

## Infant Suffocation Incidents Related to Co-Sleeping or Breastfeeding in the Side-Lying Position in Japan

Chitaru Tokutake,<sup>1</sup> Akiko Haga,<sup>1</sup> Kesami Sakaguchi,<sup>1</sup> Atsuko Samejima,<sup>1</sup>  
Miki Yoneyama,<sup>1</sup> Yoshiharu Yokokawa,<sup>1</sup> Masayoshi Ohira,<sup>1</sup> Motoki Ichikawa<sup>1</sup> and  
Makoto Kanai<sup>1</sup>

<sup>1</sup>School of Health Sciences, Shinshu University School of Medicine, Matsumoto, Nagano, Japan

Co-sleeping and breastfeeding in the side-lying position have recently been pointed out as risk factors for suffocation in sleeping infants; however, there is no actual report on an "incident." "Incident" is defined as a tense or sobering experience without a consequential fatal suffocation accident. It is important to understand infant suffocation incidents to prevent accidents during co-sleeping and breastfeeding in the side-lying position. We investigated factors and frequency of infant suffocation incidents associated with co-sleeping and breastfeeding in the side-lying position using a self-administered questionnaire survey of 895 mothers during their infant's 1-, 4-, or 10-month health checkups. Co-sleeping and breastfeeding in the side-lying position were practiced by 28.3% and 56.0% of mothers, respectively; thus, 84.3% of the mothers surveyed were practicing either co-sleeping or breastfeeding in the side-lying position. Of those who received guidance from a medical professional, 36.1% practiced only co-sleeping while 60.1% practiced only side-lying breastfeeding. In the co-sleeping group, 10.6% had faced infant suffocation incidents, while 13.2% in the breastfeeding in the side-lying position group had faced similar incidents. Regarding factors associated with suffocation incidents while co-sleeping, the frequency of occurrence was significantly more in mothers of 1-month and 4-month-old infants compared with those of 10-month-old infants. Of mothers who faced suffocation incidents while breastfeeding in the side-lying position, 45% also had faced similar incidents while co-sleeping. These results demonstrate the importance of thoroughly educating mothers about the risks associated with co-sleeping and breastfeeding in the side-lying position for preventing infant suffocation.

**Keywords:** breastfeeding in the side-lying position; co-sleeping; incident; infant; suffocation  
Tohoku J. Exp. Med., 2018 October, 246 (2), 121-130. © 2018 Tohoku University Medical Press

### Introduction

In Japan, infants and mothers co-sleep as part of common practice since ancient times, and mothers and infants usually sleep in the face-to-face position. As of 2008-2009, at least 70% of infants in Japan reportedly co-sleep with their parents (Shimizu et al. 2014). In addition, breastfeeding in the side-lying position, while co-sleeping is commonly practiced as it is comfortable for both the mother and the child and allows the mother to easily observe the infant's condition (Ball 2002).

However, co-sleeping has recently been recognized as one of the risk factors associated with infant suffocation during sleeping (American Academy of Pediatrics 2005, 2011, 2016). According to vital statistics for 2016

(Ministry of Internal Affairs and Communications Statistics Bureau 2016), suffocation accounted for > 80% of accidental infant deaths, which is the fourth-leading cause of infant deaths; accidental infant deaths caused by suffocation occurred most frequently during sleeping. Takatsu et al. (2007) investigated the details of 184 infants who died of accidental suffocation while sleeping during 1982-2006, and reported that most of the cases involved infants within the age span of birth to 6 months. The mortality associated with infants who were co-sleeping was 10.2-times higher than that of those who were not co-sleeping. Similar findings have been reported in other countries. In the UK, Weber et al. (2012) analyzed how infants died of suffocation during 1996-2005 and pointed out that more than half of these deaths occurred while co-sleeping in an adult bed.

---

Received August 7, 2018; revised and accepted October 3, 2018. Published online October 24, 2018; doi: 10.1620/tjem.246.121.

Correspondence: Chitaru Tokutake, School of Health Sciences, Shinshu University School of Medicine, 3-1-1 Asahi, Matsumoto, Nagano 390-8621, Japan.

e-mail: ctokuta@shinshu-u.ac.jp

Makoto Kanai, M.D., Ph.D., School of Health Sciences, Shinshu University School of Medicine, 3-1-1 Asahi, Matsumoto, Nagano 390-8621, Japan.

e-mail: makotok@shinshu-u.ac.jp

While previous reports, including those cited in the present study, reveal the cause of death as co-sleeping on the basis of analysis following infant death; no previous reports are present on actual incidents of infant suffocation occurring in the home during co-sleeping/breastfeeding in the side-lying position. To the best of our knowledge, this is representing the first such report.

In this study, we investigated the frequency of incidents and factors associated with infant suffocation incidents caused by co-sleeping or breastfeeding in the side-lying position in mothers of 1-, 4-, and 10-month-old infants. For this study, “co-sleeping” has been defined as a mother sleeping next to her infant, while “breastfeeding in the side-lying position” refers to breastfeeding while co-sleeping. In addition, “incident” is defined as a tense or sobering experience that did not lead to a fatal suffocation accident and, according to Heinrich’s law (Heinrich 1941), defined as the equivalent of “No-injury Accident.”

## Materials and Methods

### Participants

After an explanation of the main purpose of the study to 1,223 mothers visiting an obstetric medical institution and a health center for the infant’s 1-, 4-, or 10-month health checkups between January and September 2011 in a city in Japan, we distributed copies of self-administered questionnaire forms. Mothers were requested to return the completed form anonymously through a dedicated collection box or via mail. Responses were received from 974 mothers (79.6%). Of the 974 responses, after questionnaires with missing data were excluded, we used 895 for the analysis (valid response rate of 91.9%).

### Methods

The survey gathered information regarding age of mother, parity of mother, birth weight of the infant, method of delivering nutrition to the infant, mother’s hours of sleep, infant bedding, and items related to co-sleeping and breastfeeding in the side-lying position (whether mothers practiced co-sleeping/breastfeeding in the side-

lying position, whether guidance was given by medical professionals, what the mother paid attention to, and incidents related to infant suffocation).

### Statistical analysis

Data analysis was performed by simple aggregation, one-way analysis of variance (unpaired), Student’s t-test (unpaired), and chi-squared test ( $2 \times 2/2 \times 3$  groups) using SPSSver22.0. In the chi-squared test, intergroup significance probability was calculated after confirming significant differences among the three groups. For this study, the significance level was set at 5%.

### Ethical considerations

Subjects were informed that participation in the study was voluntary and that they would not be disadvantaged even if they refused to participate in the study. All the subjects provided their personal information anonymously, and none of them were identifiable. Submitting a response meant consent to study participation. The institutional review board at Shinshu University approved the study’s protocol (approval number 1632).

