

Effectiveness of Measures to Prevent Unintentional Deaths of Infants and Children from Suffocation and Strangulation

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Synopsis

Unintentional deaths from suffocation and strangulation account for about 20 percent of all

nontransport-related infant and child fatalities in the United States. In the late 1950s, some preventive countermeasures were introduced to reduce the number of deaths resulting from refrigerator or freezer entrapment. A few years later, countermeasures were introduced to prevent deaths resulting from suffocation by plastic bags, inhumation, and mechanical strangulation from wedging in infant cribs.

For three of these major causes of suffocation and strangulation deaths among infants and children (refrigerator or freezer entrapment, suffocation by plastic bag, and inhumation at construction sites), there appears to have been a significant decline in incidence; however, there is no evidence of a significant reduction in deaths from mechanical strangulation in cribs. The impact of current countermeasures is discussed, and some suggestions for new or modified approaches are made.

ACCORDING TO DATA FROM the National Center for Health Statistics, in 1980 there were more than 9,700 unintentional traumatic deaths among infants and children in the United States under the age of 15 years (1). About 1,000 of these deaths were probably caused by suffocation or strangulation (2).

Traumatic deaths among infants and children have long evoked strong emotion, particularly since the children are seen as not responsible for the events that led to their deaths. Government and nongovernment agencies have attempted to reduce the number of such deaths. Often, however, the preventive measures were traditional but not proven; required active measures by the infant, child, parent, or community; and were not based on epidemiologic data.

Community, or "passive," approaches to disease prevention—as opposed to individual, or "active," approaches—have been at the heart of successful public health programs for many decades. Chlorination of drinking water, treatment of sewage, and

draining of malarial swamps are examples of successful passive preventive measures that do not require active measures by individual persons to initiate or sustain protection from disease.

The application of passive approaches to the prevention of traumatic injuries and deaths was advocated early by Haddon (3,4) and later by Klein and Waller (5), Baker (6), Wigglesworth (7), and Barry (8). They demonstrated the logic of applying passive public health strategies to a large number of external causes of death, including many that affect infants and children. Some successful passive strategies include the redesign of pacifiers that formerly suffocated infants, the redesign of washing machine rollers that once crushed the hands and arms of young children, and the development of nonflammable children's clothing (9).

Suffocation and strangulation fatalities result from a number of specific external causes, including entrapment in refrigerators and freezers, wedging in cribs, covering with plastic bags (especially those

used as mattress covers), and inhumation as a result of cave-ins. Some countermeasures for these causes have been initiated by Government: for example, the Refrigerator Safety Act (10), instituted in 1958 to prevent children from suffocating in abandoned refrigerators or freezers; the Hazardous Substances Act (11), which includes provisions for the redesign of baby cribs to prevent mechanical strangulations; and a California law requiring warning labels on thin polyethylene plastic materials to prevent suffocation (12).

The Federal statute on refrigerator and freezer design is a passive countermeasure based on experiments (13) that established behavioral and physical parameters to be incorporated in the design standard.

The Federal standard on crib design is also a passive countermeasure. It was begun after case review and an epidemiologic analysis were conducted by the U.S. Consumer Product Safety Commission (14). Clinical evidence was also presented by Blackbourne (15,16), and anthropomorphic evidence was gathered by researchers at the University of Michigan (17).

California's regulation providing for label warnings on plastic bags is an active countermeasure apparently not based on research.

For inhumations, there is no comprehensive strategy in effect; however, passive prevention of some inhumations may result from barriers to access erected in places where tunneling might occur, especially at excavations or construction projects (18). No published data are available on the effectiveness of this countermeasure.

To summarize, a spectrum of active or passive measures has been used to prevent suffocations and strangulations involving refrigerators and freezers, cribs, plastic bags, and inhumations. This report has two objectives: first, to describe epidemiologically the incidence of unintentional deaths from suffocation and strangulation among infants and children; second, to determine if there is evidence that the prevention strategies employed were effective in reducing the numbers of these deaths.

