

## Unintentional Injury Deaths among Children: A Descriptive Study Using Medico-legal Documents in Okayama Prefecture, Japan (2001–2015)

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According to the World Health Organization's World Report, approx. 950,000 children and young people < 18 years old die from an injury each year, and unintentional injury deaths account for a large portion of these cases. Here we used medico-legal documents to epidemiologically analyze the cases of unintentional injury deaths among children < 5 years old in Okayama Prefecture, Japan from 2001 to 2015. Age, sex, manner/cause of death, and various circumstances of the incident were investigated. There were 73 unintentional injury deaths during the study period. Drowning (n=29), suffocation (n=24), and transport accidents (n=13) were the major categories of unintentional injury deaths. Twenty-two cases (30.1%) were autopsied. Differences in the characteristics of the unintentional injury deaths by age were observed. Information which cannot be obtained from Vital Statistics was available from medico-legal documents, and detailed characteristics of unintentional injury deaths among children < 5 years old were elucidated. Investigating medico-legal information is one of the meaningful measures for the prevention of unintentional injury deaths among children in Japan.

**Key words:** child death, unintentional injury, prevention, medico-legal document

According to the World Health Organization (WHO) World Report on Child Injury Prevention, tens of millions of children who need hospital care for non-fatal injuries exhibit permanent impairment, and approx. 950,000 children and individuals < 18 years old die from an injury each year worldwide ([http://whqlibdoc.who.int/publications/2008/9789241563574\\_eng.pdf?ua=1](http://whqlibdoc.who.int/publications/2008/9789241563574_eng.pdf?ua=1), accessed on September 7, 2018). This report also says that injury — which is defined as the damage caused by acute exposure to a physical agent or as a result of a sudden lack of an essential agent ([http://www.who.int/violence\\_injury\\_prevention/media/en/136.pdf](http://www.who.int/violence_injury_prevention/media/en/136.pdf), accessed on September 7, 2018) — is the major cause of death in

childhood throughout the world, and unintentional injury deaths account for a large portion of these cases. The WHO stresses the importance of the prevention of unintentional injury deaths of children.

In Japan, a project named Healthy Parents and Children 21 was launched by the Ministry of Health, Labour and Welfare in 2000. According to the 2013 report on this project, mortalities from transport accidents and drowning at swimming pools were greatly decreased in 2012 compared to those in 2000 (<http://www.mhlw.go.jp/file/04-Houdouhappyou-11908000-Koyoukintoujidoukateikyoku-Boshihokenka/0000034788.pdf>, accessed on September 7, 2018). Some studies also reported that the rate of unintentional injury deaths among children < 5 years old

Received September 21, 2018; accepted November 28, 2018.

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Conflict of Interest Disclosures: No potential conflict of interest relevant to this article was reported.

dropped recently [1,2], although this rate has been high in Japan compared to other developed countries for many years [3].

Sekii *et al.* reported that the majorities of deaths in childhood were due to transport accidents, other accidental threats to breathing, and accidental drowning and submersion during the years 2000 to 2009 in Japan, according to the classification of unintentional injury in Japan's Vital Statistics reports [1]. Sekii *et al.* also stated that the mortality among children aged 1 to 4 years decreased by almost half during the study period [1]. However, the reports cited above lack information about regional differences, because only the Vital Statistics of the entire country were used. Some researchers reported that the characteristics of injury deaths were different at different areas in the same country [4,5]. Saeki *et al.* emphasized the necessity of investigating regional differences of unintentional injury deaths [6].

In Japan, there is no legislative framework like the Child Death Review used in other developed countries, in which the circumstances of child deaths, *e.g.*, the site and time of death, family status, and so on are investigated with the goal of preventing child deaths [7]. However, legal constraints in Japan make it difficult to obtain information about child deaths [8]. In fact, reports on unintentional injury deaths among children in Japan have been limited to those from single institutions such as single hospitals [9,10]. Under these circumstances, it would be meaningful to elucidate regional characteristics of unintentional injury deaths among children by analyzing detailed information other than Vital Statistics for the design of effective preventive measures. In the present study, we epidemiologically analyzed the cases of unintentional injury deaths among children <5 years old in one prefecture in Japan by using medico-legal documents.