## Results

### Subjects’ background

Backgrounds of the subjects are presented in Table 1. The mean age of the mothers was 31.8 years. In all age groups, approximately half of the mothers were primiparous. Regarding infant feeding methods, 63.7% (570) of the mothers were breastfeeding, and 36.3% (325) were mixed/bottle-feeding. No significant differences were noted regarding background among the three infant age-based groups.

### Items related to sleeping environments of mothers and infants and the extent of the practice of co-sleeping or breastfeeding in the side-lying position

Characteristics related to sleeping environments of mothers and infants are presented in Table 2. The mean

Table 1. Subjects’ background.

Characteristics	Total (n = 895)	1-month-old infants (n = 325)	4-month-old infants (n = 288)	10-month-old infants (n = 282)	p value
Mother					
Age (year $\pm$ SD)	31.8 $\pm$ 4.8	31.9 $\pm$ 5.1	31.4 $\pm$ 4.6	32.1 $\pm$ 4.8	0.149
Parity (% , n)					
Primipara	51.3 (459)	52.3 (170)	49.7 (143)	51.8 (146)	0.791
Multipara	48.7 (436)	47.7 (155)	50.3 (145)	48.2 (136)	
Infant					
Birth weight (g $\pm$ SD)	3,012 $\pm$ 396	2,994 $\pm$ 387	2,989 $\pm$ 385	3,055 $\pm$ 416	0.356
Feeding methods (% , n)					
Breastfeeding	63.7 (570)	60.0 (195)	62.8 (181)	68.8 (194)	0.075
Mixed milk	36.3 (325)	40.0 (130)	37.2 (107)	31.2 (88)	

Data are provided as mean  $\pm$  SD or % (n). SD, standard deviation.

Calculated by Chi-squared test ( $2 \times 3$  groups) and one-way analysis of variance (unpaired).

Table 2. Items related to sleeping environments of mothers and infants and the extent of the practice of co-sleeping/breastfeeding in the side-lying position.

Items	Total (n = 895)	1-month-old infants (n = 325)	4-month-old infants (n = 288)	10-month-old infants (n = 282)	p value
Mother's hours of sleep (h/day $\pm$ SD)	6.1 $\pm$ 1.3	5.6 $\pm$ 1.3	6.3 $\pm$ 1.2	6.3 $\pm$ 1.1	a,b: < 0.001***
Infant bedding (%), n					
With parents	58.4 (523)	44.9 (146)	56.3 (162)	76.2 (215)	a: 0.007**
Separate from parents(%), n	41.6 (372)	55.1 (179)	43.7 (126)	23.8 (67)	b,c: < 0.001***
Whether mothers practiced (%), n					
Not performed	15.7 (141)	20.3 (66)	18.7 (54)	7.4(21)	
Only co-sleeping	28.3 (253)	33.5 (109)	29.2 (84)	22.3 (60)	b,c:
Breastfeeding in the side-lying position	56.0 (501)	46.2 (150)	52.1 (150)	71.3 (201)	< 0.001*** <sup>1)</sup>

Data are mean  $\pm$  SD or % (N). SD, standard deviation.

Calculated by chi-squared test ( $2 \times 3$  groups) and one-way analysis of variance (unpaired). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined.

a: 1-month-old infants vs. 4-month-old infants, b: 1-month-old infants vs. 10-month-old infants, c: 4-month-old infants vs. 10-month-old infants. \*\* $p < 0.01$ , \*\*\* $p < 0.001$ . <sup>1)</sup>only co-sleeping vs. breastfeeding in the side-lying position.

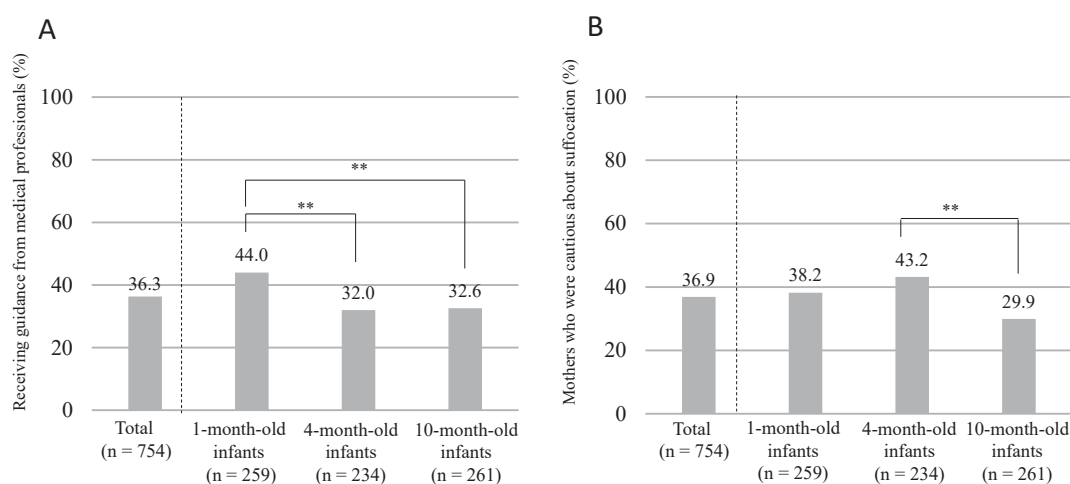


Fig. 1. Co-sleeping.

The vertical axis indicates frequency (%). The horizontal axis indicates values of the total and 1-, 4-, and 10-month-old infants. Data indicate frequency (%). Data analysis was performed by chi-square test ( $2 \times 3$  groups). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined. \*\* $p < 0.01$ . (A) Receiving guidance from medical professionals and (B) mothers who were cautious about suffocation.

sleeping time of mothers with 1-month-old infants was 5.6 hours, which was significantly shorter than the 6.3 hours for mothers with 4- and 10-month-old infants.

The percent of infants sharing bedding with parents increased significantly with age: 44.9% at 1 month; 56.3% at 4 months; and 76.2% at 10 months. In response to the question of whether co-sleeping or breastfeeding in the side-lying position was practiced regularly, 15.7% of the mothers responded as neither, 28.3% as co-sleeping only, and 56.0% as breastfeeding in the side-lying position. On examining the data based on infant age, 71.3% of mothers of 10-month-old infants were breastfeeding in the side-lying position, which was significantly higher than that for

mothers of 1- and 4-month-old infants.

