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# Infant Mechanical Suffocation Deaths in the United States, 1980–1997

Dorothy A. Drago, MA, MPH\*, and Andrew L. Dannenberg, MD, MPH‡

**ABSTRACT.** *Purpose.* To document specific patterns and products associated with mechanical suffocation among infants younger than 13 months of age for the period 1980 to 1997.

*Methodology.* A total 2178 case summaries from the US Consumer Product Safety Commission's Death Certificate File were reviewed. A computerized database was created for information about the infants, products, and patterns of suffocation. The relationships among products, patterns, and age groups were analyzed by  $\chi^2$ . Thirty-eight investigations conducted on a subset of cases involving cribs were reviewed for details on crib age, structural integrity, and compliance with the federal crib regulation. Mortality rates were calculated based on the US population younger than 1 year old.

*Results.* The most frequent causes of suffocation were 1) wedging between a bed or mattress and a wall and 2) oronasal obstruction by plastic bag. Patterns of suffocation were significantly related to age group, but not to sex. Pattern-specific mortality rates comparing three time frames for the 16-year period from 1980 to 1995 showed continued increases for overlain and oronasal obstruction; an increase followed by a plateau for wedging, a decrease for hanging, and no substantial change for entrapment with suspension.

*Conclusions.* Suffocation hazards presented by beds, bedding, pillows, and plastic bags continue to be under-recognized by parents and caregivers. Bed-sharing and use of adult beds for infants should be discouraged. Only complying cribs should be used and maintained properly to ensure structural integrity. Suffocation deaths involving plastics should be investigated to determine the specific material characteristics and use patterns to design more effective interventions than selective labeling. *Pediatrics* 1999;103(5). URL: <http://www.pediatrics.org/cgi/content/full/103/5/e59>; *suffocation, infants, beds, cribs, co-sleeping*.

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ABBREVIATIONS. CPSC, US Consumer Product Safety Commission; ICD, International Classification of Diseases; SIDS, sudden infant death syndrome.

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\*Note: Dorothy A. Drago, MA, MPH, is an independent safety consultant. From the ‡Center for Injury Research and Policy, Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland. This study was conducted without financial or other support. Received for publication Sep 3, 1998; accepted Dec 14, 1998. Andrew L. Dannenberg's current affiliation: Epidemiology Program Office, Centers for Disease Control and Prevention, Atlanta, GA. Address correspondence to Dorothy A. Drago, MA, MPH, 204 E Deer Park Dr, Gaithersburg, MD 20877. E-mail: [bkbn75b@prodigy.com](mailto:bkbn75b@prodigy.com) PEDIATRICS (ISSN 0031 4005). Copyright © 1999 by the American Academy of Pediatrics.

In 1995, the injury death rate for infants younger than 1 year old was 29 per 100 000 population, with suffocation listed as the leading cause.<sup>1</sup> With a rate per 100 000 population of 12.4 for males and 9.5 for females, the 1995 suffocation rate among infants younger than 1 was 10 times the rate among children 1 to 4 years of age.<sup>1</sup> Seventy percent of the suffocations among infants were attributable to mechanical asphyxia rather than to respiratory obstruction. The 1995 sex-specific suffocation death rates, based on data from the National Center for Health Statistics, were more than twice as high as similarly based data from 1980–1986, during which the infant injury suffocation death rates for males and females were reported as 5.3 and 4.2 per 100 000 population, respectively.<sup>2</sup>

Because infants rely on others to provide a safe environment, the products and circumstances that present suffocation hazards may not be recognized adequately by parents and caretakers. This study reviews information from death certificates for the period January 1, 1980, through September 1, 1997, to identify, where possible, specific patterns of infant unintentional suffocation death and the specific products involved. An additional purpose was to examine how patterns and products involved may have changed over the last 15 years.

## METHODS

Reports of infants up through 12 months of age who died from mechanical suffocation were requested from the US Consumer Product Safety Commission (CPSC). Under contract, the CPSC purchases from the 50 states, the District of Columbia, and New York City copies of death certificates classified with certain E codes (external cause of death) according to the International Classification of Diseases (ICD), 9th rev. Death certificates that identify a product under CPSC's jurisdiction or a product of special interest to the CPSC because of its ongoing or anticipated projects, are coded in the Commission's Death Certificate File.<sup>3,4</sup> For these reasons, the number of deaths recorded in CPSC's file and analyzed in this study must be considered a minimum number.