## Materials and Methods

We extracted the cases of unintentional injury deaths among children <5 years old from the 32,852 unexpected deaths reported to the police from 2001 to 2015 in Okayama Prefecture, Japan (population approx. 1.9 million). We used 2 types of medico-legal documents: lists of unexpected deaths, and records of medico-legal autopsies in Okayama Prefecture. The deceased's age, sex, manner/cause of death, and cir-

cumstances of the incident such as its place and date of collected cases were investigated from the lists of unexpected deaths.

Unintentional injury deaths were classified into the following 7 categories according to the condensed list of causes of death for Japan ([http://www.e-stat.go.jp/SG1/estat/GL08020101.do?\\_toGL08020101\\_&tstatCode=000001028897&requestSender=dsearch](http://www.e-stat.go.jp/SG1/estat/GL08020101.do?_toGL08020101_&tstatCode=000001028897&requestSender=dsearch), accessed on September 7, 2018), presented here with the categories' respective International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10) codes (<https://www.cms.gov/Medicare/Coding/ICD10/Downloads/2018-ICD-10-CM-Coding-Guidelines.pdf>, Accessed November 26, 2018): (1) transport accidents (V01–V99), (2) falls (W00–W19), (3) accidental drowning and submersion (drowning) (W65–W74), (4) accidental threats to breathing (suffocation) (W75–W84), (5) exposure to smoke, fire or flames (fire) (X00–X09), (6) accidental poisoning by and exposure to noxious substances (poisoning) (X40–X49), and (7) other accidents (the rest of W00–X59).

If a medico-legal autopsy was conducted for a death, we also obtained the height and weight of the deceased, his/her medical history and physical condition before death, time of day of the incident, the length of time between when the deceased was last known to be alive and the time that he or she was found injured or dead, and the family structure including the ages of family members. Maternity records were also collected in the cases of infant (aged <1 year) if available. The flow chart of the collection of unintentional injury deaths among children <5 years old is shown in Fig. 1.

The study was approved by the Ethics Committee of the Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences (approval no. 896).

## Results

There were 73 unintentional injury deaths (50 males and 23 females) during the study period (2001 to 2015). Drowning ( $n=29$ ), suffocation ( $n=24$ ), and transport accidents ( $n=13$ ) were the 3 major categories of unintentional injury deaths; these 3 categories accounted for 90.4% of the deaths (Table 1). After these 3 categories, 4 fire-based deaths, 2 falls, and 1 case in which a television fell on an infant's head were observed. There was no case of death by poisoning. The highest annual

number of deaths was 11 in 2005, and it tended to decrease until 2007, after which little change was observed with 5 or less deaths each year (Fig.2). The analysis of the collected cases by age revealed that 80% (16/20) of the infants' unintentional deaths was due to suffocation. The most common cause of death among

the children other than infants was drowning, and the number of deaths at each age is shown in Table 1.

The number of autopsied cases was 22 of the 73 cases (30.1%). The autopsy rates were 17.2% in the drowning cases (5/29) and 50.0% in the suffocation cases (12/24). None of the transport accident or fall cases was autopsied, whereas all of the fire cases were autopsied (Table 2). The autopsy rate by age was 60.0% (12/20) among the infants and 18.9% (10/53) among the children aged 1 to 4 years.

In the group of 29 drowning cases (23 males and 6 females), a higher proportion occurred in a bathtub as the site of death among the children aged 0 to 1 year. In contrast, among the children aged  $\geq 2$  years, the drowning occurred outside (Table 3). Three of the 5 drowning cases in bathtubs occurred during the child's bathing, and in the other 2 cases the child fell down into a bathtub filled with hot water. In the cases of drowning outside, no incident occurred while the child was swimming in the water; all of the cases were falls into ditches, ponds or natural water when the child was playing or walking around the water. Of the 15 cases of drowning in ditches, 13 (86.7%) occurred between June and September, which is the season when rice fields are irrigated from ditches in Okayama Prefecture.