We also examined the conditions under which the 754 mothers practiced co-sleeping or breastfeeding in the side-lying position (Figs. 1 and 2). Concerning the question of whether specific guidance and warnings were provided by medical professionals (physicians, midwives, public health nurses, and nurses) regarding co-sleeping, only 36.3% of the mothers had received guidance about co-sleeping. More than 60% of the mothers had not received any guidance. When guidance from medical professionals are analyzed according to the infant's age, 32.0% of mothers with 4-month-old infants and 32.6% of mothers with 10-month-old infants received guidance which was significantly lower

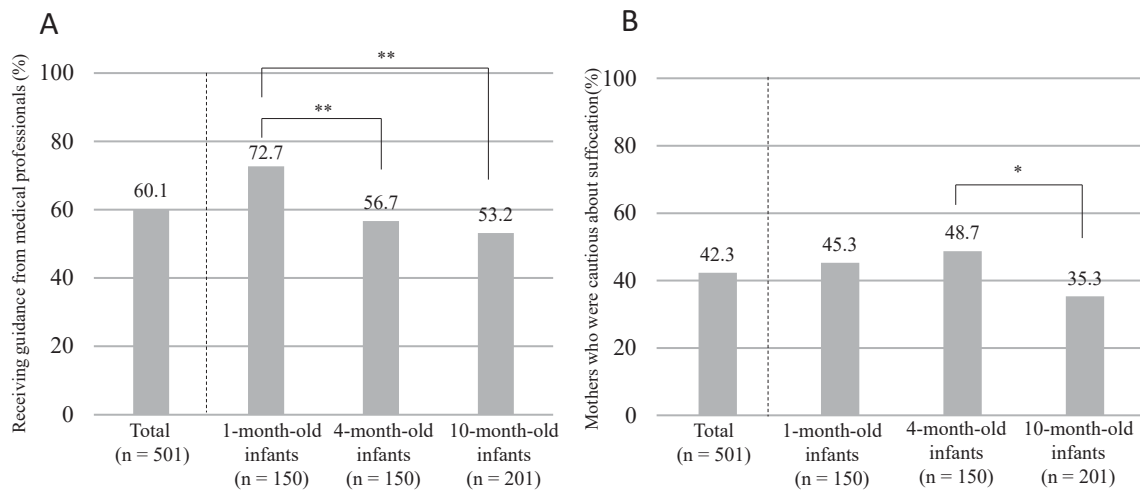


Fig. 2. Breastfeeding in the side-lying position.

The vertical axis indicates frequency (%). The horizontal axis indicates the values of the total and 1-, 4-, and 10-month-old infants. Data analysis was performed by chi-square test ( $2 \times 3$  groups). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined.  $*p < 0.05$ ,  $**p < 0.01$ . (A) Receiving guidance from medical professionals and (B) Mothers who were cautious about suffocation.

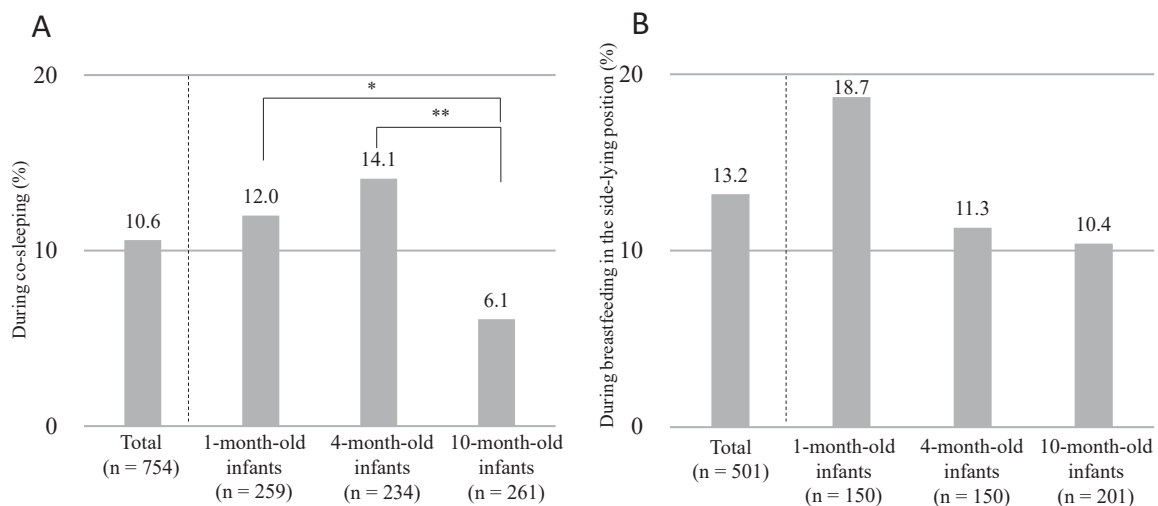


Fig. 3. Frequency of infant suffocation incidents.

The vertical axis indicates frequency (%). The horizontal axis indicates the values of the total and 1-, 4-, and 10-month-old infants. Data analysis was performed by chi-square test ( $2 \times 3$  groups). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined.  $*p < 0.05$  and  $**p < 0.01$ . (A) During co-sleeping and (B) During breastfeeding in the side-lying position.

that guidance given to 44.0% of mothers with infants at 1-month (Fig. 1A). As for the frequency at which mothers were cautious about suffocation during co-sleeping, 29.9% of mothers of 10-month-old infants were paying attention which was significantly lower in comparison with 43.2% of mothers with 4-month-old infants (Fig. 1B).

The overall frequency of receiving guidance from medical professionals about breastfeeding in the side-lying position was 60.1%. When analyzed by infant age, 56.7% of mothers with 4-month-old infants and 53.2% of mothers with 10-month-old infants had received guidance. These figures were significantly lower than the 72.7% of mothers

with 1-month-old infants (Fig. 2A). The frequency with which mothers of 10-month-old infants paid attention during breastfeeding in the side-lying position was 35.3%, which was significantly lower than the 48.3% for mothers with 4-month-old infants (Fig. 2B).

#### *Frequency of infant suffocation incidents during co-sleeping or breastfeeding in the side-lying position*

Frequencies of infant suffocation incidents during co-sleeping or breastfeeding in the side-lying position are presented in Fig. 3. Overall, of the mothers ( $n = 754$ ) who had experienced infant suffocation incidents while co-sleeping,

10.6% of mothers who were co-sleeping without breastfeeding in the side-lying position had experienced incidents of infant suffocation. Twelve percent of mothers with 1-month-old and 14.1% of 4-month-old infants experienced incidents of infant suffocation which was significantly higher than that experienced by 6.1% of mothers with 10-month-old infants. However, the difference between mothers with 1-month-old infants and mothers with 4-month-old infants was not significant (Fig. 3A). Specifically, incidents where “bedding or surrounding materials covered infant’s mouth or nose” accounted for 58.8% of the total number of incidents of suffocation, followed by “I (mother) fell asleep before the infant,” which accounted for 21.3%.

Next, infant suffocation incidents during breastfeeding in the side-lying position were experienced by 13.2% in total (experienced when mothers breastfeeding in the side-lying position [ $n = 501$ ] were breastfeeding in the side-lying position). By infant age, mothers of 1-month-old infants (18.7%), mothers of 4-month-old infants (11.3%), and mothers of 10-month-old infants (10.4%) experienced incidents of potential infant suffocation at comparable frequencies with no significant differences (Fig. 3B). Specifically, incidents where “I (mother) fell asleep before the infant” accounted for 59.1% of the total number of incidents of suffocation, followed by “breast blocked infant’s nose”, which accounted for 22.7% of the incidents.