To obtain cases for this study, search criteria included cases involving infants up through 12 months of age reported in the CPSC's Death Certificate File for the period January 1, 1980, through September 1, 1997, which were coded E913 or E983, or which contained any root of any of the following words: asphyxia, anoxia, suffocation, strangulation, and ligature. The search produced a computer printout of 3676 case summaries. After duplicates and nonrelevant cases (drownings, toxic inhalations, and chokings) were excluded, 2178 case summaries were available for analysis. A database was created using Epi Info<sup>5</sup> to store and analyze data, including age, sex, race, E code, date of death, product(s) involved, and specific pattern of suffocation.

During review of the case summaries, D.A.D. created 99 codes to describe the products involved. When one product was reported, the developed code simply identified the product, for example, high chair, bed, couch. When multiple products were

reported or when distinct parts of one product were reported, the developed code attempted to establish the relationship, for example, between mattress and crib frame, clothing on fan, between bed and chair. Certain codes subsequently were combined for better manageability in data analysis and presentation. For example, between bed and wall and between mattress and wall were combined as between bed/mattress and wall because both implied falling between an adult sleep surface and the wall, and because most mattresses were assumed to be placed on a bed-frame. Other codes were combined because of low individual frequency. For example, between bed and chair (frequency = 1), between bed and desk (frequency = 3), between crib and table (frequency = 1), and similar codes of low frequency were combined as between furniture.

The specific patterns of suffocation were categorized into the following 10 groups.

1. Wedging for being trapped between two products or between parts of one product;
2. Hanging for being suspended in a noose-like loop or by caught clothing;
3. Entanglement for ligature strangulation;
4. Positional asphyxia for the position of the head/body interfering with breathing;
5. Entrapment with suspension for head entrapment in a space through which the body had passed;
6. Entrapment without suspension for entrapment in a space through which the body had not passed;
7. Oronasal obstruction for partial or complete covering of the nose and/or mouth;
8. Compression for being trapped under an object that had toppled or collapsed;
9. Overlain for being rolled over onto or against by another person; and
10. Unknown for insufficient detail to determine a suffocation pattern.

For the current analyses, four age groups were used: 0 to <3 months, 3 to <7 months, 7 to <12 months, and 12 to <13 months. Estimated mortality rates were calculated based on the population younger than age 1 for the time period 1980 through 1995 as reported by the US Department of Commerce, Bureau of Census.<sup>6,7</sup>

Of 153 cases in the current dataset selected by CPSC for follow-up investigation since 1993, 43 involved cribs, 1 involved plastic bedding, and 2 involved a plastic bag. These investigations were of interest because few crib deaths were expected, given that the crib regulation has been in effect since 1973<sup>8</sup> and because when plastic materials are involved in deaths, summary descriptions rarely contain detail on the type or thickness. Therefore, copies of the 46 investigations were requested. Of these 46 investigations, 41 were obtained, 4 had been canceled or terminated, and 1 was reported missing from the CPSC file. Of the 41 cases obtained, 38 involved cribs, 1 involved plastic bedding, and 2 involved a plastic bag. The 38 crib cases were reviewed to learn age of the crib involved, structural problems, status of its compliance with the mandatory regulation, and how the added details available from the follow-up investigations would have affected the pattern and product codes assigned by the D.A.D., based on the information in the case summary. The 3 cases involving plastic were reviewed to learn more detail about the product. Because criteria for selection of a case for follow-up investigation by CPSC can depend on budgetary constraints and project priorities, general conclusions from the subset cannot be drawn.

## RESULTS

### Demographics

The age distribution of infants for this dataset ( $N = 2178$ ) is shown in Table 1. Infants younger than 2 months of age made up the largest single category ( $n = 313$ ; 14.4%); infants 11 to <12 months old made up the smallest single category ( $n = 64$ ; 2.9%). The sex distribution was 58.3% males and 41.7% females. Most infants were white (71.5%); others were black (25%), Indian (1.3%), Chinese (0.3%), other nonwhite (1.4%), or unknown (0.6%).

**TABLE 1.** Age of Infant at Time of Death by Unintentional Suffocation, as Reported in the CPSC Death Certificate File, January 1, 1980–September 1, 1997

Age (Months)	Number	Percent
≤1	313	14.4
2	231	10.6
3	189	8.7
4	219	10.1
5	231	10.6
6	237	10.9
7	169	7.8
8	132	6.1
9	101	4.6
10	71	3.3
11	64	2.9
12 to <13	221	10.1
Total	2178	100

The CPSC codes age of children younger than 2 years old in months. Infants younger than 1 month old are coded as 1 month.

