

# Asphyxial Deaths in Infants and Children

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**Asphyxia** is defined as inadequate oxygenation of tissue. It is the common endpoint in a variety of deaths in which the cells either fail to receive, or are unable to utilize, oxygen. Because of the innumerable pathways that lead to an asphyxial death, the classification of asphyxia may be broad and varied. Many deaths will not fit neatly into one of the categories below, as more than one asphyxial mechanism may come into play. The brain—although it accounts for only about 2% of the (adult) body weight—utilizes about 20% of the body's oxygen supply, and is therefore particularly susceptible to asphyxia. Even after respiratory arrest has occurred and the brain is irreversibly injured, the healthy heart may continue beating for many minutes.

## Classifying Asphyxia

**Suffocation:** deprivation of oxygen in the environment or blockage of the external or internal air passages

- Environmental
- Smothering
- Choking
- Mechanical
- Positional

**Strangulation:** Pressure on the neck (generally involving only the blood vessels, but sometimes the trachea)

- Hanging
- Ligature
- Manual
- 'Choke holds'

**Chemical:** Prevention of transport or utilization of oxygen at the cellular level

- Carbon monoxide
- Hydrogen cyanide
- Hydrogen sulfide

## Signs of Asphyxia

None of these are necessary for, or specific to, a diagnosis of asphyxia:

- Petechiae
  - Caused by an acute rise in venous pressure breaking small venules
  - Most often seen externally in the conjunctiva, oral mucosa, and facial skin; internally on the epicardium and visceral pleura
  - Petechiae are nonspecific! They can be seen in many circumstances; conversely, many obviously hypoxic deaths lack them
  - Petechiae can develop in dependent areas of the body after death
- Congestion and edema – nonspecific
- Cyanosis – nonspecific
- 'Engorgement of the right heart and fluidity of the blood' – nonspecific

***There is no postmortem laboratory test for hypoxia***



Florid forehead and periorbital petechiae in a young child who died of mechanical asphyxia. Such petechiae are fairly rare in most types of pediatric asphyxia.

## **SUFFOCATION**

### **Environmental**

Inadequate oxygen in the environment

Nearly all such cases will be accidental (rarely suicidal or homicidal)

Examples:

- reduction of oxygen in the environment (such as in an enclosed chamber where fungus has depleted the atmosphere of oxygen)
- sudden drop in partial pressure of oxygen (cabin failure in an aircraft)
- displacement of oxygen by another gas (such as by carbon dioxide in the base of a silo, well, or in an industrial dialysis tank)
- in the tanks of ships (where oxygen is incorporated into rust)
- being trapped in a restrictive environment (such as an older refrigerator)

Autopsy usually negative – would not expect petechiae

Diagnosis is made by circumstances, scene investigation, and exclusion of other causes

### **Smothering**

Mechanical obstruction of the nose and mouth

Cases may be accidental, homicidal, or suicidal

Many things capable of smothering: hands, clothes, pillows, plastic bags, gags, or falling into sand, grain, sawdust, etc.

Examples:

- Homicide: intentionally placing a hand or pillow over the nose and mouth; covering a victim's nose and mouth with tape
- Suicide: placing a plastic bag over the head (plastic bag suicides are very difficult to diagnose if the bag is removed before medical examiner/coroner is made aware)
- Accident: wedging and overlay deaths of small children (note that there is also a component of mechanical asphyxia here)

Particularly in very young children who are smothered (accidentally or otherwise), there often are no findings at autopsy

Homicidal smothering of adults may be associated with bruising around the mouth, nose, chin, cheeks, or neck; also look for bruises or lacerations inside lips

### **Choking**

Blocking of the internal airways

Usually accidental, may be natural or (occasionally) homicidal

Examples:

- Accident: Blockage of the pharynx or larynx by a toy or food bolus
- Natural: Bacterial epiglottitis
- Homicide: Gag rammed into the mouth

Other than blockage of the airway, autopsy findings may be minimal

Although many forensic cases show agonal aspiration of gastric contents into the airway, to ascribe death in an adult to food aspiration almost always requires neurologic disease (retardation, strokes, multiple sclerosis, etc.) or intoxication that impairs the normal gag reflex

### **Mechanical**

Also known as 'traumatic asphyxia'

Pressure on the chest and/or abdomen restricts breathing

Most are accidental

Autopsy (in adult cases) often shows marked congestion of the face and neck, with petechiae; sometimes frank scleral hemorrhage

Autopsy (in young child cases) often minimal and nonspecific

Examples:

- Car slips off a jack onto the chest of the person working underneath
- Workman buried following collapse of an excavation site
- Overlay of a small child (note that there is also a component of smothering in these cases)

### **'Positional asphyxia'**

The victim is trapped or pinned in such a way that the neck or breathing is constricted by anatomy and/or gravity

Most cases involve victims not responding to position (due to alcohol or other intoxicants) or unable to extricate themselves due to neurologic disease (such as multiple sclerosis) or young age



Airway of a toddler who choked on a small plastic plug

## STRANGULATION

*In most strangulation deaths the mechanism of death is cerebral hypoxia due to blockage of arterial inflow, or stagnation of blood in the head due to blockage of venous outflow. Approximately  $\frac{3}{4}$  of the blood supply to the brain is via the carotid arteries.*

*It is estimated that approximately 11 pounds of pressure is needed to occlude the carotid arteries; while only 4.4 pounds of pressure is needed to occlude the jugular veins. Occlusion of the trachea is said to require 33 pounds of pressure, while the vertebral arteries require 66 pounds of pressure.*

*Leading experts disagree sharply as to how often the 'carotid reflex' may explain death when the carotid body is stimulated during neck compression (see textbooks by DiMaio and Knight for further discussion).*

### Hanging

The weight of the body tightens the noose on the neck

Complete suspension is **not** required – the weight of the head alone may be sufficient for vessel occlusion. Thus, hangings can and do occur in kneeling, sitting, or even lying down positions.

Nearly all adult hangings are suicides; accidents are rare and homicides are very rare in adults

Autopsy features:

- Ligature furrow on the neck
  - The appearance of this depends on the nature of the ligature used (rope, electrical cord, wire, belts, clothing, sheets, shoelaces, etc.)
  - Inverted 'V' configuration, with apex at the point of suspension
  - Fractures of the hyoid or thyroid cartilage are uncommon
  - Neck muscle hemorrhages are uncommon
- Fractures of the cervical spine are very uncommon (except with jump or drop hangings)
- Facial petechiae and congestion more common with partial suspension hangings (thought to be due to continued arterial inflow but impeded venous outflow)

Most hangings appear to be associated with fairly gradual, subtle death that is relatively painless

## Ligature

Ligature on the neck is tightened by force, rather than by body weight

Most cases are homicides, although accidents (usually involving clothing and machinery, or small children) and suicides do occur

Women more often the victim than men; sexual assault is often associated

Autopsy features:

- Congested face with scleral and conjunctival petechiae
- Ligature mark on the neck often horizontal (compare to the inverted 'V' of hanging)
- Internal injuries of strap muscles and hyoid bone or thyroid cartilage uncommon, but do occur

## Manual

A hand ("throttling") or forearm occludes the neck vessels

Virtually all cases are homicides

Autopsy features:

- Congested face with scleral and conjunctival petechiae
- Abrasions and contusions of the neck and chin skin
- Strap muscle hemorrhage in the neck common
- Often hyoid bone or thyroid cartilage fractures, particularly in older individuals where these structures tend to be more ossified and rigid



Fracture of superior horn of thyroid cartilage (arrow) in a manual strangulation victim.

Note the hemorrhage surrounding the fracture.

### 'Choke holds'

Two basic types: the bar arm hold and the sleeper hold

- *Bar arm hold* – the forearm (or an implement like a flashlight) is placed across the neck
  - The airway collapses and the tongue is pushed upward and backward
  - Very painful – likely to make victim fight even harder due to pain and 'air hunger'
  - Thyroid and cricoid cartilages may be fractured, resulting in death
- *Sleeper hold* – neck is pinched between the forearm and the upper arm
  - Carotid arteries are compressed, while airway is not
  - Unconsciousness ensues within seconds; hold should be released right away
  - Deaths may be associated with underlying heart disease and/or drugs
  - Autopsy findings in the sleeper hold may be minimal or absent

## CHEMICAL

### Carbon monoxide (CO)

Competes with oxygen for binding by hemoglobin (hemoglobin has 250 to 300 times more affinity for CO than for O<sub>2</sub>)

Produced by the incomplete combustion of carbon-containing fuel

Lethal levels generally 50% or more saturation of hemoglobin, though underlying disease may render lower levels of CO fatal

Autopsy findings:

- 'Cherry red' lividity (not specific to CO, and may not be visible at lower levels of CO)
- Bright red coloration of fingernail beds, blood, muscles, and viscera (nonspecific)
- Fluidity of the blood (nonspecific)
- In fire deaths, look for soot in the trachea, bronchi, esophagus, and stomach

CO is not produced by decomposition, and not appreciably absorbed after death

Accidental (fires) and suicidal (automobile exhaust) deaths both common

Smoke inhalation deaths occurring during arson are homicides

### Hydrogen cyanide

Blocks utilization of oxygen by poisoning respiratory enzymes

Death can occur within seconds

Autopsy findings

- 'Cherry red' lividity (due to persistent oxyhemoglobin in red blood cells)
- Odor of bitter almonds (the ability to smell this is a genetically-determined trait)
- Ingestion of the potassium- or sodium-salt causes extensive corrosion of the stomach; contact with acid produces hydrogen cyanide