Our analysis of the 24 suffocation cases (17 males and 7 females) showed that two-thirds (16) of the cases involved infants, and half of these 16 cases were due to smothering (Table 3). Five of these 8 smothering cases occurred in infants < 5 months old who were in a prone position when they were found. Among the other 8 suffocation cases (in non-infants), 3 deaths were due to the aspiration of food. The aspirated food was nuts or a

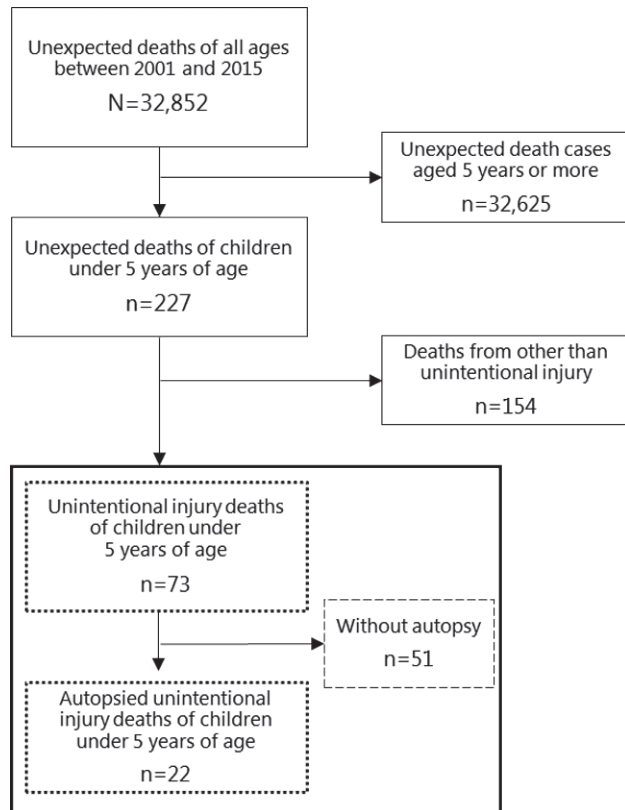


Fig. 1 Case inclusion/exclusion criteria.

Table 1 The number of unintentional injury deaths among children < 5 years old by sex and age in Okayama Prefecture, Japan (2001-2015)

	Sex		Age					Total
	Male	Female	0	1	2	3	4	
Transport accidents	8 (16.0)	5 (21.7)	2 (10.0)	2 (22.2)	1 (10.0)	3 (18.8)	5 (27.8)	13 (17.8)
Falls	0 (0.0)	2 (8.7)	0 (0.0)	0 (0.0)	0 (0.0)	2 (12.5)	0 (0.0)	2 (2.7)
Drowning	23 (46.0)	6 (26.1)	1 (5.0)	5 (55.6)	6 (60.0)	8 (50.0)	9 (50.0)	29 (39.7)
Suffocation	17 (34.0)	7 (30.4)	16 (80.0)	2 (22.2)	2 (20.0)	3 (18.8)	1 (5.6)	24 (32.9)
Fire	2 (4.0)	2 (8.7)	0 (0.0)	0 (0.0)	1 (10.0)	0 (0.0)	3 (16.7)	4 (5.5)
Poisoning	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other accidents	0 (0.0)	1 (4.3)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)
<b>Total</b>	<b>50</b>	<b>23</b>	<b>20</b>	<b>9</b>	<b>10</b>	<b>16</b>	<b>18</b>	<b>73</b>

Percentage figures of each sex group or age group are described in parentheses.