### Patterns of Suffocation and Products Involved

The frequency distribution for 10 patterns of suffocation by age group and product code is shown in Table 2. The leading pattern of suffocation overall and for each age group was wedging ( $n = 879$ ; 40%). After wedging, oronasal obstruction was the most frequent suffocation pattern ( $n = 512$ ; 24%), followed by overlain ( $n = 180$ ; 8%), entrapment with suspension ( $n = 145$ ; 7%), and hanging ( $n = 111$ ; 5%). There were fewer than 100 cases in each of the remaining patterns, except unknown ( $n = 142$ ; 7%). Figure 1 summarizes the frequency distribution by age group for the five most common patterns (except unknown).

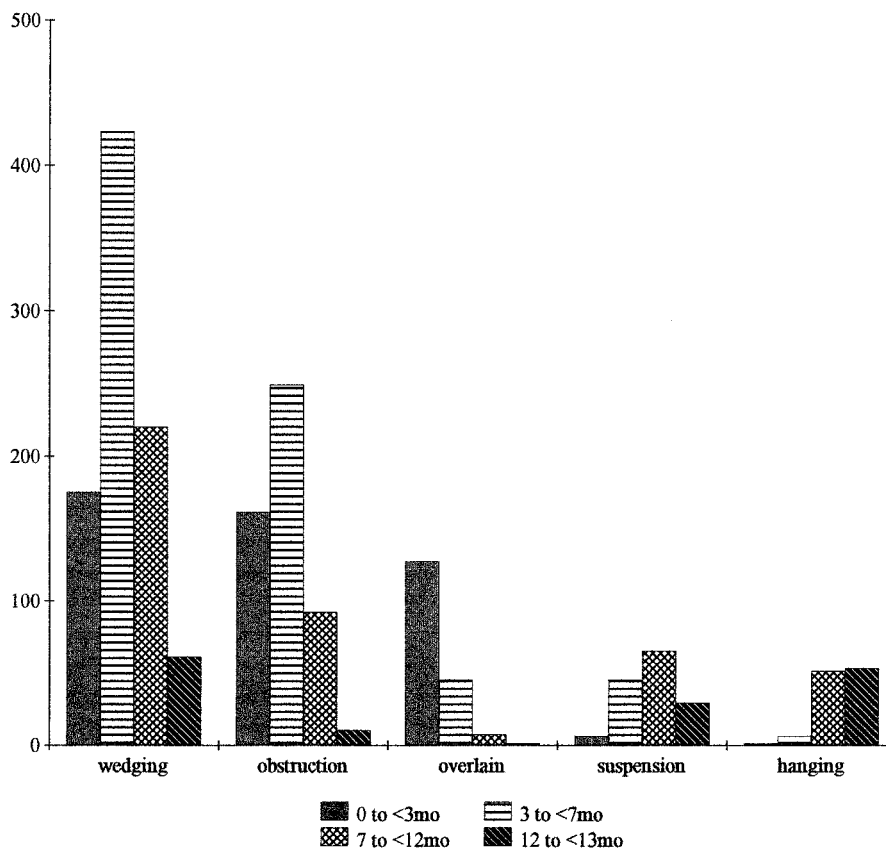
The pattern of suffocation was significantly related to age group (Table 2 and Fig 1) ( $\chi^2 = 766.0$ ;  $df = 27$ ;  $P = .000$ ). Wedging was more likely among the age group 3 to <7 months; oronasal obstruction was more likely among the age groups 3 to <7 months and 0 to <3 months; being overlain was more likely among the age group 0 to <3 months; entrapment with suspension and positional asphyxia were more likely among the age group 7 to <12 months; hanging, entanglement, entrapment without suspension, and compression were more likely among 12 month olds. There was no significant relationship between pattern and sex ( $\chi^2 = 15.2$ ;  $df = 9$ ;  $P = .086$ ).

Among the wedgings, the most likely location was between a bed or mattress and the wall (32%), followed by between a mattress and crib frame (22%). Plastic bags, pillows, and nonplastic bedding were approximately equally involved in oronasal obstruction among the age group 0 to <3 months; however, plastic bags were much more likely than were other products to be involved among the age groups 3 to <7 months (Yates corrected  $\chi^2 = 56.4$ ;  $P = .000$ ) and 7 to <12 months (Yates corrected  $\chi^2 = 44.2$ ;  $P = .000$ ). Most of overlain deaths occurred on a bed (57%) or couch (37%). Approximately one third (35%) of hangings involved clothing or necklaces, 27% involved drapery or blind cords, and 14% involved pacifier cords. Nearly half (44%) of the entrapments with suspension occurred in a crib or cradle.