## Accidental Pediatric Asphyxia

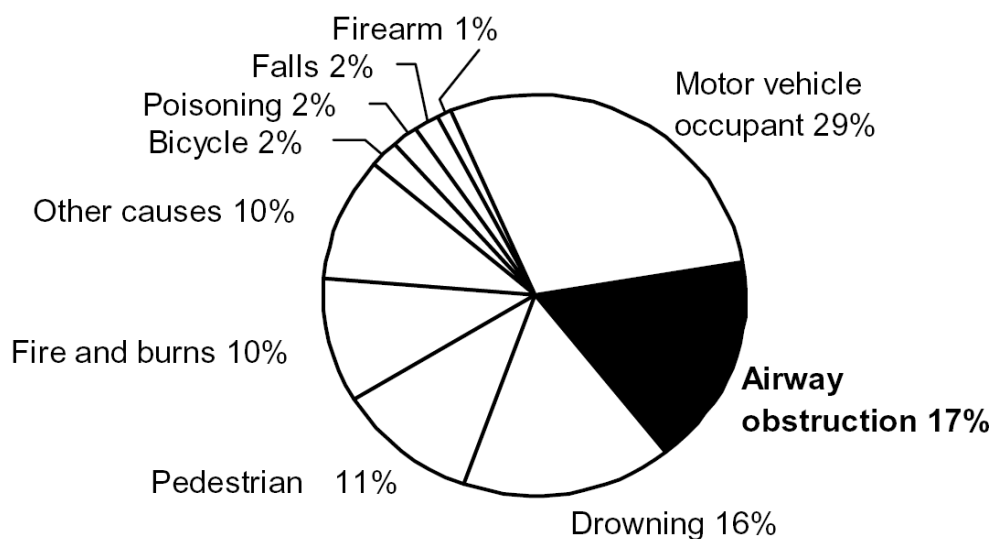
In 2004, 963 children ages 14 and under died from an airway obstruction

More than 19000 children were treated in hospital emergency departments for choking-related episodes in 2005

In 2001, nine children 8 years old and under died from choking on a toy or toy part; four of these deaths involved balloons. (Choking and suffocation/asphyxia deaths account for 40 percent of all toy-related fatalities.)

In 2003, ten children ages 1 to 9 died from choking on or aspirating a toy; three of these deaths involved balloons. (At least 110 children, most of them ages 5 and under, have died from balloon-related suffocation since 1973.)

### Leading Causes of Accidental Injury-Related Death for Children 14 and Under 2004



From [http://www.usa.safekids.org/content\\_documents/AOI\\_facts.pdf](http://www.usa.safekids.org/content_documents/AOI_facts.pdf)

## **Types of Accidental Pediatric Asphyxia**

As in adults, children can suffer death by nearly any asphyxial mechanism. In reality, however, there are certain types of asphyxia to which children are especially prone due to their small size and/or developmental level. Some types of asphyxia, such as wedging or overlaying, are virtually unique to the small child, and occur in the sleeping environment.

**Choking** (toys, food, and non-food items)

**Smothering** (plastic bags, excessive bedding, bean bag chairs, etc.)

**Strangulation** (clothing caught on cribs, unsafe or defective cribs, window blind cords, etc.)

**Overlaying** occurs when a larger individual is sleeping on the infant. It represents a complex form of asphyxia that includes airway obstruction, thoracic and abdominal compression, and impairment of neck circulation (Collins, 2001). In most instances, autopsy findings will be minimal. Nonspecific findings may include indentations or 'pressure marks' on the skin related to bedding or clothing. Because the autopsy is usually negative, it is difficult to sort out overlayings from other forms of suffocation (including intentional suffocation) or SIDS. History and scene investigation are critical.

**Wedging** occurs when the infant is trapped or caught between two objects, such as the mattress and side rails of a crib, between the slats of a crib, between a mattress and an adjacent wall, etc. Although injuries such as abrasions or contusions may occur from the agents causing the wedging, autopsy findings are usually nonspecific. Lividity pattern, if well-documented, may offer a clue as to position. As with all pediatric asphyxial deaths, scene investigation is paramount.

**Traumatic** (pinned or crushed by a large object)

## Pediatric Choking and Smothering

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**Sturner et al (1976)**, in a review of 33 childhood (2 years old or younger) asphyxial deaths over a four-year period in described two cases of suffocation by plastic bags: a bread wrapper and a dry cleaning bag. The one choking case was a 1-year-old who had a 'small rubber ball' lodged in his throat.

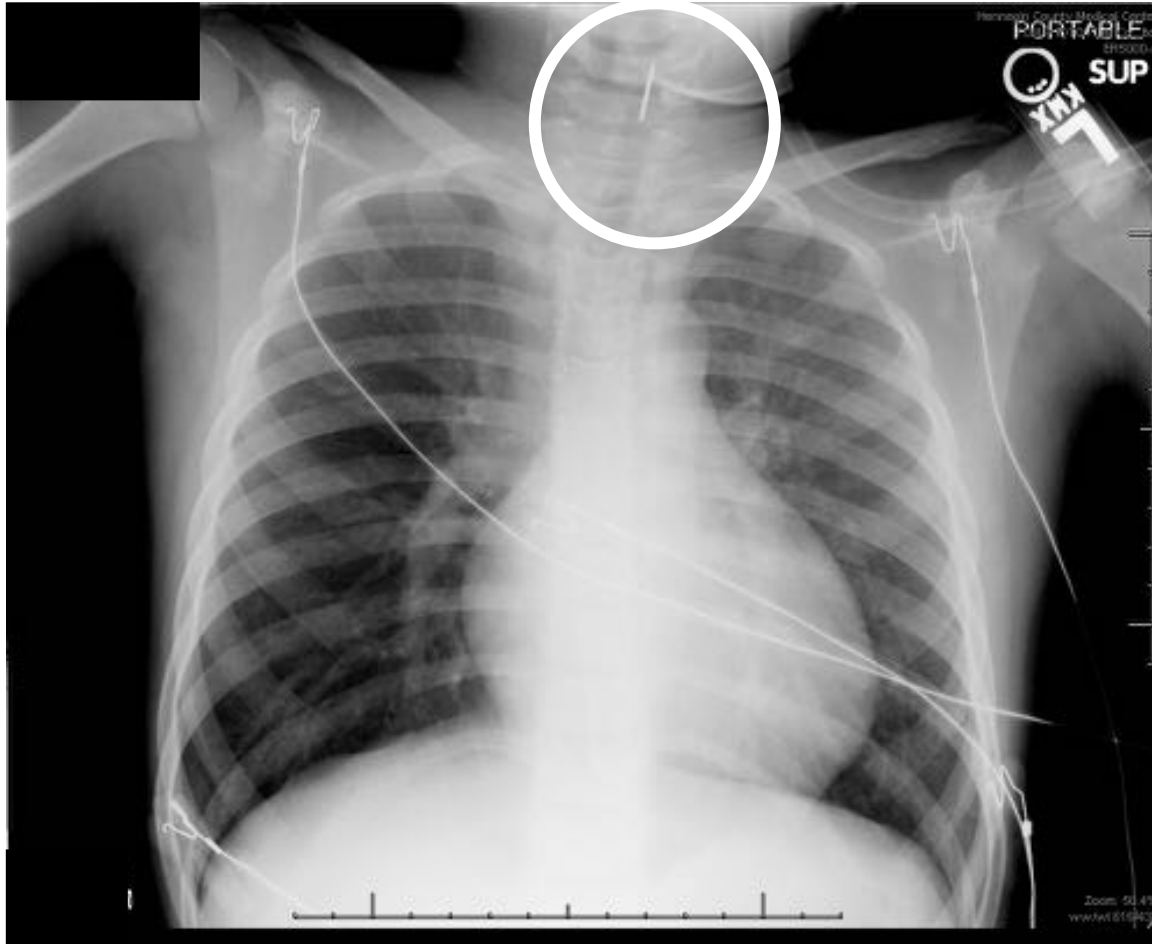
**Baker and Fisher (1980)** looked at 42 childhood (10 years old or younger) deaths from choking or suffocation in Maryland over a 9-year period. Thirty-eight of the decedents were 5 years old or younger; the remaining four were between 5 and 9.

- 12 children (8 months to 5 years old) choked to death on food (6 were hot dogs); 8 on non-food items (pacifier, rattle, wooden balls, hardware, and balloons)
- 22 deaths were from 'mechanical suffocation': these included plastic bags, wedging between crib mattresses and frames, entrapment in refrigerators, overlaying, and accidental hangings

In **Byard's (2000)** review of accidental child deaths, 14 of 59 accidental asphyxial deaths were a result of foreign body aspiration, with a mean age of 26 months. Offending agents included meat, vegetable matter, toy parts, tablets, a coin, a woodscrew, wheat, and sand. Toddlers were at particular risk of foreign body aspiration. In older children, food aspiration was often associated with mental retardation or a neurologic condition that interferes with swallowing.



Scene photo (doll reenactment) of an infant accidentally smothered by a plastic bag



Radiograph (above) of a 6-year-old who died of airway obstruction after he used a push-pin to punch a hole in a soda can. He apparently shook the can and put his mouth to it, causing the pin (shown below) to shoot into his airway under pressure. The metal part of the pin can be seen on the radiograph.