Importantly, no infant suffocation incident during co-sleeping or breastfeeding in the side-lying position actually

led to an infant suffocation.

#### *Factors related to infant suffocation incidents during co-sleeping/breastfeeding in the side-lying position*

Factors related to infant suffocation incidents during co-sleeping are shown in Table 3. Consequently, mothers of 1-month-old infants (38.8%) and 4-month-old infants (41.2%) experienced significantly more infant suffocation incidents than mothers of 10-month-old infants (20.0%).

Factors related to infant suffocation incidents during breastfeeding in the side-lying position are presented in Table 4. Regarding breastfeeding in the side-lying position, no significant differences were found for all variables for comparison.

#### *Frequencies of infant suffocation incidents during co-sleeping based on conditions of practicing breastfeeding in the side-lying position*

Fig. 4 shows frequencies of infant suffocation incidents during co-sleeping based on the conditions of practicing breastfeeding in the side-lying position. Of the mothers who faced incidents during breastfeeding in the side-lying position, 45.5% also faced incidents during co-sleeping, which was significantly higher than the 6.9% of mothers who did not face any incident and 7.9% of mothers who did not practice breastfeeding in the side-lying position.

## Discussion

In this study, we conducted a survey of 895 mothers

Table 3. Factors related to infant suffocation incidents during co-sleeping ( $n = 754$ ).

Factors	Sub items	Incidents of infant suffocation during co-sleeping		<i>p</i> value
		Incidents ( $n = 80$ )	No incidents ( $n = 674$ )	
Age of mother (year $\pm$ SD)		32.4 $\pm$ 4.1	31.8 $\pm$ 4.9	0.051
Parity (% , n)	Primipara	53.8 (43)	48.8 (329)	0.404
	Multipara	46.3 (37)	51.2 (345)	
Infant’s age (% , n)	1-month-old	38.8 (31)	33.8 (228)	1 M vs. 4 M: 0.569
	4-month-old	41.2 (33)	29.8 (201)	1 M vs. 10 M: 0.030*
	10-month-old	20.0 (16)	36.4 (245)	4 M vs. 10 M: 0.005**
Infant’s birth weight (g $\pm$ SD)		3,016 $\pm$ 333	3,009 $\pm$ 411	0.813
Infant’s feeding methods (% , n)	Breastfeeding	65.0 (52)	66.3 (447)	0.086
	Mixed milk	35.0 (28)	33.7 (227)	
Mother’s hours of sleep (h/day $\pm$ SD)		5.9 $\pm$ 1.4	6.1 $\pm$ 1.2	0.236
Infant bedding (% , n)	With parents	71.3 (57)	66.3 (447)	0.370
	Separate from parents	28.8 (23)	33.7 (227)	
Receiving guidance from medical professionals (% , n)	Yes	35.0 (28)	36.5 (246)	0.792
	No	65.0 (52)	63.5 (428)	

Data are mean  $\pm$  SD or % (n). SD, standard deviation.

Calculated by Chi-squared test ( $2 \times 2/2 \times 3$  groups) and Student’s t-test (unpaired). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined.

\* $p < 0.05$ , \*\* $p < 0.01$ .

Table 4. Factors related to infant suffocation incidents breastfeeding in the side-lying position (n = 501).

Factors	Sub items	Incidents of infant suffocation during breastfeeding in the side-lying position		p value
		Incidents (n = 66)	No incidents (n = 435)	
Age of mother (year $\pm$ SD)		32.8 $\pm$ 4.5	31.7 $\pm$ 4.8	0.514
Parity (% , n)	Primipara	48.5 (32)	45.7 (199)	0.678
	Multipara	51.5 (34)	54.3 (236)	
Infant's age (% , n)	1-month-old	42.4 (28)	28.0 (122)	0.058
	4-month-old	25.8 (17)	30.6 (133)	
	10-month-old	31.8 (21)	41.4 (180)	
Infant's birth weight (g $\pm$ SD)		3,003 $\pm$ 343	3,042 $\pm$ 368	0.748
Infant's feeding methods (% , n)	Breastfeeding	77.3 (51)	74.5 (324)	0.626
	Mixed milk	22.7 (15)	25.5 (111)	
Mother's hours of sleep (h/day $\pm$ SD)		6.1 $\pm$ 1.3	6.1 $\pm$ 1.3	0.978
Infant bedding (% , n)	With parents	69.7(46)	72.9 (317)	0.596
	Separate from parents	30.3 (20)	27.1 (118)	
Receiving guidance from medical professionals (% , n)	Yes	65.2 (43)	59.3 (258)	0.367
	No	34.8 (23)	40.7 (177)	

Data are mean  $\pm$  SD or % (n). SD, standard deviation.

Calculated by Chi-squared test ( $2 \times 2/2 \times 3$  groups) and Student's t-test (unpaired).

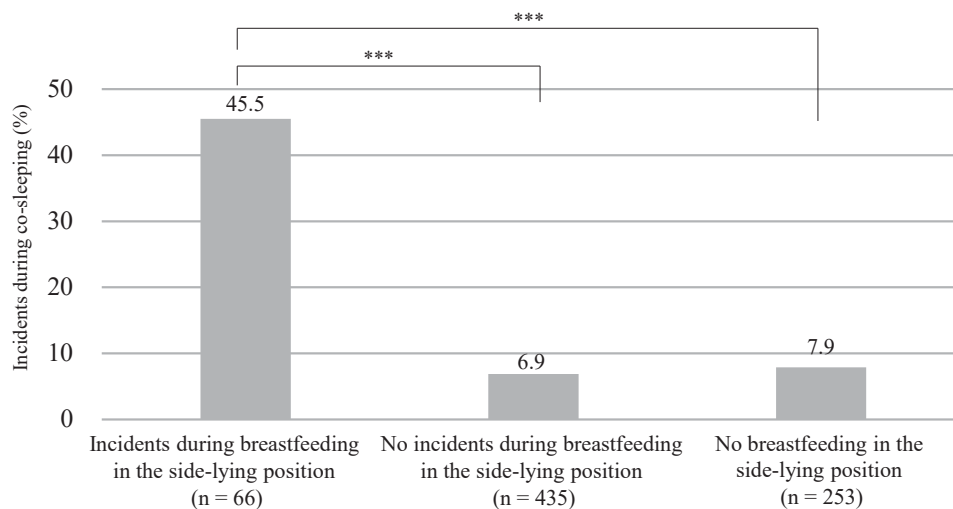


Fig. 4. Frequencies of infant suffocation incidents during co-sleeping based on conditions of practicing breastfeeding in the side-lying position.