Methods

For purposes of this study, "suffocation" was defined as death due to oxygen deprivation from mechanical causes, excluding deaths from inhalation or ingestion of foreign bodies or food and deaths from drowning. "Strangulation" was defined as suffocation resulting from mechanical pressure on the trachea, and "inhumation" as suffocation

following burial alive by earth, sand, rock, or related materials.

The California mortality master computer file was used to locate death certificates for infants and children aged 0-14 years, dated between January 1, 1960, and December 31, 1981, with causes of death falling within the International Classification of Diseases (ICD) Seventh Revision rubrics E924 and E925 (for the period 1960-68) and the Eighth and Ninth Revision rubric E913 (for the period 1969-81). Each certificate was examined, and coroners' reports were obtained, when necessary, to verify and classify more precisely the exact cause of death. Two California residents who died outside the State were included in the analysis.

The Seventh Revision rubrics cover accidental mechanical suffocation in bed or cradle (E924) and accidental mechanical suffocation in other and unspecified circumstances (E925). These titles do not include deaths from inhalation and ingestion of food or other objects causing obstruction or suffocation (E921 and E922). Since some certificates might have been coded E921 or E922 when E924 or E925 was the correct rubric, a 5 percent sample of certificates coded E921 and E922 (140 certificates) was reviewed for evidence of this error. None were miscoded.

The E913 rubric of the ICD Eighth and Ninth Revisions covers "accidental mechanical suffocation." This title does not specify place of occurrence—for example, bed or cradle. A 5 percent sample of certificates of death related to mechanical suffocation (E911 and E912) was reviewed for possible miscoding. On 2 of the 260 certificates examined, obstruction of the trachea by pieces of plastic sheeting was noted; however, since ingestion of (as opposed to covering by) plastic sheeting was not within the scope of this study, these cases were not included.

It appeared, therefore, that the procedure of case identification was adequate to find all suffocation deaths of infants and children in California from 1960 through 1981 (table 1).

As each certificate was reviewed, the cause of death was recoded into 1 of 17 new, specific titles (table 2). To ensure conformity in coding, 1 in 10 certificates was independently recoded by a different person without knowledge of the first code assigned. Lack of consistency of coding was identified with respect to infants found wedged between bed-frame or bedrail and mattress. A few of these deaths were coded as "crib death" but most were coded as "strangulation." All cases of this type were recoded a third time, excluding any infant death for which it was not clear from the death certificate (or

the coroner's report) that suffocation or strangulation resulted from the infant's being wedged in the structure of the crib.

Data on numbers of infants and children at risk were obtained from the 1950, 1960, 1970, and 1980 U.S. Census reports for California. Population estimates for intercensus years were derived using linear interpolation.

Refrigerator and freezer sales since 1960 were used as a surrogate of exposure to entrapment. Data on sales were obtained from the Association of Home Appliance Manufacturers. No information

Table 1. Suffocation and strangulation deaths among children 0-14 years, 1960-81, from California mortality computer file,¹ and exclusions from study by reason

Category	Number
Total deaths identified	1,153
Deaths excluded	184
Unknown cause	11
Over age 14	25
Cause of death miscoded	11
"Crib death" or SIDS	131
Nonresident of California	6
Total pertinent deaths	969

¹ Using ICD rubrics E924 and E925 (Seventh Revision) and E913 (Eighth and Ninth Revisions).

could be located on plastic sheeting or plastic bags sold or used during this period. The number of new construction building permits by year for California counties was used as a surrogate of exposure to inhumations at construction sites. Crib sales were used as an index of exposure for crib wedging deaths, and information on these sales for California was obtained from the Juvenile Products Manufacturing Association.