## Pediatric Strangulation

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**Sturner (1976)** reported an 8-month-old child entangled and hanged by a rope used to hold his crib together, and two cases of children hanged by pacifier strings.

**Feldman and Simms (1980)** reviewed 233 cases of childhood strangulation collected from the children's hospital (13 year period), fire department medic team (4 year period) and medical examiner's office (4 year period) in Seattle, as well as 156 reported deaths from death certificate surveys and 39 in-depth death investigations by the Consumer Products Safety Commission (CPSC) for the year 1977.

The most frequent cause of strangulation injury was cribs, with an age range of 1 month to 4 years (average 11.0 months). About ½ of the cribs were designed unsafely; the remaining deaths included those cribs with broken slats or other defects, mattresses that were too small for the crib (allowing 'wedging' to occur), and loose bedding strings allowing entanglement of the child's neck.

Other mechanisms of injury included ropes and cords, entrapment between furniture, clothing entanglement, high chairs, windows (automatic and manual), and suicides. For all categories there was a male predilection.

| <b><u>Mechanism</u></b> | <b><u>%</u></b> | <b><u>Mean Age</u></b> | <b><u>Range</u></b> |
|-------------------------|-----------------|------------------------|---------------------|
| Cribs                   | 28              | 11 mo                  | 1 mo - 4 yr         |
| Ropes, cords            | 27              | 7.5 yr                 | 7 mo – 16 yr        |
| Suicide                 | 16              | 12.6 yr                | 7 yr – 17 yr        |
| Between furniture       | 9               | 14.1 mo                | 3 mo – 18 yr        |
| Clothing entangle       | 8               | 4.5 yr                 | 5 mo – 14 yr        |
| High chairs             | 4               | 10.9 mo                | 5 mo – 2 yr         |
| Automatic windows       | 2               | 3.0 yr                 | 15 mo – 5 yr        |
| Autoerotic              | 2               | 15.0 yr                | 14 yr – 16 yr       |
| Manual windows          | 2               | 10.0 yr                | 9 yr – 11 yr        |

Feldman and Simms, 1980

**Rauchschwalbe and Mann (1997)** specifically focused on pediatric window cord strangulations cases reported to the CPSC and the National Electronic Injury Surveillance System (NEISS) from 1985 to 1995. One hundred eighty-three deaths were reported, of which 93% involved victims 3 years old or younger. The vast majority (86%) of responsible window coverings were horizontal blinds (which comprise 75% of the market), and the injuring component was usually the pullstring (88%).

The two typical scenarios seen were:

- Infants in cribs near windows becoming entangled in cords
- Toddlers jumping or falling from furniture placed too near a window and becoming entangled in cords

Interestingly, many of the deaths appeared to be 'silent,' in that adults or older siblings sleeping in the same room reportedly heard nothing, or young siblings reporting that the victim was 'sleeping' or 'standing funny.'

*Specific safety recommendations regarding window coverings, as well as free kits to repair or retrofit blinds, can be obtained from the Window Covering Safety Council [<http://www.windowcoverings.org/>]*



Scene photo of a looped and knotted shoelace (arrow) being used by an older sibling as a step to the upper bunk in this bedroom.

A 13-month-old accidentally hanged himself with this.





Cribs that strangled infants due to missing hardware. The doll reenactment below shows how easily this tragedy can happen.



**Moore and Byard (1993)** reported hanging (9) and wedging (5) deaths in infants and children up to 36 months old in South Australia over a 20-year period. Eleven of the deaths occurred in/around cribs, while there was one death each in a stroller, in a car seat, and via a curtain cord. Nearly all the deaths in cribs resulted from clothing getting caught or entangled on part of the crib. The authors observed that those children who were hanged were older (18.5 months average age) than those who died from wedging (9 months average age), reflecting the mobility of the older children. Petechiae were much more likely in hanging than in wedging.

**Cooke et al (1989)** reported 12 hanging deaths in children (12 years old or younger) over a 16-year period in Western Australia. These represented 3.7% of hanging deaths among all age groups for the same time period. The 12 cases were varied by circumstances and age, but the authors noted typical scenarios (among their cases and previously reported cases) were either (a) infants in cribs or strollers or (b) accidental hanging while playing, usually involving boys. In one of the authors' cases, the victim was actually playing 'hanging' with a macramé plant holder (having been told earlier that day by his mother to stop playing this game). The authors did not report any suicides in this group, but one of the 12 cases did appear autoerotic in nature.

**Clarke et al (1993)** reported 12 hanging deaths in children (13 years old or younger) over a 5-year period in Marion County, Indiana and Franklin County, Ohio (combined population 2.4 million). They classified 3 of their deaths as suicides (one of which was an 8-year-old boy), 5 as accidents, and 4 as undetermined (since suicidal intent could not be documented). Not surprisingly, the accidental hangings included very young children, while the suicidal and equivocal cases were older (6-13 years old). The authors noted that facial and conjunctival petechiae were more commonly seen in partial hangings and more commonly absent in complete hangings, but point out that this is hardly an absolute relationship. They noted subgaleal petechiae in some cases—which they regarded as a 'real' finding—though acknowledging that some textbooks regard this as autopsy artifact.

**Wyatt et al (1998)** reported 12 hanging deaths in children (15 years old or younger) over a 12-year period in southeast Scotland. These deaths constituted 8% of the 143 deaths from all injuries in this age group over the same period, equal to the number of deaths from falls but ranking behind drownings (12%), fires (15%) and road accidents (48%). Six of the deaths, which occurred in children 11 to 14 years old, were classified as suicides based on a suicide note or expression of intent. Five children 6 to 14 years old appeared to involve experimental behavior, and one child (4 years old) was hanged by a dog leash. Facial and neck petechiae were seen in only 5 cases, all of which involved partial suspension.



Based on their review of the literature regarding childhood hanging deaths, Wyatt et al suggested the following 'broad classification' of childhood hangings:

| <u>Age group</u>                 | <u>Typical scenario</u>                           |
|----------------------------------|---------------------------------------------------|
| Infants and young children (0-2) | Trapped in sleeping environment                   |
| Young children (2-8 years)       | Caught during play with a ligature                |
| Older children (> 8 years)       | Playing with a ligature or acting out a 'hanging' |
| Older children (> 11)            | Suicide                                           |
| Older children (> 13)            | Autoerotic behavior                               |

**Denton (2002)** reported an accidental hanging from a lanyard in which a 10-year-old boy, apparently jumping on a bed, was hanged on a bedpost. This child actually had C1 and C2 dislocation, indicating a drop-type hanging.

**Andrew and Fallon (2007)** described a new and lethal variant of childhood asphyxia known (among other names) as "the choking game." While asphyxial games have apparently been played as long as there have been adolescents, an increase in the use of ligatures in recent years has considerably raised the stakes in such "games." A full discussion of this phenomenon is outside the scope of this presentation, but it is worth noting (and these authors point out) that these "games" must be considered when evaluating pediatric asphyxial deaths involving ligatures.

## **Wedging, overlaying, couches, adult beds, and other unsafe sleeping environments**

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In **Byard's (2000)** study, 40 of the 59 asphyxial deaths were related to an unsafe sleeping environment: 20 wedging/positional asphyxia, 13 hangings, 4 suffocations, and 3 overlayings. The average age of death in the unsafe sleeping group was 10 months.

**Sturner et al (1976)** noted three cases of smothering due to co-sleeping (in one case, the co-sleeper was said to be a 1-year-old sibling). Eleven of the authors' cases were ascribed to wedging.

**Nakamura et al (1999)** reviewed CPSC data pertaining to deaths in adult beds of children less than 2 years old. Admittedly, much of the CPSC data is anecdotal or derived from death certificates, and therefore is an underestimate of the true number of deaths.

Over an 8-year period, 515 children were reported dead: overlaying accounted for 121 deaths, waterbeds for 68 deaths, and the remainder were various forms of entrapment (wedgings and strangulations). The majority (77%) of the overlaying deaths were in children less than 3 months old. Only 2 incidents of alcohol use by the caretaker were reported. Eighty-nine percent of the entrapment deaths occurred in children younger than 1 year old.

The authors identified four major unsafe sleep environments:

- suffocation by overlaying
- positional asphyxia due to wedging
- suffocation on waterbeds due to being placed face down on the mattress
- strangulation by sideboard/headboard/footboard railings



Wedging death (doll reenactment at scene) of an infant trapped between an adult mattress and the adjacent wall about six inches away. The infant shared this bed with two adolescent siblings.

**Drago and Dannenberg (1999)** reviewed CPSC data regarding 2178 infant (13 months old or younger) suffocations in the United States from 1980-1997. Like Nakamura's study, their data were based on death certificate statistics. Deaths were classified as wedgings, hangings, entanglements with ligatures, positional asphyxia, entrapments, oronasal obstruction, compression, and overlaying. They found that wedging was the most common cause of death for all ages, followed by oronasal obstruction, overlaying, entrapment with suspension, and hanging. Wedgings were especially common in the 3 to 7 month old group—children who are able to move into corners of beds, but unable to lift themselves out of wedged positions.

**Collins (2001)** studied 32 cases certified as overlaying (11 cases), 'undetermined – SIDS versus overlaying' (10 cases), and wedgings (8 cases) or other accidental asphyxias (3 cases). In the 21 cases that were overlaying or undetermined, there were a variety of sleeping situations that included adults beds, twin beds, and sofas.