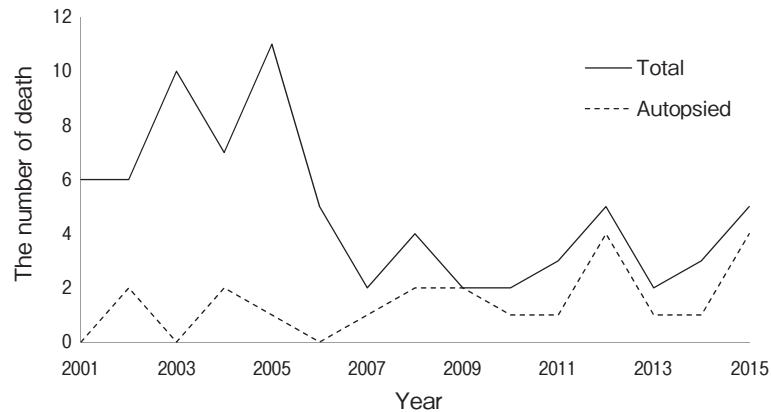


Fig. 2 Annual numbers of unintentional injury deaths among children < 5 years old in Okayama Prefecture, Japan (2001–2015).

Table 2 Autopsies of unintentional injury deaths among children < 5 years old in Okayama Prefecture, Japan (2001–2015)

	0 year old	1 year old	2 years old	3 years old	4 years old	All ages
Transport accidents	0/2	0/2	0/1	0/3	0/5	0/13
Falls	0/0	0/0	0/0	0/2	0/0	0/2
Drowning	1/1	0/5	1/6	1/8	2/9	5/29
Suffocation	10/16	0/2	1/2	1/3	0/1	12/24
Fire	0/0	0/0	1/1	0/0	3/3	4/4
Poisoning	0/0	0/0	0/0	0/0	0/0	0/0
Other accidents	1/1	0/0	0/0	0/0	0/0	1/1
Total	12/20	0/9	3/10	2/16	5/18	22/73

The denominators and the numerators are respectively the number of cases and the number of autopsied cases.

piece of apple. There were 2 cases of suffocation due to malfunctions of an artificial ventilator and 1 case of sudden deterioration during the implementation of mucus aspiration. These 3 children had required respiratory management because of a congenital anomaly or perinatal accident. Most of the suffocation cases occurred at the child's own home with various cause of deaths. Of the 3 cases that did not occur at home, 2 cases occurred at the grandparents' home due to food aspiration and 1 case occurred in a car due to thoracic compression.

The 13 transport accidents (8 males and 5 females) consisted of 3 car occupants and 10 pedestrians. The car occupants were 2 infants and a 1-year-old child, and the pedestrians were children aged  $\geq 1$  year (Table 3). A child safety seat was not used in the cases of 2 of the 3 car occupants. Eight of the 10 pedestrian deaths occurred during the hours from sunrise to sunset. Three were collisions with a train on the railway track. One case was that of a 4-year-old child in a collision

with a truck while playing in the street.

Table 4 summarizes the details of the 22 autopsied cases (13 males and 9 females). More than half of the incidents (63.6%) occurred during daytime (6 AM to 6 PM). The length of time between the time point at which the child was last known alive and the time point at which he or she was found injured or dead ranged from 0 to 6.5 h, which depended on characteristics of the cases. The heights and weights of all children at autopsy were within the normal range of physical growth. Several children had a notable medical history or physical condition before death, as shown in Table 4. Among the 22 autopsied cases, 17 of the children had siblings, and there were 2 or more siblings in 7 of these cases. The siblings' age information was obtained in 16 cases, and 13 of the deceased children had older siblings. Eight of the 10 infants in the suffocation group had siblings. The ages of the mothers at the delivery of the 8 infants was  $28.2 \pm 5.1$  (mean  $\pm$  SD) years old. There were 3 single-parent households.