Information on details of hazard reduction countermeasures (and dates of their implementation) for suffocations and strangulations involving refrigerators and freezers, cribs, plastic bags, and inhumations was obtained from the California Health and Safety, Business and Professions, and Penal Codes (for appliance safety and use of plastic bags); the Federal Refrigerator Safety Act; the U.S. Consumer Product Safety Commission; and the California Department of Industrial Safety (for inhumations).

Death rates were calculated by dividing the number of observed deaths by the number of children in each age range at risk. Since there were no cases of suffocation from plastic bags in children more than 10 years old (except for glue sniffing), the denominator was limited to those aged 0-9 years.

Since the annual number of cases for each specific cause was generally small, rates were de-

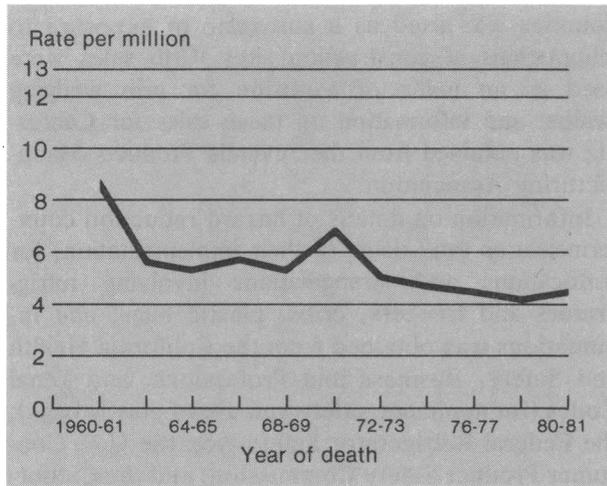
Table 2. Suffocation and strangulation deaths among children 0-14 years, by specific causes, California, 1960-81

Cause of death	Number of deaths	Percent of total	Percent of major causal category
Suffocation	471	49	100
Plastic garment bag	109	11	23
Plastic sheeting	41	4	9
Entrapment:			
Refrigerator or freezer	84	9	18
Dryer or washer	8	1	2
Ice chest, toy box, trunk	23	3	5
Other containers	9	1	2
Inhumation:			
Nonconstruction site	70	7	15
Construction site	40	4	8
Covered over—bedding, etc.	178	8	16
Covered over—other	19	1	2
Strangulation	498	52	100
Hanging	116	12	23
Neck caught in cord or rope	93	10	19
Head/neck compressed between objects	113	12	23
Neck caught between mattress and frame	126	13	25
Neck caught in container lid	12	1	2
Neck caught in auto window	9	1	2
Miscellaneous or no details	29	3	6
Total	969	2101	

¹ Probably includes some "crib deaths."

² Does not add to 100 because of rounding.

Figure 1. Average annual incidence rate of suffocation and strangulation deaths among children age 0-14 years, California, 1960-81



rived as average annual rates within 3- or 4-year intervals except for overall suffocation and strangulation rates, which are presented in 2-year intervals.

Chi-square tests of goodness of fit (corrected for continuity) were used to determine significance. Expected values were based on the actual distribution of the population at risk by age and gender or the distribution of the index of exposure (for example, crib sales).

Results

The California mortality file from 1960 through 1981 contained reports of 1,153 suffocations or strangulations among infants and children less than 15 years old (table 1). Eleven cases were excluded from the study because the information recorded was not adequate for classification. Also excluded were 25 cases involving persons more than 14 years old and 11 cases in which the cause of death was obviously miscoded. Another 131 cases were excluded because "crib death" or sudden infant death syndrome was noted on the certificates. Six cases did not involve California residents, and these cases too were excluded. Table 2 gives the number and percentage of the remaining 969 suffocations and strangulations by external cause.

Among the 471 suffocations, 109 (23 percent) involved plastic bags. Entrapment in appliances or other containers caused 124 (27 percent) of the suffocations, and refrigerators or freezers were the items most frequently involved. Inhumations were the cause of 111 suffocations; 70 inhumations were

related to cave-ins at places other than construction or excavation sites.