- In 12 of the cases, the child had been sleeping with more than one other person. When the overlaying and undetermined cases were compared, there were only minor external findings in a minority of the cases, and no findings in the other cases. In both groups, intrathoracic petechiae were common.

- The wedging cases had a similar paucity of external findings, and only 2 cases had intrathoracic petechiae.
- In none of the cases studied were there documented oral or intraoral injuries.

**Thogmartin et al (2001)** reviewed all infant deaths in a sleep environment over a 14 year period. All cases were included, except those certified as homicides. Of the 217 cases studied, 139 were classified as SIDS, 40 as miscellaneous natural causes, 19 as asphyxia (overlying or soft bedding), 5 as other accidents (wedging or entrapment), and 14 as undetermined. Regardless of the cause of death, the annual number of deaths at the end of the study period (1999) was less than half that seen at the beginning (1986). Only 30 of the deaths occurred in infants older than 5 months. Bed sharing was present in 40.1% of the deaths, and 89% of the deaths involved bed-sharing or prone sleep position or both. The majority of the cases (74.5%) had negative autopsy findings.

**Person et al (2002)** reviewed 56 infant death cases certified as SIDS (43), undetermined (3), or sudden unexpected death in infancy (10). Of the total cases, 19 were found in adult beds and 12 on couches. Twenty-three of the decedents had been cosleeping with one (or more) adults in an adult bed, and 9 were cosleeping on a couch with an adult. The only autopsy finding of note was circumoral cyanosis in 17 of the infants (9 cosleeping, 8 sleeping alone).

**Pasquale-Styles et al (2007)** reviewed all unexpected infant deaths in Wayne County, MI, from 2001 to 2004. Scene investigations were performed to assess the position of the infant at the time of discovery and identify potential risk factors for asphyxia including bed sharing, witnessed overlay, wedging, strangulation, prone position, obstruction of the nose and mouth, coverage of the head by bedding, and sleeping on a couch. One or more potential risk factors were identified in 85.2% of the cases. These authors suggest that asphyxia plays a greater role in many sudden infant deaths than has been historically attributed to it.

Infant found dead after co-sleeping on a couch. Although the mother insisted the child was face up, the lividity pattern on the face tells otherwise. Since lividity can be fleeting, it is important for on-scene investigators to document what they see.



Doll scene re-enactment of a co-sleeping death on a couch. Walking a caretaker through this may be one of the hardest things a death investigator will ever do.







Doll scene re-enactment of an infant left sleeping alone on a pillow on a chair (above).  
A second pillow had been placed on the floor in case the child rolled off.  
Unfortunately, the child did roll off and was asphyxiated as he lay face down in the pillow on the floor (below).



## Traumatic asphyxia

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Traumatic asphyxia appears to be relatively rare in children, at least compared to other forms of pediatric asphyxia and when the definition of traumatic (or mechanical) is used as it is in adult cases (thus excluding wedging and overlaying). The injuries seen—which are dependent on the circumstances—vary by the offending agent. The ages of children is typically older than the infants who die in an unsafe sleep environment or toddlers who aspirate food or toy parts, and likely reflects the increased strength and mobility of this older group. The limited number of published cases suggests a male predilection.

**Campbell-Hewson et al (1996)** described a fatal case (a chest of drawers fell onto an 18-month-old) and a nonfatal case (a 2-year-old who was run over by a delivery van).

**Sarihan et al (1997)** reported eight nonfatal cases in children ranging 2.5 to 12 years old. Six of the cases were the result of motor vehicle events.

**Byard (2003)** reported six accidental fatal cases (all boys) from South Australia over a 35-year period. The cases included entrapment under a chest of drawers, under a table tennis table, under a pile of wooden pallets, and between a conveyor belt and frame. Two cases involved motor vehicles.



Scene photo of a dresser that a toddler pulled onto himself, resulting in fatal mechanical asphyxia. The autopsy showed florid facial and conjunctival petechiae, but no blunt force injuries.

The child had pulled the dresser over before.

## Accidental/Non-homicidal Pediatric Asphyxias: The Role of the Pathologist

**Byard (2000)**, in his review of 369 cases of fatal childhood accidents, pointed out that a program to detect and investigate child deaths in Australia documented several previously unrecognized dangers, including mesh-sided cots, V-shaped pillows, and some types of strollers. Although asphyxial deaths (16%) ranked well below motor vehicle accidents (51%) and slightly below drowning (17%), ***they were substantially more common than more 'dramatic' deaths such as fires, poisoning, electrocutions, and falls.***

### Investigating the Pediatric Death

Like all child deaths, the investigation of the possible asphyxial death of a child should involve three major components: the **death scene**, the **case history**, and a **complete autopsy**

#### Death scene

- ❑ The death scene is where the child was found dead or unresponsive.
- ❑ The death scene is **not** the back of the ambulance or the resuscitation bay of the emergency room.
- ❑ It is almost always helpful to re-enact the death scene where possible (which is often facilitated by the use of a doll)

Things to look for:

- |                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>❑ Crib and Playpen Problems<ul style="list-style-type: none"><li>• Slats too far apart</li><li>• Missing slats</li><li>• Missing hardware</li><li>• Mattress too small</li><li>• Crib hardware that can catch clothing</li><li>• Plastic bag left on mattress</li><li>• Mesh on side of playpen loose</li><li>• Mesh allows catching of buttons</li></ul></li></ul> | <ul style="list-style-type: none"><li>❑ Other sleep environment problems<ul style="list-style-type: none"><li>• Plastic pillow covers</li><li>• Beanbag chairs</li><li>• Harnesses</li><li>• Waterbeds</li><li>• Rocking cradles</li><li>• Blinds near crib</li><li>• Bedding materials</li></ul></li></ul> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Scene Investigations in Infant Deaths

(adapted from Hanzlick, 2001)

**Provides information for:**

- Assessing causes of injuries
- Assessing other causes of death besides SIDS
- Estimation of time since death
- Interpretation of autopsy findings



### **The scene investigation**

- Allows more immediate access to witnesses
- Allows referrals to other agencies or services (e.g. counseling)
- Allows collections of evidence if needed (bottles, bedding, etc.)
- IS NOT the back of the ambulance or the treatment bay of the emergency room
- IS the location where the child was found unresponsive, or where events that may have led to death occurred

### **Key steps in scene investigation**

- Document basic circumstances and timeline
  - Obtain basic medical history (prenatal and postnatal)
  - Evaluate the household environment
  - Evaluate immediate environment where the infant was found
  - Note bodily findings (injuries, livor, rigor, temperature)
  - Diagram scene as needed
  - Photography
  - Doll re-enactment if possible
- 

### **Case history review**

Past medical history  
Prenatal and birth history  
Vaccinations  
Welfare of other children in the household  
Social history

### **Ways to Effect Change**

Public education  
Safety legislation  
Design improvement

### **Complete autopsy**

Photography  
Radiography  
External examination  
Internal examination with microscopy  
Cultures  
Electrolyte testing  
Metabolic screening  
Toxicologic testing

## The SUIDI “Top 25” from the Centers for Disease Control

- ☐ Case Information
- ☐ Asphyxia
- ☐ Sharing sleep surfaces
- ☐ Change in sleep conditions
- ☐ Hyperthermia/hypothermia
- ☐ Environmental hazards  
(CO, chemicals, etc)
- ☐ Unsafe sleeping condition
- ☐ Diet
- ☐ Recent hospitalizations
- ☐ Previous medical diagnosis
- ☐ History of acute life threatening events
- ☐ History of medical care without diagnosis
- ☐ Recent fall or other injury
- ☐ History of religious, cultural, or ethnic remedies
- ☐ Cause of death due to natural causes other than SIDS
- ☐ Prior sibling deaths
- ☐ Previous encounters with police or social service agencies
- ☐ Request for tissue or organ donation
- ☐ Objection to autopsy
- ☐ Pre-terminal resuscitative treatment
- ☐ Death due to trauma (injury), poisoning, or intoxication
- ☐ Suspicious circumstances
- ☐ Other alerts for pathologist’s attention
- ☐ Description of circumstances (what happened?)
- ☐ Pathologist information



### KEYS:

- Interviews
- Scene investigation
- Doll reenactment
- Communication



## Conclusions

- ❑ Many forms of pediatric asphyxia—particularly infant deaths such as wedging, overlaying, and smothering—will, more often than not, have negative autopsies or autopsies with nonspecific findings.
- ❑ In most cases, the autopsy findings in a suffocation death of an infant (accidental or intentional) will not differ from the findings in “SIDS.” Therefore, the death investigation (scene, medical history, witnesses) is paramount.
- ❑ Death investigators, law enforcement officials, coroners, medical examiners, and physicians reviewing childhood deaths should NOT assume that a negative autopsy alone is sufficient for a determination of “SIDS.”
- ❑ The likelihood of petechiae is highly dependent on the particular type of asphyxia involved. In general, external petechiae (facial, conjunctival) are more rare in the very young child than the older child or adult.
- ❑ Childhood asphyxial deaths, particularly those that occur in the sleep environment, are largely preventable. Parents should receive instruction from their health care providers regarding appropriate sleep environments and sleep positioning. Both the CPSC and American Academy of Pediatrics have specific recommendations in this regard.
- ❑ Don’t dismiss pediatric asphyxias as “merely another example of one of the inevitable risks of early life. The pathologist is in an excellent position to identify these hazards and can recommend [assessment by] product safety experts.” (Byard, 2000)

## Homicidal Pediatric Asphyxia

In most homicidal pediatric asphyxiation deaths, the victims are very young, the child is smothered, and autopsy findings are minimal or absent. The smothering agent may be a pillow, blanket, hand, sheet of plastic wrap, or innumerable other items. Many cases come to light only after a confession, or when multiple children die in the care of the same caretaker. In the investigation of a homicidal asphyxiation of a child—if it is even recognized—three questions often loom:

- ❑ How long does it take to suffocate an infant?
- ❑ Is the autopsy consistent with the confession?
- ❑ Do infants and small children “put up a fight”?