**Table 3** Characteristics of the three major categories of unintentional injury deaths among children < 5 years old in Okayama Prefecture, Japan (2001–2015)

	0 year old	1 year old	2 years old	3 years old	4 years old	Total
Drowning (n = 9)						
Site						
Ditch		2 (40.0)	4 (66.7)	4 (50.0)	5 (55.6)	15 (51.7)
Bathtub	1 (100.0)	3 (60.0)			1 (11.1)	5 (17.2)
Farm pond			1 (16.7)	1 (12.5)	2 (22.2)	4 (13.8)
Natural water			1 (16.7)	2 (25.0)		3 (10.3)
Others*				1 (12.5)	1 (11.1)	2 (6.9)
Suffocation (n = 24)						
Cause						
Smothering	8 (50.0)			1 (33.3)		9 (37.5)
Obstruction of respiratory tract (gastric contents)	6 (37.5)					6 (25.0)
Obstruction of respiratory tract (food)		2 (100.0)	1 (50.0)			3 (12.5)
Obstruction of respiratory tract (other objects)	1 (6.3)					1 (4.2)
Accidental hanging and strangulation				1 (33.3)		1 (4.2)
Suffocation caused by thoracic compression	1 (6.3)					1 (4.2)
Others†			1 (50.0)	1 (33.3)	1 (100.0)	3 (12.5)
Transport accidents (n = 13)						
Car occupant collision with						
Car, pick-up truck or van	2 (100.0)					2 (15.4)
Heavy transport vehicle		1 (50.0)				1 (7.7)
Pedestrian collision with						
Car, pick-up truck or van		1 (50.0)		2 (66.7)	3 (60.0)	6 (46.2)
Heavy transport vehicle					1 (20.0)	1 (7.7)
Railway train or railway vehicle			1 (100.0)	1 (33.3)	1 (20.0)	3 (23.1)

Percentage figures of each age group are described in parentheses.

\*Others included tank for irrigation and garden pond.

†Others included malfunctions of artificial ventilator (2 cases) and sudden deterioration during implementing a mucus aspiration (1 case) in children who had needed respiratory managements because of congenital anomaly or perinatal accident.

Among the 29 cases of drowning, 5 were autopsied (Table 4). Two of the children drowned in bathtubs when they were left alone for a few minutes: a 10-month-old girl who was left in a floating device for 2 min when her mother took her twin sister out of the bathroom (case 1), and a 4-year-old boy who took a bath with his old siblings' supervision while his mother was at work and was left alone for 5 min (case 5). Two incidents occurred while the children's mothers were away in a single-parent household. Two cases of drowning in a ditch occurred as part of the same incident; both children fell into a ditch near a park where they had played together (cases 3 and 4). They had left the park without their parents' supervision and reached the ditch by going through a 40-cm interspace between fences that were installed along the ditch.

Autopsies were conducted in 12 of the 24 suffoca-

tion cases (Table 4). Among the 10 infant suffocation cases, maternity records could be obtained in 8 cases, of which the birth height and weight were  $49.1 \pm 1.6$  cm and  $3,113.3 \pm 285.2$  g (mean  $\pm$  SD), respectively. These 8 infants were delivered at term with not abnormality or inborn error of metabolism. In 3 cases, the deceased was found dead in the prone position during sleep (cases 6, 8 and 9), and they apparently were unable to roll over. A parent co-slept with the infant in 2 cases (cases 6 and 8). In 4 of the 7 incidents that occurred during the daytime (other than during napping/sleeping), the infant was left alone for >20 min: just after feeding (case 10), in a prone position although he could not roll over (case 7), on a mattress and found dead on the floor (case 12), and in a crib with many brackets and other bedding sets (case 14).