**TABLE 2.** Frequency Distributions by Age and Product Code for 10 Patterns of Unintentional Infant Suffocation January 1, 1980–September 1, 1997\*

Pattern	Age Group (Months)				Row Total	% <i>n</i>
	0 to <3	3 to <7	7 to <12	12 to <13		
<b>Wedging (<i>n</i> = 879)</b>						
Between bed/mattress and wall	55	153	60	17	285	32.4
Between bed/mattress and frame	26	72	40	11	149	17.0
Between bed/mattress and other	5	31	19	2	57	6.5
Between mattress and crib frame	29	96	60	8	193	22.0
Other within crib/bed	33	36	18	15	102	11.6
Other	27	35	23	8	93	10.6
Column total	175	423	220	61	879	100.0
<b>Oronasal obstruction (<i>n</i> = 512)</b>						
Plastic bag	24	130	51	3	208	40.6
Pillow	35	25	4	1	65	12.7
Bedding, nonplastic	27	24	14	3	68	13.3
Bedding, plastic	3	11	3	0	17	3.3
Waterbed	17	17	3	0	37	7.2
Sofa	14	5	2	0	21	4.1
Other	41	37	15	3	96	18.8
Column Total	161	249	92	10	512	100.0
<b>Overlain (<i>n</i> = 180)</b>						
In a bed	76	24	2	0	102	56.7
On a sofa	47	16	3	1	67	37.2
Other	4	5	2	0	11	6.1
Column total	127	45	7	1	180	100.0
<b>Entrapment with suspension (<i>n</i> = 145)</b>						
In crib/cradle	1	23	34	6	64	44.1
In bed	2	10	8	9	29	20.0
In high chair	0	0	15	6	21	14.5
Between furniture	1	3	3	2	9	6.2
Other	2	9	5	6	22	15.2
Column total	6	45	65	29	145	100.0
<b>Hanging (<i>n</i> = 111)</b>						
By clothing/necklace	1	2	13	23	39	35.1
By blind/drapery cord	0	1	16	13	30	27.0
By pacifier cord	0	0	9	7	16	14.4
Other cord	0	0	9	4	13	11.7
Other	0	3	4	6	13	11.7
Column total	1	6	51	53	111	100.0
<b>Entanglement (<i>n</i> = 91)</b>						
Plastic bag	2	9	0	2	13	14.3
Bedding, nonplastic	2	5	5	2	14	15.4
In blind/drapery cord	0	0	9	4	13	14.3
In pacifier cord	0	1	1	1	3	3.3
In other cord	0	4	20	13	37	40.7
Other	0	3	3	5	11	12.1
Column total	4	22	38	27	91	100.0
<b>Compression (<i>n</i> = 55)</b>						
Collapsed crib	2	5	6	0	13	23.6
Other crib/cradle/playpen	3	2	0	0	5	9.1
Other	0	4	14	19	37	67.3
Column total	5	11	20	19	55	100.0
<b>Positional asphyxia (<i>n</i> = 33)</b>						
Infant carrier	1	1	1	1	4	12.1
Hammock	2	1	0	0	3	9.1
Crib	1	0	1	1	3	9.1
Bed	1	3	2	0	6	18.2
Basket/hamper	1	0	1	0	2	6.1
Other	1	3	8	3	15	45.5
Column total	7	8	13	5	33	100.0
<b>Entrapment without suspension (<i>n</i> = 30)</b>						
In infant's furniture/product	2	1	3	1	7	23.3
Under furniture lid	0	0	2	5	7	23.3
Other	2	5	4	5	16	53.3
Column total	4	6	9	11	30	100.0
<b>Unknown (<i>n</i> = 142)</b>						
Bed	20	18	5	1	44	31.0
Crib/cradle/playpen	11	25	10	2	48	33.8
Sofa/chair	11	1	1	0	13	9.2
Bedding	2	3	0	0	5	3.5
Other	10	14	6	2	32	22.5
Column total	54	61	22	5	142	100.0
Grand total	544	876	537	221	2,178	100.0

\* Ranked in decreasing order by frequency (*n*), except for the pattern unknown, which is placed last.



**Fig 1.** Number of unintentional suffocation deaths by age group for five patterns, January 1, 1980 to September 1, 1997. Obstruction indicates oronasal obstruction; suspension indicates entrapment with suspension.

### Follow-up Investigations

The information from the 38 crib investigations is summarized in Table 3. Three of the 38 incidents were reported to have occurred at day care centers.