### **How long does it take to suffocate an infant?**

Obviously, there is no ethical way to study this. Confessions often contain a time estimate, but the accuracy and truthfulness of these must be interpreted with a great deal of caution. However, early work on infants suspected of having imposed airway obstruction (Munchausen syndrome by proxy, or MSBP) offers some insight as physiologic monitoring is correlated with the onset of apnea.

**Rosen et al, in 1983**, described a 4-month-old girl with nearly daily episodes of cardiopulmonary arrest, requiring resuscitation by her mother. An extensive medical work-up and trials of numerous medications were fruitless. At 7 months old, the child underwent re-evaluation with extensive physiologic monitoring. EEG and EKG artifact showed the infant was actively moving for 90 seconds after the onset of respiratory obstruction. Bradycardia ensued 30 seconds into the event, and the EEG slowed and then flattened after 90 seconds. The child was limp and apneic, requiring resuscitation. The episode was captured by covert video surveillance (CVS). The 4-year-old brother of this infant had suffered similar previous episodes since infancy, and was cured when his mother was no longer allowed to be alone with him.

**Southall et al, in 1987**, described two children in which video and electrophysiologic monitoring documented the changes that occur with intentional smothering. The first was a 20-month-old who had suffered weekly cyanotic episodes since the age of 4 months. Gross movements stopped at 70 seconds, the EEG flatlined just after 70 seconds, and gasping breaths began. A second episode showed similar features, with gasping at 72 seconds. Covert video surveillance showed that the mother smothered the sleeping child with a tee shirt; the child ‘awoke immediately and struggled violently.’ In the second case, a 5 month old had a similar pattern of physiologic changes emerge after 71 seconds, and the videotape showed a struggle when the smothering of the previously-sleeping infant began.

**Meadow (1989)** opined that “. . .generally the smothering has to persist for a minute to cause seizures . . . longer to cause brain damage and perhaps two minutes (depending on the circumstances) to cause death . . .”

#### **Is the autopsy consistent with the confession?**

As with many accidental asphyxiations, the autopsy alone may offer few (if any) clues as to the cause of death. Petechiae would be uncommon.

**Meadow (1990)** reported on 27 children from 27 different families in Britain. Criteria for inclusion in the study were a filmed or witnessed suffocation, or confession of suffocation with evidence supporting the confession. Nine of the children were dead, while 18 were survivors. Five had facial petechiae, 2 had bruises on the neck, and *at least 14 had no markers for inflicted asphyxia*.

Soberingly, the author then looked at the history of the 33 siblings in these families who were born before the index case was suffocated. Eighteen of these 33 had died suddenly and unexpectedly, and 13 of these 18 had had recurrent acute life-threatening events (ALTEs). Thirteen had been certified as SIDS, 3 as choking on vomit or a foreign body, and 2 causes of death were not ascertained.

**Southall (1997)** reported on 39 cases referred to a children’s hospital after exhaustive medical evaluations for ALTEs. The patients had had reports of between 2 and 50 events (median=7). Using constantly monitored covert video surveillance, the authors documented abuse in 33 of the 39 cases. In 30 of 39 cases, the abuse was intentional suffocation. Only four of the 30 suffocated children had petechiae. Nasal/oral bleeding was seen in only 11 of the abused children (compared to zero instances of nasal/oral bleeding among 46 normal controls).

**Meadow (1999)** collected a series of unnatural infant deaths over an 18 year period in Britain. He reported on 81 children in 50 families (24 families had more than one death), and noted that 75 of the 81 had had previous unexplained events such as seizures, twitching, cyanosis, or apnea. Of the 70 children known to have been examined at the time of death, 27 had blood in the mouth, on the nose, or on the face; 10 had bruises/petechiae on the head or neck; and 40 had no injuries.

A number of valuable lessons emerge from these studies regarding the care and diagnostic evaluation of living children. For the pathologist charged with the postmortem examination of a dead infant, one lesson is clear: *more often than not, even in a child known to have been smothered, the autopsy will not demonstrate specific physical injuries referable to intentional asphyxia*.

#### **Do infants and small children ‘put up a fight’?**

Some texts, in classifying infant homicides, use the term ‘gentle’ to describe the intentional smothering of infants. Those who have captured on film and/or witnessed such events have written:

*Smothering has been labeled 'gentle' battering. We reject this. The video and physiological recordings showed that both children struggled violently until they lost consciousness. Considerable force was used to obstruct their airways (Southall et al, 1987)*

*Smothering is violent; a young child who cannot breathe struggles and tries to get air. The smothering needs considerable force, even when the child is young. (Meadow, 1989)*

*Covert video . . . reveals the violence that smothering entails. Infants and young children struggle hard when their airways are blocked: the mothers have to lean on them with force. (Meadow, 1990)*

**Other types of asphyxia**—presumably less common than smothering—may be intentionally inflicted upon children.

**Boos (2000)** described in detail the abuse and eventual death inflicted on a 7-week-old boy. The child's father admitted to wrapping the child so tightly in a blanket that he could not move, then placing him face down in a bassinet knowing there was a "10% chance" he would die if left that way. The author coined the term *constrictive asphyxia*—a subtype of traumatic asphyxia—to describe this death.

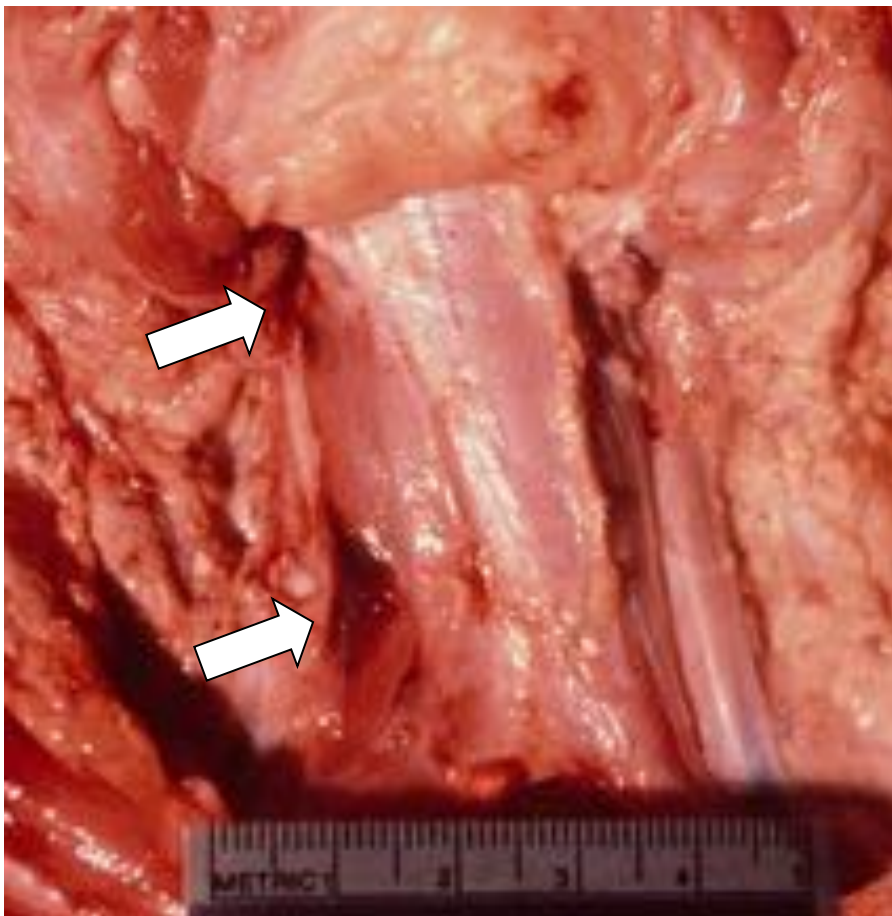
**Kohr (2003)** described the death and autopsy findings of a 2-year-old, 13.5 kg girl who was restrained by an adult 'until she appeared to have fallen asleep.' The 60 kg adult, who had an orthopedic cast on one leg, had placed her legs across the child's back for 30-40 minutes to achieve restraint. The only autopsy finding referable to asphyxia was rare intrathoracic petechiae; however, the child had an abrasion on her back that appeared consistent with the care provider's cast. The author concluded the child died of compressional (mechanical) asphyxia.

**Corliss (2007)** described the death of a 7-week-old girl who became unresponsive after being placed in a prone restraint hold with a 260-pound man on her back for upwards of 35 minutes. Due to behavioral issues, the child had been subjected to similar discipline eight times in the past, with three holds last for more than an hour. The autopsy showed only a forehead abrasion and nonspecific mesenteric hemorrhage.

**Krugman et al (2007)** described four infants—two of whom died—who were asphyxiated by baby wipes in their upper airways. Each of the children was found to have other injuries (such as skeletal, pharyngeal, soft tissue) on further investigation. Three of the cases led to guilty pleas or prosecution; one case was not prosecuted.