Two of the 4 fire cases were caused by a child playing

Table 4 Descriptions of 22 autopsied unintentional injury deaths among children &lt; 5 years old in Okayama Prefecture, Japan (2001–2015)

	Age (Month)	Sex	Time of day of the incident*	Time length between the child last known to be alive and found (h)	Site of the incident	Height at autopsy (cm)	Weight at autopsy (kg)	Medical history	Physical condition before death	Siblings		Age of mother	Single-parent household	Position of infant at found dead†
										Number	Age			
Drowning														
1	0 (10)	F	Night	0.03	Home (Bath tub)	69	7.2	-	-	2	1, 0 (Twin)	26	No	No
2	2	F	Night	6.5	Ditch	90	14	-	-	0	-	33	Yes	Prone
3	3	M	Afternoon	1.5	Ditch	99	16.6	-	-	0	-	34	No	Prone
4	4	M	Afternoon	1.5	Ditch	105	17.7	-	-	1	0	25	No	Prone
5	4	M	Night	0.08	Home (Bath tub)	110	16.6	Neonatal asphyxia	-	2	6, 13	41	Yes	Prone
Suffocation														
6	0 (2)	M	Midnight	4.83	Home	60	4.6	-	-	1	1	27	No	Prone
7	0 (3)	M	Afternoon	0.5	Home	63	6.94	-	-	0	-	19	No	Prone
8	0 (3)	M	Midnight	3.38	Home	65	7.14	-	-	0	-	23	No	Prone
9	0 (4)	M	Morning	2.75	Home	63	7.5	-	-	1	4	31	No	Prone
10	0 (5)	M	Afternoon	0.33	Home	67	6.9	-	-	2	13, 9	33	No	Prone
11	0 (6)	M	Morning	0.17	Car	72	10	-	-	1	NA	24	Yes	Prone
12	0 (6)	F	Afternoon	1	Home	70	7.5	-	-	1	2	23	No	Prone
13	0 (8)	F	Morning	0.08	Home	68	7.6	Alimentary allergy	Vaccination	1	3	33	No	Prone
14	0 (8)	M	Afternoon	2	Home	70	7.8	-	Cold	2	2, 3	25	No	Prone
15	0 (9)	F	Morning	NA	Home	68	7.4	-	-	2	2, 3	27	No	Spine
16	2	F	Night	0	Home	81	16	Hypoxic encephalopathy, epilepsy	Ventilator use	0	-	39	No	Prone
17	3	M	Afternoon	3.5	Home	104	19	Hypoxic encephalopathy	Ventilator use	1	0	31	No	Prone
Fire														
18	2	F	Morning	-†	Home	-†	-†	Neonatal convulsion	-	2	9, 11	37	No	No
19	4	F	Night	-†	Home	-†	-†	-	-	3	6, 7, 10	35	No	No
20	4	M	Afternoon	-†	Home	-†	-†	-	-	1	5	27	No	No
21	4	M	Midnight	-†	Home	-†	-†	Fever convulsion	-	1	0	30	No	No
22	0 (2)	F	Night	0	Home	59	5	-	-	1	2	31	No	No

NA, not available. \* Midnight (12:01 AM to 6 AM), Morning (6:01 AM to 12 noon), Afternoon (12:01 PM to 6 PM), and Night (6:01 PM to 12 midnight). †Victims were found after the fire was extinguished. ‡Smothering cases among infants.

with fire, and the other 2 deaths were due to another type of accidental fire.

## Discussion

The number of unintentional injury deaths in Okayama Prefecture decreased during the years 2001 to 2015. This tendency is consistent with previous reports [1]. As Sekii *et al.* also observed [1], differences in the characteristics of unintentional injury deaths by age were also observed in the present study: the sites of the drowning, the causes of suffocation, and the scenarios in the transport accident cases. Other studies have also described variations in of unintentional injury deaths among children by age [11, 12].

Our analysis of the cases of drowning revealed that the drownings occurred mainly in bathtubs among the 0- to 1-year-old children, but in ditches among the 2- to 4-year-old children. These results are in stark contrast to the report by Suzuki *et al.* [13], who found that most of the drowning deaths among children < 5 years old occurred in a bathroom. This discrepancy in case characteristics might be explained by the difference in the areas investigated. Suzuki *et al.* analyzed the cases in Tokyo, a metropolitan area with 13.7 million residents. Our case series was drawn from one of the western parts of Japan, Okayama Prefecture, with the far lower population of 1.9 million.