Among the 38 cases, 18 patterns would have been revised based on the additional information: 8 unknowns would have been revised to entrapment with suspension (6) or oronasal obstruction (2); 10 wedgings would have been revised to entrapment with suspension (9) or unknown (1). Among the 38 cases, eight product codes would have been revised based on the additional information: eight cribs

would have been revised to beds (3), playpens (2), pillows (1), between bed and crib (1), or bassinets (1). For 7 cases, a more specific location within the crib would have been determined.

The two investigations involving plastic bags revealed that in each case, the infant fell off a bed and onto plastic bags filled with clothes. The investigation involving plastic bedding revealed that the article was an absorbent mat. One side of the mat was plastic and airtight, and the other side was made of a woven fabric. For all 3 cases, there was no information on material thickness.

**TABLE 3.** Summary of Information from 38 Crib Investigations Conducted by CPSC During 1993–1997

Product age	
Unknown	30
2 y old	2
3–4 y old	3
>20 y old	3
Reported problem*	
Missing or loose hardware	5
Improper mattress fit	8
Mattress support bent or unhooked	4
Missing slats or wide interslat space	8
Improper assembly	2
Damaged side	3
Repaired previously broken	1
Homemade/makeshift crib	2
None reported	10
Subject to federal crib regulation	
Yes	5
No, based on age	3
No, based on product type	10
Unknown	20

\* Exceeds 38 because some products had multiple problems.

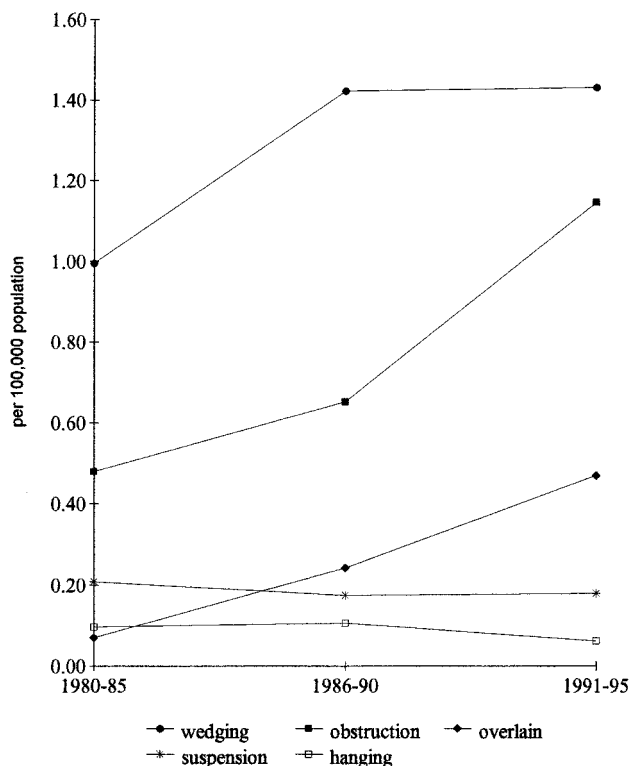
### E Codes

More than half of the 2178 cases (58%) were assigned the code E913.0 (accidental mechanical suffocation in bed or cradle, excluding suffocation by plastic bag). The next most frequently assigned codes were E913.8 (accidental mechanical suffocation by other specified means, accidental hanging, except in bed or cradle) for 15% of the cases, E913.1 (accidental mechanical suffocation by plastic bag) for 10% of the cases, and E913.9 (accidental mechanical suffocation by unspecified means) for 9% of the cases. Two percent were coded E918.0 (caught accidentally in or between objects), and 5% were coded one of 25 other E codes.

### Time Trends

The five most frequently occurring suffocation patterns were compared for three time periods, 1980 to 1985, 1986 to 1990, and 1991 to 1995 (Fig 2). The years 1980 to 1995 were selected for comparison purposes





**Fig 2.** Estimated mortality rates for five patterns of unintentional suffocation among infants 0 to 11 months of age, 1980 to 1995. Obstruction indicates oronasal obstruction; suspension indicates entrapment with suspension.

because the CPSC data collection is reasonably complete, whereas data collection for 1996 and 1997 is not yet complete. Pattern-specific mortality rates were estimated by dividing the number of reported deaths for infants up through 11 months of age by the population younger than 1 year of age for the time period indicated.

The estimated mortality rates for wedging increased by a factor of 1.4 between the periods 1980 to 1985 and 1986 to 1990, then remained unchanged between 1986 to 1990 and 1991 to 1995. The rate for oronasal obstruction increased over the three periods; the rate for overlain increased the greatest, by a factor of 3.4 between 1980 to 1985 and 1986 to 1990 and by a factor of 1.95 between 1986 to 1990 and 1991 to 1995. The estimated rates for entrapment with suspension were relatively unchanged, whereas the rates for hanging decreased by approximately half between 1986 to 1990 and 1991 to 1995.