## Conclusions

- ❑ Smothering of infants is the most common type of homicidal asphyxia in children, but other types do occur.
- ❑ In most cases, the autopsy findings in the intentional suffocation death of an infant will not differ from the findings in SIDS, overlaying, wedgings, and other non-homicidal infant deaths. Significant nasal or oral bleeding may suggest inflicted airway obstruction, but would be expected only in a minority of cases.
- ❑ Death investigators, law enforcement officials, coroners, medical examiners, and physicians reviewing childhood deaths should NOT assume that a negative autopsy alone is sufficient for a determination of SIDS.
- ❑ Physiologic data and covert video from MSBP studies can help answer some of the relevant questions in known fatal infant smotherings.



“Strap muscle”  
contusions (arrows) in  
a 5-month-old fatally  
asphyxiated by her  
father.

She also had facial and  
scalp abrasions. A  
witness had previously  
seen the father  
sublethally smother  
this girl and an older  
sibling.

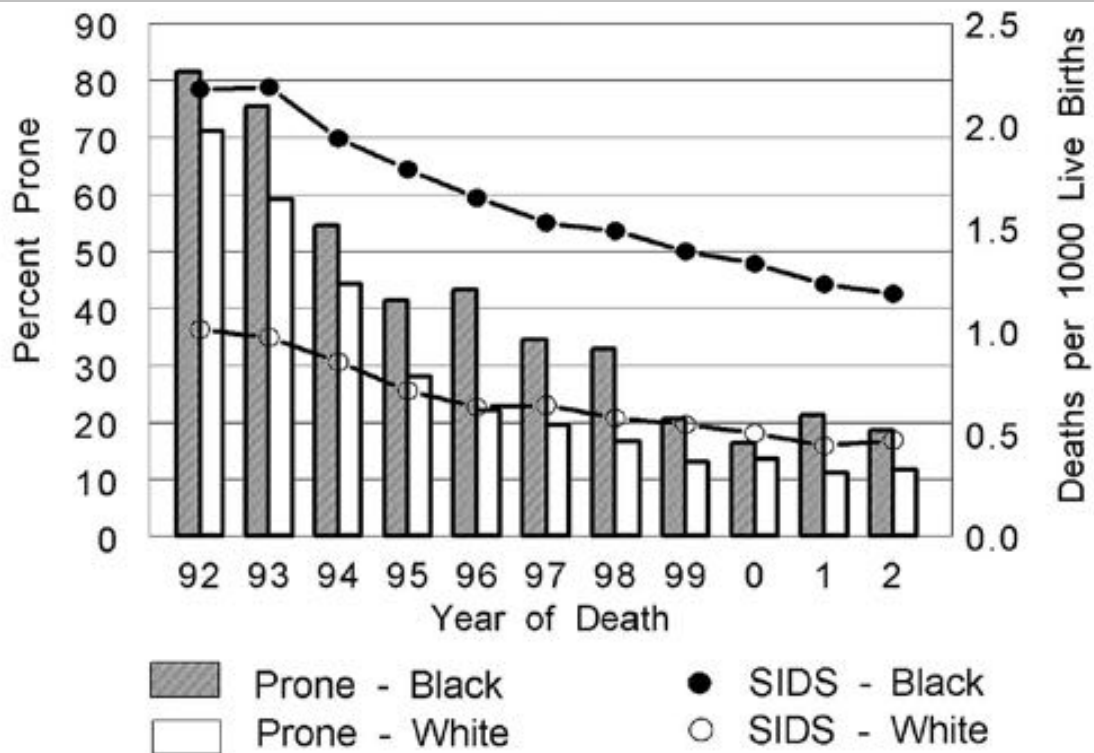


# SIDS, Co-sleeping, and Bedsharing

## Sudden Infant Death Syndrome

### Current Definition:

**The sudden death of an infant under one year of age which remains unexplained after a thorough case investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history. Cases failing to meet the standards of this definition, including those without a postmortem investigation, should not be diagnosed as SIDS** (National Institute of Child Health and Human Development, 1989).



From American Academy of Pediatrics Policy Statement, *Pediatrics*, October 2005

### Limitations of the “SIDS” appellation

- Term itself is controversial
- Great variability in its use
- Every pathologist “draws the line” between SIDS and an unsafe sleeping environment at a different point
- No consensus as to what constitutes a complete autopsy

### Proposed Definition:

The sudden death of an infant <1 year of age, with the onset of the fatal episode apparently occurring during sleep, that remains unexplained after a thorough investigation, including performance of a complete autopsy and review of the circumstances of death and the clinical history (Krous et al, 2004).

### Definitional approach (from Krous et al, 2004)

#### **Class IA: "Classic" SIDS**

- Between 21 days and 9 months old
- Normal prenatal and postnatal history
- No similar deaths within same family or under same caregiver
- Scene and circumstances do not provide an explanation of death
- Safe sleeping environment\*‡
- Autopsy shows no trauma, abuse, injury, or potentially fatal condition
- Negative ancillary studies (toxicology, radiology, chemistry, cultures, metabolic testing, radiographs)

#### **Class IB: "Classic SIDS" but incompletely documented**

- Same as IA, but lacking investigation of circumstances and/or one or more ancillary studies

#### **Class II: SIDS (one or more of the following)**

- Younger than 21 days or older than 9 months
- Similar deaths within same family or under same caregiver not suspicious for infanticide or genetic disorder
- Resolved prenatal or neonatal conditions
- Mechanical asphyxia or suffocation by overlaying not ruled out with certainty
- Abnormal growth and development
- Inflammatory changes or autopsy abnormalities not sufficient to be an unequivocal cause of death

#### **Unclassified**

- Alternative diagnoses of natural or unnatural conditions are equivocal
- Autopsy not performed

\*Prone position does not exclude SIDS unless specific evidence of suffocation present

‡Shared sleeping does not exclude SIDS if the infant was not at risk of asphyxia

## **Co-sleeping and bedsharing—what is their relationship to infant death?**

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A large volume of literature—from anthropology, pediatrics, and pathology—exists regarding the controversial relationship of co-sleeping/bedsharing and infant death. A wide spectrum of opinions and conclusions has emerged, which range from co-sleeping being protective against infant death to co-sleeping being a significant cofactor for infant death. It is important to realize that (1) different authors use different definitions for “SIDS” versus “overlaying” versus “undetermined,” (2) that not all co-sleeping is bedsharing (individuals may co-sleep in a variety of places, such as on sofas), (3) that many studies are limited by poorly selected or no controls, and (4) many risk factors (such as parental drug/alcohol use or fatigue) are ascertained by self-reporting. Many medical examiners certify a substantial percentage of their unexpected infant death cases in a co-sleeping environment as SIDS, while other medical examiners are of the opinion that co-sleeping *per se* precludes a diagnosis of SIDS (and ‘undetermined’ or ‘overlaying’ should apply).

**Bedsharing** is but one form of co-sleeping. When reading the literature, it is important to discern how carefully the authors make the distinction between bedsharing and co-sleeping. In Western society, most bed-sharing takes place on a fairly traditional bed (mattress ± a box spring on some kind of frame). Mattresses placed on a floor may be a particularly dangerous place for infant sleeping, as wedging between the mattress and a nearby wall or furniture item may occur.

**Co-sleeping** may take place in many locations: adults beds, sofas, chairs (especially recliners), daybeds, child beds, or other locations. Research that lumps these varied forms of co-sleeping together with bedsharing may well exaggerate the risk of bedsharing, as some co-sleeping locations (like sofas) are known to be highly risky.

**Room-sharing** can also be considered a form of co-sleeping. Several studies indicate that the risk of SIDS is lower for infants who room-share with an adult caregiver, when compared to infants who sleep in a separate room.

**Klonoff-Cohen and Edelstein (1995)**, in a case-control study, compared 200 cases of SIDS among various ethnic/racial groups in California to 200 live controls matched by birth hospital, date of birth, sex, and race. The authors examined both day- and nighttime bed sharing. Forty-five (22.4%) of the deaths occurred in infants who were bed sharing. There was no difference in likelihood of prenatal care between the case and control groups, although birth weights were significantly lower in the case group (3236 gm v 3459 gm). The adjusted odds ratio of sudden infant death and bed sharing was 1.38 (95% CI 0.59 to 3.22) during the day and 1.21 (95% CI 0.59 to 2.48) during the night. There was no interactive effect between bed sharing and smoking, alcohol use, and/or drug use. The authors concluded that bed sharing was not a risk factor for SIDS. They cited 5 previous studies reporting that bed sharing was a risk factor for SIDS, and concluded that these studies variously suffered from poorly selected or no controls, did not account for maternal or infant characteristics, or did not adjust for confounding variables such as passive smoking, maternal education, drug use, or neonatal medical conditions.

**Blair et al (1999)**, in a larger study (325 case and 1300 control infants), found in a multivariate analysis that—for infants of parents who do not smoke—bedsharing does not pose a hazard. The authors noted that factors other than bedsharing *per se*—such as parental tiredness, maternal alcohol use, overcrowding, and numerous blankets—resulted in adverse bed sharing conditions. Sharing a sofa with an adult during sleep proved to be particularly hazardous (a point also made by **Byard et al, 2001**, who also point out the danger for infants sleeping alone on sofas).