The vertical axis indicates frequency (%) of incidents during co-sleeping. The horizontal axis indicates the values obtained during breastfeeding in the side-lying position (incidents, no incidents, no breastfeeding in the side-lying position). Data analysis was performed by chi-square test ( $2 \times 3$  groups). After confirming that there was a significant difference in the three groups, the significance probability among the groups was determined. \*\*\* $p < 0.001$ .

with infants regarding co-sleeping/breastfeeding in the side-lying position for investigating the frequency of incidents and factors related to infant suffocation in 754 mothers who were co-sleeping/breastfeeding in the side-lying position.

As the three groups of mothers in this survey shared a similar background with no significant intergroup differences in terms of mother's age, parity, or infant's birth weights, background variables were matched allowing for analysis of characteristics related to frequency of incidents of infant suffocation.

#### *The extent of co-sleeping or breastfeeding in the side-lying position*

In this study, more than 80% of mothers were co-sleeping which was similar to findings reported by previous surveys conducted in Japan (Iwata et al. 2013; Shimizu et al. 2014). This supports the conclusion that co-sleeping is widely practiced in Japan. Conversely, there are differences among countries in the extent of co-sleeping: 20%-30% of mothers in the UK (Blair and Ball 2004), 13.5%-40% in the United States (Tackett et al. 2010; Colson et al. 2013), 8.8%-19% in New Zealand (Hutchison et al. 2011), and



88% in China (Nelson et al. 2001). On the basis of these facts, co-sleeping is considered as a part of the Japanese culture and is commonly practiced. While there are no studies comparing the frequency of breastfeeding in the side-lying position by country, it was reported that approximately 40% of mothers in the US reportedly breastfeed during the night in the bed (Tackett et al. 2010). No previous reports exist on the frequency of breastfeeding in the side-lying position in Japan. In the present study, approximately 60% of mothers were breastfeeding in the side-lying position, suggesting that breastfeeding in the side-lying position is also commonly practiced in Japan.

*The necessity of guidance for mothers for the prevention of infant suffocation when co-sleeping or breastfeeding in the side-lying position*

In this study, 36.3% of co-sleeping mothers and 60.1% of mothers breastfeeding in the side-lying position had received guidance on specific ways of practicing this nursing method as well as caution on inherent risks from medical professionals. Approximately 40% of mothers were actively exercising caution. It is difficult to conclude that guidance on prevention of suffocation is being adequately provided. While there are no recommendations for preventing the suffocation of infants during sleeping in Japan, there has been a call for attention to this issue based on the Child Product Safety Guide (European Child Safety Alliance 2014) which specifies the following: ensuring that bedding or items do not block the mouth and nasal cavities; use of a hard mattress for infant bedding, and not falling asleep while co-sleeping. However, the call for attention does not include breastfeeding in the side-lying position. For this reason, we feel that it is necessary to provide knowledge regarding ways of preventing infant suffocation including suffocation during breastfeeding in the side-lying position.

*Frequency of incidents and factors related to infant suffocation during co-sleeping or breastfeeding in the side-lying position*

In this study, 10.6% of all mothers had infant suffocation incidents during co-sleeping. During co-sleeping, the infant's mouth and nasal cavities can be obstructed by bedding or objects when the mother and infant are close to each other. Furthermore, the significantly higher frequency of mothers with 1-month-old infants and 4-month-old infants experiencing incidents of infant suffocation compared with mothers of 10-month-old infants suggest a possible risk-based association with infant stage of growth and development. In general, infants can hold their head up in 3-4 months, can roll over in 5-6 months, and can sit up alone in 10 months (Ministry of Health, Labor and Welfare 2010). Until infants are able to move their own body and are capable of rolling over, they are unable to avoid danger (Colvin et al. 2014) and are likely at increased risk for suffocation from bedding covering mouth and nasal cavities. In addition, mothers become accustomed to the handling of infants

as the infant's age increases; it can be inferred that this is a factor in reducing risk of infant suffocation.

There were 21 reports of infant suffocation associated deaths/accidents with co-sleeping in Japan and other countries (Table 5: Nixon et al. 1995; Drago and Dannenberg 1999; Nakamura et al. 1999; Kemp et al. 2000; Thogmartin et al. 2001; Aoki et al. 2006; Takatsu et al. 2007; Kikuchi et al. 2008; Blabey and Gessner 2009; Senter et al. 2010; Weber et al. 2012; Brixey et al. 2011; Schnitzer et al. 2012; Suzuki et al. 2014; Colvin et al. 2014; Sauber-Schatz et al. 2015; Bugeja et al. 2016; Thompson and Moon 2016; Chu et al. 2016; Kassa et al. 2016; Gaw et al. 2017). Of the sudden unexpected infant deaths and accidental suffocation and strangulation in bed (ASSB, ICD-10-W75) incidents, 20%-80% occurred during co-sleeping. The mean age at the time of occurrence was 3.8 months in the United States (Gaw et al. 2017), while infants under 6 months were involved in more than 90% of deaths/accidents in Australia (Bugeja et al. 2016) consistent with more frequent occurrence at a lower age. On the basis of these reports and the results of the present study, co-sleeping was shown to increase the risk for infant suffocation incidents during early infancy, with some incidents potentially leading to deaths/accidents. Therefore, the decreasing frequency of incidents associated with co-sleeping can also lead to a decrease in deaths of infant suffocation associated with co-sleeping. The need to implement the aforementioned preventive measures is urgent.

In addition, 13.2% of the mothers in the survey faced incidents during breastfeeding in the side-lying position. Many of these incidents were attributed to the mother falling asleep before the infant. In all reported deaths/accidents caused by infant suffocation related to breastfeeding in the side-lying position, infant suffocation occurred after the mother fell asleep during breastfeeding in the side-lying position (Table 6: Abramson 1944; Byard 1998; Shigeta 2005; Hutchison et al. 2011; Feldman and White 2013; Hoffend and Spherhake 2014; Thach 2014). When breastfeeding in the side-lying position, the mother and infant are closer to each other than when co-sleeping. Furthermore, when the mother falls asleep during breastfeeding in the side-lying position, she may not notice the obstruction of the infant's mouth and nasal cavities early on; therefore, the risk of suffocation is likely to increase.

In this study, 45.5% of mothers who faced incidents during breastfeeding in the side-lying position also faced incidents during co-sleeping. This rate was significantly higher compared to mothers who do not have incident or mothers who do not breastfeed in the side-lying position. It can be inferred that mothers who have incidents during breastfeeding in the side-lying position may also be in close contact with the infant during co-sleeping; however, further investigations are required to address this point as no clear reasons could be identified in this study.

The incidence of infant ASSB in Japan was 2.5 per 100,000 births in 2016 (Ministry of Internal Affairs and

Table 5. Reports of infant suffocation death/accident associated with co-sleeping of Japan and foreign countries.