The role of plastic bags in oronasal obstruction over the three time periods and age groups described in Fig 2 was compared with the role of all other products combined. There was a significant difference ( $\chi^2 = 11.1$ ;  $df = 2$ ;  $P = .004$ ), with plastic bag involvement decreasing during 1991 to 1995, compared with the previous two time periods.

## DISCUSSION

This study analyzed 2178 mechanical suffocation deaths among infants 12 months of age or younger by age group, pattern of suffocation, and products involved. The major limitation of the data used in

this study is that they may be incomplete because of initial underreporting to the CPSC or incomplete retrieval of records based on either coding errors or search strategy. Another limitation is that the age group 12 to <13 months old is artificially inflated because it includes some infants 13 to 23 months of age. Through personal communication with CPSC staff, it was learned that during the early 1980s, some contractors supplying death certificate information coded infants who were 1 year old at death as 12 months old, rather than calculating age at death in months based on the date of birth. When CPSC became aware of the coding error, some retrospective corrections were made, but not to all years of data affected. The coding error was rectified so that data from 1989 onward are considered accurate. Based on this information, we reviewed the frequency for 12-month-olds in the current dataset by year of death. For the years 1980 to 1986, the average number of deaths per year was 19; for the years 1987 to 1995, the average number of deaths per year was 10. Based on the latter average, which is believed more accurate, it is estimated that the number of 12 to <13-month-olds is more likely to be approximately 164 rather than 221, as reported.

The five most frequently occurring patterns were wedging, oronasal obstruction, overlain, entrapment with suspension, and hanging. The pattern of suffocation was found to be significantly related to age. This finding is consistent with the expected developmental changes that occur during the first year of life. Other authors have recognized the relationship between level of development and mechanism of suffocation death.<sup>9</sup>

## Wedging

Wedging was primarily a pattern among the age group 3 to <7 months. Three- to 6-month-old infants have begun to develop several motor skills. They usually can rock from side to side and roll over. They may be able to crouch up on hands and knees and move by pushing against a flat surface. Thus, they have the capability to move to corners in beds and cribs. Yet, they do not have the muscle development or motor control to be able to lift themselves out of a wedged position. More than half of the wedgings involved a bed, including 32% wedged between the bed and wall. Wedging involving a bed is not a new pattern of suffocation,<sup>10,11</sup> nor is it a pattern that occurs only in the United States. Wedging suffocation deaths attributed to slipping between a mattress and bed sides or wall have been reported in South Australia<sup>12</sup> and in England and Wales.<sup>9</sup> In the latter study, beds and cots were implicated in nearly one third of accidental asphyxia deaths among children. In 1977, Smialek suggested that economic reasons or temporary-use circumstances might be factors in the use of a bed for an infant.<sup>11</sup> Those still may be valid reasons today. The positioning of a bed close to a wall may be a physical necessity or it may be the result of parents' belief that pushing a bed against a wall prevents a child from falling out. In 1976, Sturner and associates suggested that parents be ed-

ucated as to the danger of poorly positioned beds;<sup>10</sup> however, the fact that suffocation deaths involving a bed and wall continue to occur indicates that the message has not been communicated successfully.

Approximately 22% of wedgings occurred in a crib. This suggests improper fit of a mattress or lack of structural integrity of the crib frame. The federal crib standard<sup>8</sup> requires that a mattress fit within a crib frame so that no more than a 1-inch space can be created between the mattress and any side. However, cribs may be used generationally, so that some old cribs in use may not meet the standard, whereas others may have met the standard when first manufactured, but may fail to meet it now because of wear and tear effects on structural integrity or improper size of replacement mattresses. The information from the 38 crib investigations (Table 3) supports these possibilities. In most cases, the age of the crib was unknown. Several were described as hand-me-downs and were likely to be quite old, prestandard cribs. Compromised structural integrity (missing or loose hardware or slats etc) suggested the effect of wear and tear. Improper mattress fit suggested the effect of age, the original mattress having been replaced. For that subset of 38, only five cribs were known to be subject to the federal regulation. Of those five, the compliance status of one was unknown. The other four complied theoretically with the regulation when new; however, the compliance status at the time of the incident was likely to have been compromised. Two cribs were reported damaged in moving, one had been assembled improperly, and one had been used with a previous child.