**Beal and Byard (2000)** reviewed all unexpected infant deaths in a 100-km radius of Adelaide, South Australia, over a 27-year period. Of the 701 cases where the sleeping conditions could be ascertained, 63 involved sharing a bed, couch, mattress, or cot with another person. The rate of co-sleeping among infant deaths was higher than the rate of co-sleeping among parents of living infants who responded to a questionnaire. The authors point out that two situations in their study group appeared to be especially dangerous: sleeping in makeshift bedding (while visiting or being on vacation) and co-sleeping (or sleeping alone) on a sofa. They emphasized that—for parents who choose to bedshare—alcohol and drugs, situations that allow wedging or positional asphyxia, and excessive bedding should be avoided. They concluded that “the potential for accidental death is increased in bed-sharing infants. The answer should not be to condemn bed sharing, but to ensure that where it is undertaken, then the infant is safe.”

**Kemp et al (2000)** reviewed 119 infant deaths from the St Louis area over a four-year period, focusing on what they considered four ‘well-established risk factors’: sleep position, bedding over the infant’s face or head, sharing a sleep surface with others, and sleeping on a surface other than those recommended for infants. The study was not designed to establish the risk of certain practices, nor to compare the findings to the general population. SIDS was the diagnosis in 88 of the cases, suffocation in 16, and undetermined in 15. The decedents were found on a sleeping surface other

than those recommended for infants in 75.9% of cases, sharing a sleep surface in 47.1% of the cases, prone in 61.1% of cases, and with the head or face covered in 29.4% of cases. Only 8.4% of the deaths were a nonprone child sleeping alone. The authors acknowledge that “it is controversial whether bedsharing per se increases risk for sudden death,” but also point out that “there is little question that the sleep surfaces used by infants dying while bedsharing fail to meet widely recognized standards of safety.”

**Scheers et al (2003)** compared infant suffocation deaths in the 1980s (513 cases) to the 1990s (883 cases). They found an increase in the number of deaths in adult beds/sofas, and a decrease in deaths occurring in cribs. The increase could be explained, at least in part, by diagnostic shift—fewer medical examiners/coroners ruling a case SIDS when dangers that were not appreciated in the 1980s are now recognized.

The authors compared the 1990s data to a sample of thousands of comparable, living infants with known sleeping habits. Even after specifically excluding those deaths certified as “overlying,” the risk of death to an infant in adult bed was 20.4 times that of a child in a crib.

**Carpenter et al (2004)**, in a case control study spanning 20 regions in Europe, compared 745 sudden unexpected infant deaths to 2411 live controls to calculate multifactorial odds ratios for a variety of risk factors and SIDS. Caretakers were interviewed at a median interval of 15 days from the day of death.

All-night bedsharing with adult carried an increased risk, which was higher with younger infants. For non-smokers, this increased risk was significant only at less than 8 weeks old. Mother's consumption of >3 alcoholic drinks in the preceding 24 hours also carried an increased risk, but only for infants who bed-shared all night.

This study was not without controversy: a statement issued by UNICEF UK the following month noted:

*There is some controversy as to whether the results of the Lancet study clearly and unambiguously indicate an increased risk of bed sharing with non-smoking parents in the absence of other known risk factors. There is serious disagreement among the study authors about the statistical methods employed, the significance of the findings and their implications for parents. Similar concerns have also been raised about a forthcoming Scottish study on the same subject. Until these issues are resolved, it remains inappropriate to give advice to parents based on the results of this study.*

**Alexander and Radisch (2005)** reviewed 102 infant (12 months old or younger) deaths from North Carolina 2000-01, including all deaths from SIDS, accidental asphyxia, and aspiration for which the sleep surface, sleep position, and occurrence of co-sleeping were known. SIDS was the listed cause of death in 80 (78.4%) of the cases.

They found that 67% of the deaths occurred outside a crib/bassinet. Prone sleeping occurred in 61.8% of the deaths. Co-sleeping was present in 52.9% of cases. Only 7.8% of the deaths occurred in which none of the three risk factors studied (prone, co-sleeping, outside a bassinet) was present.

The authors recognized the limitations of this retrospective, uncontrolled study, and also acknowledged that no systematic recording of bedding, head coverings, or smoking/substance abuse by a parent was included in their cases. They concluded that their data showed that SIDS was rare for an infant sleeping alone, in a crib, on his/her back or side.

**Knight et al (2005)** retrospectively reviewed 697 unexpected infant deaths from a 10-year period in Kentucky. Co-sleeping with adults or children at the time of death was identified in 252 cases, although co-sleeping did not necessarily prevent a SIDS determination at the time of death certification. For the 125 co-sleeping cases in which information on bedding was available, the authors identified 67 adult mattresses, 42 couches, and 8 waterbeds. Prone sleeping was much more common than supine in both co-sleepers and non-co-sleepers, and autopsy findings did not differ between co-sleepers and non-co-sleepers.

The authors' meta-analysis of living controls from four other large series yielded a co-sleeping rate of 24.6%; thus, the relative risk of death in the authors' co-sleeping group (252 of 697 cases) was 1.74. Although this suggests co-sleeping is a risk factor for unexpected death, the authors readily acknowledge a number of potential confounders, such as couches and other unsafe sleep surfaces, parental intoxication or exhaustion, smoking, and non-elective co-sleeping with a disinterested caregiver.

**Tappin, Ecob, and Brooke (2005)** compared 123 sudden unexpected infant deaths in Scotland with 263 live controls to examine the relationship between bedsharing and SIDS. (Three cases excluded from the original 131 deaths included two overlays on couches and one case of pulmonary hemorrhage where the child was sleeping between both parents). The authors administered a questionnaire to the parents within 28 days of death, and collected data on multiple factors related to socioeconomic status. They did not inquire about alcohol use, as previous work had demonstrated an inability to get accurate data.

Not surprisingly, the odds ratio for couch sleeping was 66.95. With regard to bedsharing, 64 of 123 SIDS deaths shared their last sleep surface, compared to 53 of 263 controls (odds ratio 2.89). Being in a room separate from the parent(s) carried an increased risk for SIDS (odds ratio 3.26) – an increased risk that only held if a parent smoked. The strongest interaction increasing the risk of SIDS when bedsharing was infant age. This increased risk held even when the mother was not a smoker.

The authors concluded that the risk of SIDS is increased when

- Sharing a couch for sleep
- Sleeping in a room alone
- Bedsharing with parent(s) (even if the mother is a non-smoker, or the infant is breastfed)

**McKenna and Mosko (2001)** write that "... mandatory, non-elective bed-sharing by smoking mothers that occurs in socially chaotic households where bedsharing is the only option leads to outcomes quite different from those situations in which bedsharing is chosen by a non-smoking mother specifically to protect, nurture and breastfeed her infant, under more routine and stable social circumstances".

"Just as most researchers accept without question the necessity of distinguishing between safe and unsafe cribs ... we call attention to the need to distinguish between safe and unsafe beds and bed-sharing."

By analogy, "merely because some parents lay their baby in a crib prone with a covered head, loose coverings and a poorly fitted soft mattress, it is not appropriate to conclude that crib sleeping is a risk factor for SIDS, only that there are safe and unsafe ways to use cribs."

So many factors are associated with bed-sharing that no blanket statement can be made that bed-sharing is “a way to reduce SIDS or to enhance the night-time attachment behaviors shared between parents and their children;” conversely, there is not strong evidence to recommend that “infants should ‘never’ sleep with their parents.”

**McKenna and Prahlow (2003)** point out that a spectrum of co-sleeping exists, ranging from an attentive, bed-sharing, breast-feeding mother in a safe environment on one end to a drug- or alcohol-using adult co-sleeping in an unsafe environment (such as a sofa) on the other. The authors feel that “the unconditional implication that any form of adult-infant co-sleeping is harmful is inappropriate, untrue, and not supported by scientific research.” They go on to say that “there are unsafe ways in which to co-sleep/bed-share, and there are safe ways in which to co-sleep/bed-share.”

**McKenna and McDade (2005)**, in a lengthy review article, comment that “... the overwhelming number of suspected accidental overlays or fatal accidents occur not within breast feeding-bedsharing communities but in urban poverty, where multiple independent SIDS risk ‘factors’ converge and bottle feeding rather than breast feeding predominates. Additional adverse risk ‘factors’ associated with bedsharing in high-risk populations are maternal smoking, infants placed to sleep on pillows or under duvets, with other children and co-sleeping with infants on sofas, waterbeds, or couches. Bedsharing when the infant sleeps with an adult other than the mother, maternal exhaustion, alcohol or drug use, or leaving infants unattended on an adult bed also increase SIDS risks and/or fatal accidents.”