Reference (country)	Year	Year of research (Investigation period)	Infants age	Sample size(n)	Reports of infant suffocation death/accident associated with co-sleeping
Nixon et al. (UK)	1995	1990-1991 (2 years)	< 15 years old	Choking, suffocation, or strangulation (136)	29 cases (21.3%) of suffocation death; 12 of these patients (41.2%) were under 1 year. There are six cases of suffocation death (21.0%) and the cause was overlaying.
Drago and Dannenberg (The U.S.)	1999	1980-1997 (18 years)	< 1 year of age	Mechanical suffocation (2,178)	180 cases (8.3%) of overlaying; 70% patients were less than 3 months old.
Nakamura et al. (The U.S.)	1999	1990-1997 (8 years)	< 1 years of age	ASSB (515)	121 patients (23.5%) died because of overlaying by co-sleeping.
Kemp et al. (The U.S.)	2000	1994-1997 (4 years)	< 2 years of age	SUID (119)	56 cases (47.1%) of SUID were caused by co-sleeping.
Thogmartin et al. (The U.S.)	2001	1986-1999 (14 years)	< 1 year of age	SUID (217)	10/16 (62.5%) of ASSB were caused by co-sleeping.
Aoki et al. (Japan)	2006	1996-2006 (10 years)	< 2 years of age	Other ill-defined or unspecified causes (8)	5/8 unspecified causes were sleeping and 4 among these were caused by co-sleeping.
Takatsu et al. (Japan)	2007	1982-2006 (14 years)	Aged 7-365 days	Suffocation deaths (47)	Half of suffocation death group had taken co-sleeping. More than 90% patients were < 6 months old.
Kikuchi et al. (Japan)	2008	2006 (1 year)	< 1 year of age	Other ill-defined or unspecified causes (5)	There was one case of suffocation death as a mother's underlying by co-sleeping.
Blabey and Gessner (The U.S.)	2009	1992-2004 (12 years)	< 1 year of age	All infant deaths (891)	Among all infant deaths, co-sleeping was observed as a cause in 126 cases (37.9%).
Senter et al. (The U.S.)	2010	2000-2003 (2 years)	< 1 year of age	ASSB (19)	110 (87%) of these deaths were caused by co-sleeping with caretakers. Co-sleeping was the cause in 10 cases (52.6%).
Weber et al. (UK)	2012	1996-2005 (10 years)	Aged 7-365 days	"Unexplained SUID" (344)	17 patients (89.5%) were < 4 months old. 174 cases (55%) of unexplained SUID were caused by co-sleeping. SUIDs are frequent among infants < 6 months old.
Brixey et al. (The U.S.)	2011	2007-2008 (2 years)	< 1 year of age	ASSB (11)	Co-sleeping was observed in 10 cases (90.9%). Nine patients (81.8%) were within 3 months old.
Schnitzer et al. (The U.S.)	2012	2005-2008 (4 years)	< 1 year of age	Suffocation deaths (939)	More than 80% patients were < 6 months old. 574 (61%) patients co-slept, half of whom slept with adults.
Suzuki et al. (Japan)	2014	2006-2010 (5 years)	< 18 years old	Suffocation deaths (54)	50 cases (93%) occurred during sleep; 48 (89%) were < 1 year old. 40 cases (80%) of the deaths during sleep were caused by co-sleeping and in the facedown position.
Colvin et al. (The U.S.)	2014	2004-2012 (8 years)	< 1 year of age	SUID (8,207)	Co-sleeping within 3 months of age was observed in 73.8% cases, and half of the patients co-slept in an adult bed.
Sauber-Schatz et al. (The U.S.)	2015	2008 (1 year)	< 1 year of age	SUID (215)	Co-sleeping was observed in 117 cases (54.4%).
Bugeja et al. (Australia)	2016	2008-2010 (3 years)	< 1 year of age	ASSB (72)	Over 80% of co-sleeping was in an unsafe environment (adult bed and sofa). Co-sleeping was observed in 33 cases (45.8%).
Thompson and Moon (The U.S.)	2016	2008 (1 year)	< 1 year of age	Deaths (6) Injuries (20)	65 (90.3%) patients were < 6 months old. Suffocation death associated with co-sleeping was observed in five out of six (83%) cases. Seven out of 20 (35%) cases were associated with co-sleeping injuries.
Chu et al. (The U.S.)	2016	2004-2010 (7 years)	< 1 year of age	ASSB (255)	Co-sleeping was observed in 167 cases (80.8%).
Kassa et al. (The U.S.)	2016	2004-2014 (11 years)	< 1 year of age	ASSB (11,717)	Co-sleeping was observed in 5,348 cases (57.1%), and the use of adult beds was observed in 4,999 cases (53.4%).
Gaw et al. (The U.S.)	2017	2000-2012 (13 years)	< 1 year of age	ASSB (1,736)	The average monthly age of ASSB was 3.8 ± 2.5 months. 1,168 of 1,736 (67.3%) patients were < 5 months old.

SUID, sudden unexpected infant death; ASSB, accidental suffocation and strangulation in bed.

Table 6. Reports of infant suffocation death/accident associated with breastfeeding in the side-lying position in Japan and foreign countries.

Reference (country)	Year	Year of research (Investigation period)	Infants age	Sample size(n)	Infant suffocation death/accident reports associated with breastfeeding in the side-lying position
Abramson (The U.S.)	1944	1939-1943 (10 years)	< 1 year of age	Suffocation deaths (139)	19 cases (15%) had a cover over as a result of sleeping after breastfeeding in bed. All 19 patients were < 4 months old.
Byard (Australia)	1998	1996 (1 year)	< 1 year of age	SUID (3)	3 cases (10.7%) of SUIDs occurred during breast feeding in parents' bed. Both mothers were tired and slept while breastfeeding in both cases causing airway obstruction in the infants.
Shigeta (Japan)	2005	1982-2004 (23 years)	< 1 year of age	Suffocation deaths (44)	7 cases (15.9%) of death were caused when the infant was lying with their mothers; of which, 4 (57.1%) mothers fell asleep while breastfeeding. 13 cases (86.7%) had the mother overlaying the infants.
Hutchison et al. (New Zealand)	2011	2000-2009 (10 years)	Aged 7-365 days	SUID (221)	SUID with co-sleeping was observed in 121 cases (64%).
Feldman and White (Canada)	2013	Unknown	< 1 month of age	SUID (1) CP (1)	12 cases (9%) were caused by falling asleep while breastfeeding in the side-lying position.
Hoffend and Spherhake (Germany)	2014	1996-2011 (16 years)	< 7 days age	SUID (46)	2 cases mothers fell asleep while breastfeeding in the side-lying position.
Thach (UK)	2014	1999-2013 (14 years)	< 7 days age	SUID (16) Near deaths (2)	22 cases (48%) were co-sleeping on the bed with parents. 15 cases (32.6%), mothers fell asleep while breastfeeding in the side-lying position.