Our comparison of the urban and rural areas in Okayama Prefecture showed that the mortality rate from drowning in the rural areas tended to be higher than the rate in urban areas, although the difference was not significant (data not shown). Other studies have also revealed differences

in the characteristics of unintentional injury deaths between urban and rural areas [4,5]. Regarding the present study's cases of drowning in a ditch, 13 of the 15 cases occurred between June and September. This might be associated with the agricultural circumstances in Japan. In these 4 months, the ditches used to irrigate rice fields are filled with water. Naci *et al.* reported a relationship between the mortality rate from drowning among males aged 1 to 4 years and the geographic areas that are dotted with such ditches in the Newly Independent States and Russian Federation [14]. They also pointed out that educational interventions for children and adults and the addition of fences along ditches could be beneficial to prevent child drownings [14]. Their suggestions could also be beneficial in Japan.

In the present study's cases of suffocation, the main cause was smothering among the infants but food aspiration among the children aged 1 to 4 years. Among the smothering cases, 5 infants aged < 5 months were found in a prone position. The American Academy of Pediatrics has repeatedly emphasized the importance of a safe sleep environment for children — including not leaving infants in the prone position — for the prevention of sleep-related deaths [15]. Unfortunately, the frequency of infantile injury deaths by smothering in the prone position in the present study was high (5/8 cases). It would be beneficial to thoroughly educate Japanese parents regarding what constitutes a safe sleep environment for infants. According to Suzuki's report, suffocation was the major category of unintentional injury deaths among infants in the special wards of Tokyo [13]. Consistent with that report, our present analyses demonstrated that suffocation accounted for 80% of the unintentional injury deaths in infants. We did not observe a difference in the mortality rate due to suffocation between the urban and rural areas in Okayama Prefecture (data not shown). This might be because there was only one case of suffocation in a rural area, and most of the suffocation cases occurred at home.

Suffocation by food aspiration was documented in 3 of the present cases among the children aged 1 to 4 years; the aspirated foods were nuts or a piece of apple. It is reported that the education of parents and caregivers regarding the selection of appropriate food is necessary to prevent infant and child deaths from aspiration [16,17]. In these reports, the following foods were referred to as high-risk: hot dogs, candies, raw carrots,

nuts, apples, and similar foods. The U.S. Centers for Disease Control (CDC) also lists those foods mentioned above as choking hazards [<https://www.cdc.gov/nutrition/infantandtoddlernutrition/foods-and-drinks/choking-hazards.html>, accessed on November 1, 2018]. Tanaka *et al.* reported that in Japan, accidental aspiration or suffocation was experienced in approx. 17% of children aged 2 to 6 years, and more than half of mothers might underestimate the risk of suffocation [18]. Our present findings revealed the importance once again of informing both parents and other caregivers about the risk of food aspiration, as has been pointed out [16,17].

We found that in the present transport accident group, the 0- to 1-year-old children were mostly occupants of a car, whereas the 2- to 4-year-old children were pedestrians. In Japan, it has been mandatory since 2000 to keep a child under 6 years of age in a safety seat in a moving vehicle, and Inoue *et al.* reported that an increase in the use of child safety seats could decrease the number of deaths of children as car occupants [19]. Our present results demonstrated that the ratio of children who had died as car occupants without using safety seats was 2 : 3. Promoting the use of child safety seats is likely to contribute to reduce the number of child deaths in transport accidents. Children who could move around by themselves were likely to be involved in transport accidents as pedestrians in this study. Although the importance of the close supervision of a child by caregivers for the prevention of injuries has been emphasized [20], we observed some fatal cases of child pedestrians with inadequate/inappropriate supervision. For example, as noted earlier, a 4-year-old-boy was hit by a truck while under the supervision of his father, who had let the child play in the street. Our comparison of urban and rural areas in Okayama Prefecture showed that the transport accident mortality rate tended to be higher in the rural areas compared to the urban areas (data not shown); however, there was only one case of a transport accident in a rural area. We did not observe a significant difference in this mortality rate between urban and rural areas, but our sample size may be too small to detect such a difference.