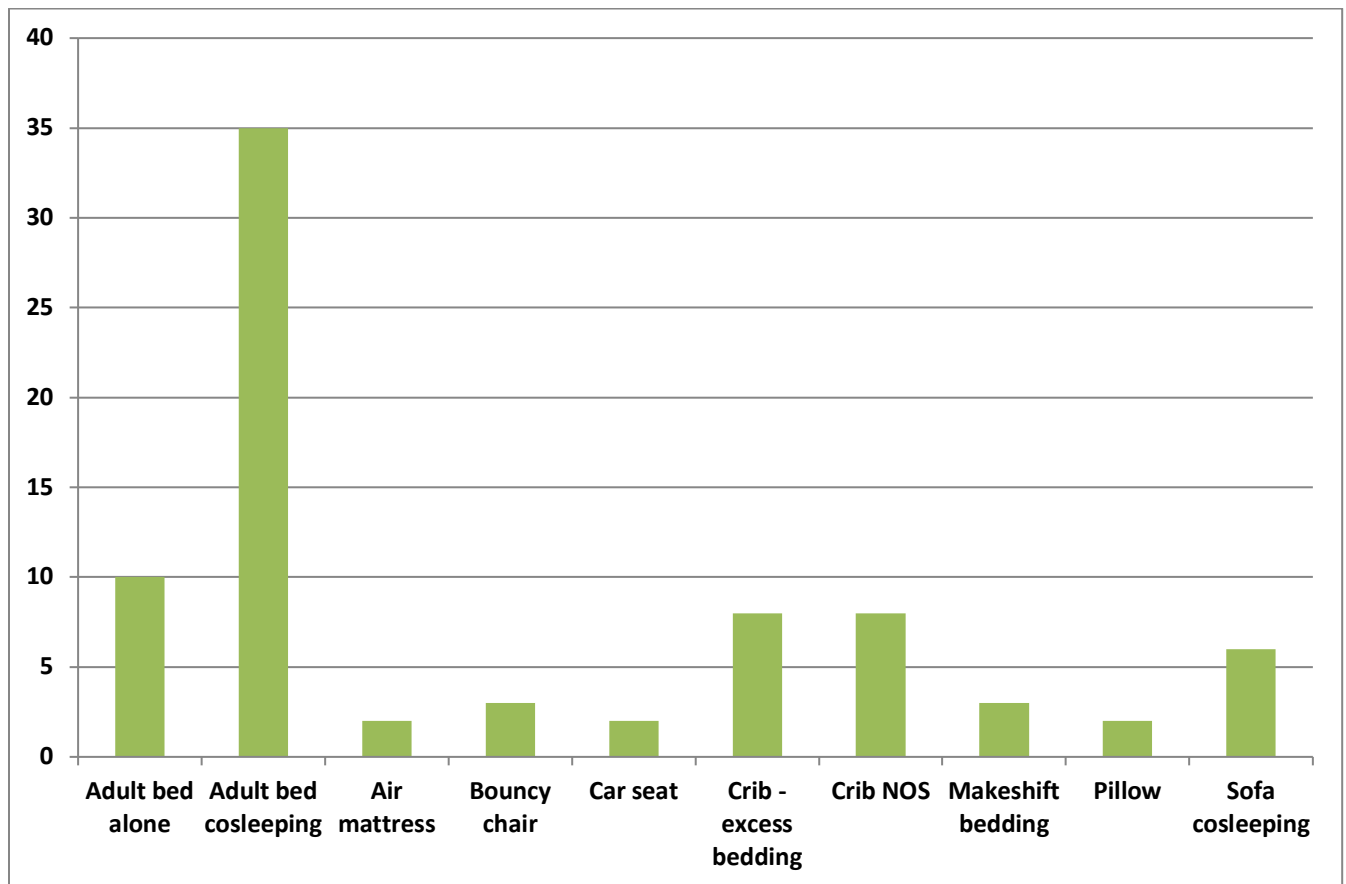
The authors also write that “... while bedsharing can never be publicly recommended due to its complexity, blanket recommendations against bedsharing and eliminating safety information for bedsharing families cannot be justified either.”

**Ostfeld et al (2006)** reviewed all SIDS cases reported to the New Jersey SIDS center from 1996 to 2000. Their findings concluded that “bed-sharing cases were distinguished from non-bed-sharing cases by a greater proportion of risk in the bedding environment, defined as the use of a couch; the presence of another child; proximity to blankets, pillows, and other soft bedding; a greater proportion of placement in a less-stable lateral sleep position; and, on multivariable analysis of sociodemographic risk factors, a greater proportion of race self-identified as black, higher gravida, adolescent mothers, and mothers self-identified as smokers. Breastfeeding was not more common in bed-sharing cases.



**Venneman et al (2009)** compared 333 SIDS cases with 998 matched controls, collected from a three year period in Germany (1998-2001), after the “Back to Sleep” campaign when very few infants in Germany were still regularly sleeping prone. They found an increased risk of SIDS with sleeping prone, bedsharing (especially if younger than 13 weeks), duvets, and sleeping in the home of a friend or relative (compared to sleeping in parental home). The population was drawn from an area accounting for ~50% of all births in Germany during the study period. All decedents had a complete autopsy (including microbiology and toxicology), and all cases were reviewed by a multidisciplinary panel to assess SIDS versus “explained” sudden unexpected deaths.

**Blair et al (2009)**, in a population based, 4-year study (2003-2006) in south west England compared 80 SIDS cases with a group of randomly selected (age- and time-matched controls) and controls (age- and time-matched) from a group considered high risk for SIDS. The study population was 4.9 millions, and included more than 184 000 live births. 54% of the SIDS cases had been cosleeping, compared to 20% of controls. Other factors that were significantly higher among the SIDS cases than the controls were maternal use of alcohol in last 24 hours, smoking during pregnancy, swaddling during last sleep, prone sleeping, and infant use of a pillow. The authors concluded that many SIDS infants had coslept in a hazardous environment, and many risk factors were amenable to change and specific advice – regardless of markers for socioeconomic deprivation.



**Sleep-related infant deaths in Hennepin County, MN, 2005-2009  
(unpublished data)**

In 2005, The **American Academy of Pediatrics** released the following recommendations regarding infant sleep environments [excerpted directly from Policy Statement, *Pediatrics* 2005; 116(4)]

1. **Back to sleep:** Infants should be placed for sleep in a supine position (wholly on the back) for every sleep. Side sleeping is not as safe as supine sleeping and is not advised.
2. **Use a firm sleep surface:** Soft materials or objects such as pillows, quilts, comforters, or sheepskins should not be placed under a sleeping infant. A firm crib mattress, covered by a sheet, is the recommended sleeping surface.
3. **Keep soft objects and loose bedding out of the crib:** Soft objects such as pillows, quilts, comforters, sheepskins, stuffed toys, and other soft objects should be kept out of an infant's sleeping environment. If bumper pads are used in cribs, they should be thin, firm, well secured, and not "pillow-like." In addition, loose bedding such as blankets and sheets may be hazardous. If blankets are to be used, they should be tucked in around the crib mattress so that the infant's face is less likely to become covered by bedding. One strategy is to make up the bedding so that the infant's feet are able to reach the foot of the crib (feet to foot), with the blankets tucked in around the crib mattress and reaching only to the level of the infant's chest. Another strategy is to use sleep clothing with no other covering over the infant or infant sleep sacks that are designed to keep the infant warm without the possible hazard of head covering.
4. **Do not smoke during pregnancy:** Maternal smoking during pregnancy has emerged as a major risk factor in almost every epidemiologic study of SIDS. Smoke in the infant's environment after birth has emerged as a separate risk factor in a few studies, although separating this variable from maternal smoking before birth is problematic. Avoiding an infant's exposure to second- hand smoke is advisable for numerous reasons in addition to SIDS risk.
5. **A separate but proximate sleeping environment is recommended:** The risk of SIDS has been shown to be reduced when the infant sleeps in the same room as the mother. A crib, bassinet, or cradle that conforms to the safety standards of the Consumer Product Safety Commission and ASTM (formerly the American Society for Testing and Materials) is recommended. "Cosleepers" (infant beds that attach to the mother's bed) provide easy access for the mother to the infant, especially for breastfeeding, but safety standards for these devices have not yet been established by the Consumer Product Safety Commission. Although bed-sharing rates are increasing in the United States for a number of reasons, including facilitation of breastfeeding, the task force concludes that the evidence is growing that bed sharing, as practiced in the United States and other Western countries, is more hazardous than the infant sleeping on a separate sleep surface and, therefore, recommends that infants not bed share during sleep. Infants may be brought into bed for nursing or comforting but should be returned to their own crib or bassinet when the parent is ready to return to sleep. The infant should not be brought into bed when the parent is excessively tired or using medications or substances that could impair his or her alertness. The task force recommends that the infant's crib or bassinet be placed in the parents' bedroom, which, when placed close to their bed, will allow for more convenient breastfeeding and contact. Infants should not bed share with other children. Because it is very dangerous to sleep with an infant on a couch or armchair, no one should sleep with an infant on these surfaces.

In 2011, The **American Academy of Pediatrics** released the following policy statement and recommendations regarding infant sleep environments [excerpted directly from Policy Statement, *Pediatrics* 2011; 128: 1030-1039]

#### POLICY STATEMENT

## SIDS and Other Sleep-Related Infant Deaths: Expansion of Recommendations for a Safe Infant Sleeping Environment

- **Back to sleep for every sleep**
- **Use a firm sleep surface**
- **Room-sharing without bed-sharing is recommended**
- **Keep soft objects and loose bedding out of the crib**
- **Pregnant women should receive regular prenatal care**
- **Avoid smoke exposure during pregnancy and after birth**
- **Avoid alcohol and illicit drug use during pregnancy and after birth**
- **Breastfeeding is recommended**
- **Consider offering a pacifier at nap time and bedtime**
- **Avoid overheating**
- **Do not use home cardiorespiratory monitors as a strategy for reducing the risk of SIDS**

**Expand the national campaign to reduce the risks of SIDS to include a major focus on the safe sleep environment and ways to reduce the risks of all sleep-related infant deaths, including SIDS, suffocation, and other accidental deaths; pediatricians, family physicians, and other primary care providers should actively participate in this campaign**

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