SUID, sudden unexpected infant death; ASSB, accidental suffocation and strangulation in bed; CP, cerebral palsy.

Communications Statistics Bureau 2016). Rates in other countries, such as, 23.0 in the United States in 2015 (Lambert et al. 2018) and 29.0 in New Zealand (The New Zealand Mortality Review Group 2016), were higher than

the rate in Japan, while the 1.9 in Canada (Gilbert et al. 2012) was similar to Japan. The incidence of ASSB in Japan is lower than in other countries, despite the fact, that co-sleeping is commonly practiced. We believe that this



may be attributed to the use of wide and relatively hard bedding (*futon*) used in Japan. With traditional Japanese bedding, mothers rarely place themselves over infants, while co-sleeping is often performed in a sofa or soft bedding in other countries (Tackett et al. 2010).

As deaths caused by co-sleeping/breastfeeding in the side-lying position are preventable, we believe they should not occur. While the incidence of ASSB is low in Japan, complete awareness of factors that lead to infant suffocation incidents associated with co-sleeping/breastfeeding in the side-lying position and increasing attention for the prevention of infant suffocation among mothers are crucial for preventing infant deaths as mothers customarily co-sleep/breastfeed in the side-lying position.

### Conclusions

In this study, we investigated the frequency of occurrence and factors related to infant suffocation associated with co-sleeping/breastfeeding in the side-lying position. Our conclusions are as follows:

1. Of the 895 survey responses, 28.3% (253) of mothers were co-sleeping only and 56.0% (501) of the mothers were breastfeeding in the side-lying position. In total, 84.3% were co-sleeping with the infant.

2. Of the mothers who had received specific guidance on co-sleeping as well as the risks of co-sleeping from medical professionals, 36.3% received guidance on co-sleeping and 60.1% on breastfeeding in the side-lying position.

3. Of the mothers surveyed, 10.6% and 13.2%, respectively, had infant suffocation incidents during co-sleeping and breastfeeding in the side-lying position.

4. Factors related to incident experiences during co-sleeping were significantly more for mothers with 1- or 4-month-old infants compared with mothers of 10-month-old infants. Regarding incidents experienced during breastfeeding in the side-lying position, no significant differences were found for all variables.

5. Of mothers who experienced incidents during breastfeeding in the side-lying position, 45.5% also faced similar incidents during co-sleeping. This frequency was significantly higher than that for mothers who had no incidents experience during breastfeeding in the side-lying position or mothers who did not breastfeed in the side-lying position.

These results indicate the importance of making mothers aware of the risk for infant suffocation before beginning the practice of co-sleeping, since co-sleeping with children in early infancy, such as at 1 month or 4 months of age, is a risk factor for infant suffocation incidents.

### Acknowledgments

We thank all the mothers who participated in this study. The study was supported by JSPS KAKENHI Grant Numbers JP22792217, JP17K12342.

### Conflicts of Interest

The authors declare no conflict of interest.

### References

- Abramson, H. (1944) Accidental mechanical suffocation of infants. *J. Pediatr.*, **25**, 404-413.
- American Academy of Pediatrics (2005) The changing concept of sudden infant death syndrome: Diagnostic coding shifts, controversies regarding the sleeping environment, and new variables to consider in reducing risk. *Pediatrics*, **116**, 1245-1255.
- American Academy of Pediatrics (2011) SIDS and other sleep related infant deaths: expansion of recommendations for a safe infant sleeping environment. *Pediatrics*, **128**, 1030-1039.
- American Academy of Pediatrics (2016) SIDS and other-related infant death: expansion of recommendation for a safe infant sleeping environment. *Pediatrics*, **138**, 1-12.
- Aoki, Y., Kanetake, J. & Takamiya, M. (2006) Differential diagnosis of exogenous death in sudden death autopsy cases of infants. *J. Jap. SIDS Res. Soc.*, **6**, 121-125 (in Japanese).
- Ball, D.H. (2002) Reasons to bed-share: why parents sleep with their infants. *J. Reprod. Infant. Psychol.*, **20**, 207-222.
- Blabey, M.H. & Gessner, D.G. (2009) Infant bed-sharing practices and associated risk factors among births and infant deaths in Alaska. *Public Health Rep.*, **124**, 527-534.
- Blair, P.S. & Ball, H.L. (2004) The prevalence and characteristics associated with parent-infant bed-sharing in England. *Arch. Dis. Child.*, **89**, 1106-1110.
- Brixey, S.N., Kopp, B.C., Schlotthauer, A.E., Collier, A. & Corden, T.E. (2011) Use of child death review to inform sudden unexplained infant deaths occurring in a large urban setting. *Inj. Prev.*, **17**, i23-27.
- Bugeja, L., Dwyer, J., McIntyre, S.J., Young, J., Stephan, K.L. & McClure, R.J. (2016) Sleep-related infant deaths in victoria: a retrospective case series study. *Matern. Child Health J.*, **20**, 1032-1040.
- Byard, R.W. (1998) Is breast feeding in bed always a safe practice? *J. Pediatr. Child Health*, **34**, 418-419.
- Chu, T., Hackett, M. & Kaur, N. (2016) Housing influences among sleep-related infant injury deaths in the USA. *Health Promot. Int.*, **31**, 396-404.
- Colson, E.R., Willinger, M., Rybin, D., Heeren, T., Smith, L.A., Lister, G. & Corwin, M.J. (2013) Trends and factors associated with bed-sharing: the national infant sleep position study (NISP) 1993-2010. *JAMA Pediatr.*, **167**, 1032-1037.
- Colvin, J.D., Collie-Akers, V., Schunn, C. & Moon, R.Y. (2014) Sleep environment risks for younger and older infants. *Pediatrics*, **134**, e406-e412.
- Drago, D.A. & Dannenberg, A.L. (1999) Infant mechanical suffocation deaths in the United States, 1980-1997. *Pediatrics*, **103**, e59.
- European Child Safety Alliance (2014) Child Product Safety Guide-European Child Safety Alliance. <http://www.childsafetyeurope.org/publications/info/product-safety-guide.pdf> [Accessed: July 30, 2018].
- Feldman, K. & White, R.K. (2013) Two cases of apparent suffocation of newborns during side-lying breastfeeding. *Nurs. Womens Health*, **17**, 337-341.
- Gaw, C.E., Chounthirath, T., Midgett, J., Quinlan, K. & Smith, G.A. (2017) Types of objects in the sleep environment associated with infant suffocation and strangulation. *Acad. Pediatr.*, **17**, 893-901.
- Gilbert, N.L., Fellb, D.B., Josephc, K.S., Liua, S., Leóna, J.A. & Sauved, R. (2012) Temporal trends in sudden infant death syndrome in Canada from 1991 to 2005: contribution of