### Oronasal Obstruction

Oronasal obstruction was the second leading cause of suffocation death. Infants in the age groups 0 to <3 and 3 to <7 months of age made up 80% of the cases. Up to 2-month-olds exhibit largely reflexive actions, whereas 3- to 6-month-olds, relatively more developed, display more oral and manual exploratory behavior and more motor ability. Because bedding, pillows, and plastic bags were involved equally in the oronasal obstruction deaths of the 0- to <3-month-olds, rebreathing may play a role in their suffocation. Chiodini and Thatch conducted an observational study of 11 infants 0.2 to 6 months of age and reported that all infants slept face down at some point, either spontaneously or after positioning, and that all infants regardless of age could turn the head out of the face down position.<sup>13</sup> They concluded that although capable of turning the head, an infant may retain the face down position, in which rebreathing usually occurs. Alternative possibilities are that infants' head-turning is interfered with by the presence of bedding or pillows or that infants may turn the head into a physical barrier made of bedding or pillows. There is insufficient detail in the data used for the present study either to support or to refute these alternative theories. However, from a developmental point of view, they are plausible because this age group would be unable to retreat from or move a barrier.

More than half of the oronasal obstructions among the age group 3 to <7 months of age involved plastic bags. This suggests a more deliberate, exploratory interaction with the environment than the younger infants exhibit. Three- to 6-month-olds can swipe at and manipulate objects; however, this ability is coupled with fledgling motor skills that are insufficient to enable the infant to extricate him/herself from danger. Thus, infants of this age can bring plastic to the face, but may be unable to remove it. They also may fall from elevated surfaces onto filled plastic bags, as reported in two follow-up investigations, and be unable to move away.

Plastic bag dangers have been recognized since the 1950s, when plastic drycleaning bags used as waterproof sheets for infant beds were reported as the principal cause of mechanical suffocation death.<sup>14</sup> The inherent dangers of plastic film are 1) that it adheres, partially by the act of inhaling and partially by static electricity generated by the movement of the plastic film itself; and 2) it is strong, thus, infants cannot tear it.<sup>15</sup> Jeffrey<sup>15</sup> reported that if plastic film is not removed from an infant's face within 1 minute, the infant will die of suffocation. The causal association between plastic bags and mechanical suffocation death led to efforts by many groups, including the American Medical Association, the National Institute of Drycleaning, and the Society of the Plastics Industry, Inc, to publicize and warn about the hazard. Over the years, warning labels have been required by some jurisdictions, such as New York and Chicago, but there are no national standards or regulations requiring safety labels on plastic bags. The Society of the Plastics Industry, Inc periodically reminds the industry about the importance of continuing its warning labeling and similar activity;<sup>16,17</sup> however, the content of its informational bulletin has not changed since 1982. The bulletin refers to the tragic plastic bag suffocation deaths that occurred during the 1950s as a "cause celebre" and states, "The danger of misuse of ultra-thin dry cleaner bags has probably become as much a part American child safety folklore as the proverbial warning to children not to touch a hot stove. Even so, it is best to take nothing for granted. . . so let's make sure those warnings are on all dry cleaner bags—education is still the answer here!" As this study shows, plastic bags continue to be involved with a substantial number of infant suffocations, on average one a month for the past 16 years. Perhaps it is time to revisit the plastic bag hazard and identify an alternative to education/warning. Because other plastic materials, such as plastic wrap, trash bags, toys, and cups, also are involved, albeit in small numbers, it may be useful to revisit the hazard of plastic materials in general. In a 1981 report, CPSC identified infant suffocation cases involving trash bags and other plastic materials thicker than 1 mm and indicated that those findings might suggest that any new campaigns include these thicker materials.<sup>18</sup> We are unaware that any consumer education efforts have included these other plastics.

## Overlying

Seventy percent of infants overlain were younger than 3 months old. More than half of the deaths by this pattern occurred in a bed. There may be several factors that place this age group at particular risk. These infants are the smallest and have not yet developed much motor ability. They are engaged primarily in eating and sleeping. New parents may take their infants to bed with them to enhance infant-parent bonding or for feeding convenience.

Overlying historically has been recognized as a cause of infant suffocation death.<sup>19,20</sup> In 1970, Francisco recommended that "Parents must be informed that to sleep in the same bed with an infant is to invite disaster. . .".<sup>19</sup> However, suffocation by overlying became a largely unrecognized entity, superseded by sudden infant death syndrome (SIDS).<sup>9,20</sup> To the contrary, the data in this study suggest that overlying increasingly presents a problem, whether in a bed or on a sofa. The estimated mortality rate for 1986–1990 was more than triple the estimated rate for 1980–1985; the estimated rate for 1991–1995 was nearly twice the rate for 1986–1990. A possible explanation for the increase could be an increase in the rate of infant-parent co-sleeping related to reported benefits, including increased breastfeeding and reduction in the rate of SIDS,<sup>21,22</sup> despite the statement by the American Academy of Pediatrics that there is no basis for encouraging bed-sharing as a strategy to reduce SIDS.<sup>23</sup> Knowledge of rates of co-sleeping would have been helpful in understanding the potential causal relationship to overlying.