In our investigation of the autopsied cases, more information that could not be obtained from Vital Statistics was available in the cases of drowning and suffocation. In the autopsied drowning cases, the limits

of supervision were highlighted: 1 parent taking care of 2 children at the same time, and during a parent's absence in single-parent households. A pitfall of the prevention of unintentional injuries was also recognized: even though fences were installed along the ditch, 2 children who unexpectedly had gotten through an interspace between the fences (which seemed narrow enough for adults) drowned in the ditch. Not only the importance of supervision but also a pitfall of a prevention strategy which seemed effective [14] should be emphasized to parents.

Among the present autopsied suffocation cases of infants, the parents co-slept with infants in two-thirds of the suffocation during sleep cases. Co-sleeping is known as a risk for accidental suffocation [15], but it might not be familiar enough among Japanese parents. Schnitzer *et al.* reported that less supervision increased the injury severity among children aged  $\leq 4$  years, and they proposed that close supervision by parents/caregivers was the most important to reduce the injury risk among children [20]. However, our present findings indicated a lack of supervision in some cases. Regarding the cases of suffocation that occurred during the daytime, children who had been left unsupervised for longer than 20 min accounted for 4 of the 7 deaths. It was also reported that the presence of older siblings increased this risk, by impairing the parent's adequate supervision [21]. In the present investigation, of the 10 suffocation cases in infants, older sibling(s) were present at the death in 8 cases.

All 4 deaths due to fire in this study were autopsied. According to Istre *et al.*, smoke alarms were not sufficient to prevent fires created by children playing with fire, and more extensive education of children and their parents about the danger of playing with fire could be effective [22]. Our present analyses elucidated that the cause of fire was the child playing with fire in 2 of the 4 autopsied cases, which also emphasizes the need for such education.

To prevent unintentional injury, close supervision has been shown to be important [20], but we found that many cases in each category of unintentional injury death had occurred without caregivers' supervision in this study. We propose that caregivers (including grandparents) need to be reminded of the significance of close supervision for unintentional injury prevention.

An advantage of this study was that detailed infor-

mation from 2 types of medico-legal documents was available, unlike prior studies that used only the Vital Statistics information from Japan's government [1,2]. We found that the use of autopsy documents was informative; with them, we were able to determine how the incidents of unintentional injury had occurred, including, notably, the lack of supervision by caregivers. As with the study by Suzuki *et al.* [13], our investigation revealed the effectiveness of analyzing medico-legal documents for the prevention of unintentional injury deaths among children, because in Japan a review process of child deaths has not been established and the access to such information is limited [8,23].

Another advantage of this study is that the practical scenario of unintentional injury deaths among the children in one prefecture (somewhat similar to a state in the U.S.) was elucidated. Several studies reported that characteristics of such deaths and their prevention methods differed among regional areas even when these deaths were investigated in the same country [4-6].

However, our study has several limitations. First, the unintentional injury deaths covered in this study were only cases that were reported to the police. Although a Japanese law requires that a report of an unexpected death be submitted to the police, we could not exclude the possibility that there were some unreported cases. Second, the number of cases in this study was small ( $n = 73$ ). This is in part because the study was of a single region, and the number of unintentional injury deaths has dropped recently in Japan [1]. Third, the autopsy rates varied depending on the categories of unintentional injury deaths and age. Because more detailed information can be obtained from autopsy medico-legal documents, the variation in the autopsy rate might have resulted in an uneven amount of information among the investigated cases and death categories. It was reported that the education level and occupation of parents were related to the cause of unintentional injury deaths [24]. However, we could not obtain the socioeconomic status of the victims' families from medico-legal documents. This is an additional study limitation.

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