauma caused by falls from a crib or sofa [8,24,25], should be provided. Most importantly, safety practices for which there is good evidence should be adopted and communicated according to the culture and context of each country.

There are some limitations of this study. First, the database is composed of household members enrolled in the same insurance. Because we included the households which had father and mother in the same insurance, the results may not be applicable to single parents or those enrolled in different insurances. Studies have suggested that a single parent status is a risk factor for infant safety [26,27] and the inclusion of high-risk families may result in further increases in early injuries. Second, injuries were identified by diagnoses recorded in the claims data. We could not describe the situations in which injuries occurred, and our results may include injuries that were not preventable. Information such as the time, place, and cause of injury are important to improve preventive measures. Also, although the insurers cover most medical services, conditions treated without seeking medical services

(e.g., those treated by items purchased in pharmacies) could not be identified. Such minor injuries may have occurred even earlier. Third, although the basic characteristics of participants were similar to those in nationwide data, we were unable to obtain their socioeconomic statuses. Finally, this study was conducted in Japan, so the results may not be applicable to countries with different cultural backgrounds or healthcare systems.

5. Conclusion

This study found that one-fifth of infants who visited outpatient clinics or emergency rooms for the first time because of wounds/fractures, foreign bodies, and burns did so within 4 months of birth. Moreover, being the first-born infant was associated with an increased risk of obtaining wounds/fractures and burns. Earlier opportunity to obtain basic knowledge about children's injuries may lead to injury prevention.

Ethical approval

This study was approved at the institution of the first author.

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Declaration of competing interest

None declared.

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