- changes in cause of death assignment practices and in maternal and infant characteristics. *Paediatr. Perinat. Epidemiol.*, **26**, 124-130.
- Heinrich, H.W. (1941) *Industrial Accident Prevention: A Scientific Approach*, 2nd edition., McGraw-Hill Book Company, New York, pp.27.
- Hoffend, C. & Spherhake, J.P. (2014) Sudden unexpected death in infancy (SUDI) in the early neonatal period: the role of bed-sharing. *Forensic Sci. Med. Pathol.*, **10**, 157-162.
- Hutchison, B.L., Rea, C., Stewart, A.W., Koelmeyer, T.D., Tipene-Leach, D.C. & Mitchell, E.A. (2011) Sudden unexpected infant death in Auckland: a retrospective case review. *Acta Paediatr.*, **100**, 1108-1112.
- Iwata, S., Iwata, O. & Matsuishi, T. (2013) Sleep patterns of Japanese preschool children and their parents: implications for co-sleeping. *Acta Paediatr.*, **102**, e257-e262.
- Kassa, H., Moon, R.Y. & Colvin, J.D. (2016) Risk factors for sleep-related infant deaths in in-home and out-of-home settings. *Pediatrics*, **138**, 1-6.
- Kemp, L.S., Unger, B., Wilkins, D., Psara, R.N., Ledbetter, T.L., Graham, M.A., Case, M. & Thach, B.T. (2000) Unsafe sleep practices and an analysis of bed sharing among infants dying suddenly and unexpectedly: results of a four-year, population based, death-scene investigation study of sudden infant death syndrome and related deaths. *Pediatrics*, **106**, e41.
- Kikuchi, Y., Shigeta, A. & Fukunaga, R. (2008) Death cause analysis system for infant sudden death-Introduction of the current situation of the Tokyo Metropolitan Inspectorate-. *J. Jap. SIDS Res. Soc.*, **8**, 29-32 (in Japanese).
- Lambert, A.B., Parkc, S.E. & Shapiro-Mendosa, C.K. (2018) National and State trends in sudden unexpected infant death: 1990-2015. *Pediatrics*, **141**, 1-7.
- Ministry of Health, Labour and Welfare. (2010) National growth survey on preschool children Report.11-19. <http://www.mhlw.go.jp/toukei/list/dl/73-22-01.pdf> [Accessed: July 30, 2018] (in Japanese).
- Ministry of Internal Affairs and Communications Statistics Bureau. (2016) Vital statistics; Death by causes (the list of three-character categories), sex and age: Japan (2) ICD code V-Y, U. [https://www.e-stat.go.jp/en/stat-search/files?page=dataset&stat\\_infid=000031450317](https://www.e-stat.go.jp/en/stat-search/files?page=dataset&stat_infid=000031450317) [Accessed: July 30, 2018].
- Nakamura, S., Wind, M. & Danello, M.A. (1999) Review of hazard associated with children placed in adult beds. *Arch. Pediatr. Adolesc. Med.*, **153**, 1019-1023.
- Nelson, E.A., Taylor, B.J., Jenik, A., Vance, J., Walmsley, K., Pollard, K., Freemantle, M., Ewing, D., Einspieler, C., Engele, H., Ritter, P., Hildes-Ripstein, G.E., Arancibia, M., Ji, X., Li, H., et al. (2001) International child care practices study: infant sleeping environment. *Early Hum. Dev.*, **62**, 43-55.
- Nixon, J.W., Kemp, M.A., Lvne, S. & Sibert, J.R. (1995) Suffocation, choking, and strangulation in childhood in England and Wales: epidemiology and prevention. *Arch. Dis. Child.*, **72**, 6-10.
- Sauber-Schatz, E.K., Sappenfield, W.M. & Shapiro-Mendoza, C.K. (2015) Comprehensive review of sleep-related sudden unexpected infant deaths and their investigations: Florida 2008. *Matern. Child Health J.*, **19**, 381-390.
- Schnitzer, P.D., Covington, T.M. & Dykstra, H.K. (2012) Sudden unexpected infant deaths: Sleep environment and circumstances. *Am. J. Public Health*, **102**, 1204-1212.
- Senter, L., Sackoff, J., Landi, K. & Boyd, L. (2010) Studying sudden and unexpected infant deaths in a time of changing death certification and investigation practices: evaluating sleep-related risk factors for infant death in New York City. *Matern. Child Health J.*, **15**, 242-248.
- Shigeta, A. (2005) Infant mechanical suffocation death during sleeping and its risk factors -analysis of forensic autopsy cases-. *Tokyo Jikeikai Ika Daigaku Zasshi*, **120**, 167-175 (in Japanese).
- Shimizu, M., Park, H. & Greenfield, P.M. (2014) Infant sleeping arrangements and cultural values among contemporary Japanese mothers. *Front. Psychol.*, **5**, 1-10.
- Suzuki, H., Hikiji, W., Tanifuji, T., Abe, N. & Fukunaga, T. (2014) Child deaths from injury in the special wards of Tokyo, Japan (2006-2010): a descriptive Study. *J. Epidemiol.*, **24**, 178-182.
- Tackett, K.T., Cong, Z. & Hale, T.W. (2010) Mother-infant sleep locations and nighttime feeding behavior U.S. Data from the survey of mother's sleep and fatigue. *Clinical Lactation*, **1**, 27-31.
- Takatsu, A., Shigeta, A., Sakai, K. & Abe, S. (2007) Risk factors, diagnosis and prevention of sudden unexpected. *Leg. Med. (Tokyo)*, **9**, 76-82.
- Thach, B.T. (2014) Deaths and near deaths of healthy newborn infants while bed sharing on maternity wards. *J. Perinatol.*, **34**, 275-279.
- The New Zealand Mortality Review Group (2016) Child and Youth Mortality Review Committee 12th data report. [https://www.hqsc.govt.nz/assets/CYMRC/Publications/Child\\_and\\_Youth\\_Mortality\\_Review\\_Committee\\_s\\_12th\\_data\\_report\\_2011\\_15.pdf](https://www.hqsc.govt.nz/assets/CYMRC/Publications/Child_and_Youth_Mortality_Review_Committee_s_12th_data_report_2011_15.pdf) [Accessed: July 30, 2018].
- Thogmartin, J.R., Siebert, C.F. Jr. & Pellam, W.A. (2001) Sleep position and bed-sharing in sudden infant deaths: an examination of autopsy findings. *J. Pediatr.*, **138**, 212-217.
- Thompson, E.L. & Moon, R.Y. (2016) Hazard patterns associated with co-sleepers. *Clin. Pediatr.*, **55**, 645-649.
- Weber, M.A., Risdon, R.A., Ashworth, M.T., Malone, M. & Sebire, N.J. (2012) Autopsy findings of co-sleeping-associated sudden unexpected deaths in infancy: relationship between pathological features and asphyxial mode of death. *J. Paediatr. Child Health*, **48**, 335-341.