## Other Patterns

Entrapment with suspension, hanging, and entanglement occurred less frequently than did the other patterns. These types of suffocation occurred primarily among infants older than 6 months of age, probably as a reflection of increasing mobility and exploratory behavior that comes with increasing age. The 7- to 11-month-old has much more head control, can push up on hands and knees, may move by "creeping/crawling" along, and can pull to a standing position. Usually, the 12-month-old begins to toddle or walk and can climb, including climbing out of the crib. The entrapments with suspension that occur in a crib or cradle are likely attributable to problems in structural integrity of the product, because the pattern involves falling feet first through a space between the mattress and frame, a space too small to allow the head to pass. Table 3 showed that structural problems were common among the investigated cases. Many hangings involved "nooses" created by necklaces, pacifier cords, and blind cords. Any items worn around the neck create a strangulation hazard because they can catch on protrusions. Since 1977, it has been illegal to sell a pacifier with any type of cord; in addition, all pacifiers are required to have a warning label to inform about the hazards of strangulation.<sup>24</sup> The strangulation hazard associated with blinds has been reported by Rauchschwalbe and Mann.<sup>25</sup> Pacifier cords and blind cords also were involved in entanglements.

Compression and entrapment without suspension were the least frequent patterns, together accounting for 85 reports. As expected, these involved older infants whose mobility was probably a contributing factor.

## Follow-up Investigations

Based on the information from the crib investigations, many contributing factors became obvious (Table 3). In some cases, the investigations provided a basis for clarification. Some of the patterns identified initially as wedging or unknown were found to actually be entrapments with suspension. Therefore, the actual number of wedgings may be somewhat lower and the actual number of entrapments with suspension may be somewhat higher than reported in Table 2. Also, some products described as cribs were found actually to be beds or other products. This emphasizes the importance of follow-up investigation to ensure optimum accuracy of information, better understanding of contributing factors, and provide a basis for effective interventions.

## E Codes

Most of the patterns of suffocation were given the code E913, accidental mechanical suffocation. Approximately 80% of wedgings, 60% of overlains, and 40% of oronasal obstructions were coded E913.0, accidental mechanical suffocation in bed or cradle. Such general coding conceals the actual manner of many deaths. It also makes location impossible to identify correctly unless other information is concurrently available, because the code combines data for cradles, products intended for infants and children, with beds, which could be used by adults, infants, or children. Knowledge of both actual manner and location is important in designing successful interventions. Perhaps subsequent ICD revisions should consider one code for beds and one for cribs, cradles, bassinets, and other products generally recognized as intended for infants and toddlers, especially because suffocation deaths are primarily a concern during the first year of life.

## CONCLUSIONS

Creating a safe sleep environment for infants could reduce infant suffocation deaths substantially. Cribs, beds, or bedding were involved in more than half of the suffocations described in this study, suggesting that sleep environment-related hazards are not well recognized by parents and caregivers. The cribs involved probably had some structural problem that created the hazard, but the beds involved were more likely to become hazardous because of their location near a wall, the presence of pillows or soft bedding, or because of bed-sharing. The perception of beds, pillows, and soft bedding as appropriate for infants must be dispelled, but attitudinal change is the most difficult to achieve. Because many hospitals will not discharge newborns unless there is a safety seat for the ride home, perhaps there also should be a requirement that the family be told about and given a checklist reminder about safe sleep environments. Day care providers also need to be educated and



trained about safe sleeping environments. Licensing procedures for day care providers could be made to require inspection of cribs, allowing only complying cribs in good condition to be used. Such procedures also could forbid the use of a bed for an infant or toddler.

Because plastic materials continue to be involved in a substantial number of infant suffocation deaths, more of these cases should be investigated by the CPSC to determine the specific nature of the plastic. Only thin plastic bags, eg, drycleaner bags and newspaper bags, tend to carry a warning statement regarding the suffocation potential. Perhaps other types of plastic, eg, trash bags, also should carry a warning, including one that informs that a filled trash bag also can present a suffocation hazard.

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Dorothy A. Drago and Andrew L. Dannenberg

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