Among the 498 strangulations, 126 (25 percent) involved infants who became wedged between mattress and bedframe, bed slats, or other crib parts. Another 113 cases (23 percent of strangulations) involved wedging that did not occur in a crib or an infant bed—typically, cases in which a piece of furniture overturned, pinning the child against a wall or another object. Hangings (116 cases; 23 percent of strangulations) were termed "unintentional" by the coroner and in almost all instances involved children at play. Ninety-three of the strangulations (19 percent) involved such objects as pacifier cords, high chair straps, or cords from venetian blinds.

Overall pattern of incidence. Since the 22-year pattern of incidence for suffocations and strangulations involving four of the major causes (entrapment in refrigerators and freezers, wedging in cribs, covering by plastic bags, and inhumations) is the subject of interest in this report, it was important to determine if the overall mortality pattern for all 969 cases (17 causal categories) had changed during this period.

Figure 1 shows, following a sharp decline between 1960-61 and 1962-63, a plateau in overall suffocation-strangulation death rates until 1970-71, when there was a peak in incidence followed by a gradual decline until 1980-81. Except for the early sharp drop, the decline was not statistically significant ($P = .40$). The reason for the increase in rate in 1970-71 is not known.

Refrigerator and freezer entrapments. In 1951, the California legislature made it illegal to discard a refrigerator or an icebox of 1.5 cubic feet or larger in a place accessible to children (19). In 1953, the law was amended to require that doors or latches, or both, be removed before discarding or abandoning such appliances (20).

The Federal Refrigerator Safety Act became effective October 30, 1958, and the 1953 California statute was amended (21) to prohibit the sale of new refrigerators or freezers of 2 cubic feet or more that could not be opened from the inside by the exertion of 15 pounds of force against the latch edge of the closed door. This amended statute was effective January 1, 1970.

The percentage of children in California at risk of death from refrigerator or freezer entrapment, by age, and the percentage distribution of cases (1960-81) are given in figure 2. Most cases involved children between 2 and 7 years old, and twice as

many boys as girls were involved.

Figure 3 shows death rates per million children from suffocation in refrigerators and freezers in California from 1960 through 1981. The rates were high in the early 1960s, then declined, then increased in 1966–68. Since then, the death rate has declined significantly ($P = .05$).

The ratio of suffocation events per million refrigerators and freezers sold in California is also displayed in figure 3. Since 37 percent of entrapments in refrigerators or freezers involved more than 1 child (table 3), it was appropriate to determine the ratio of events of entrapment in refrigerators or freezers (regardless of the number of children involved) to the number of units sold. As seen in figure 3, the pattern is about the same as for death rates; that is, there is a peak in ratio in the mid-to-late 1960s followed by a steady decline ($P = .025$) through 1981. It should be noted that the approximate lifespan of a refrigerator built in the 1950s was 15 years, according to the Association of Home Appliance Manufacturers. This may account for the lag before the decline in the incidence rate begins.

Plastic bags. Children at risk of suffocation by plastic bags were mostly less than 2 years old (fig. 4); the greatest proportion of these deaths occurred among infants aged 4–6 months. The two deaths in early adolescence were due to glue sniffing. The ratio of deaths of boys to deaths of girls was 1.3 to 1 ($P = .2$).

All but 5 of the 39 deaths involving plastic sheeting were of infants under 1 year (fig. 5). The ratio of male to female deaths was 1.6 to 1 ($P = .15$). Almost all deaths from suffocation by plastic sheeting occurred when the material was used as a protective cover on a crib mattress.

The hazard associated with plastic bags was recognized in the late 1950s, coincidentally with their introduction in the dry-cleaning industry. The hazard countermeasure was introduced by statute. In California, effective July 6, 1959, all plastic bags made of material thinner than 0.001 inch and large enough to fit over a child's head were not to be used by any retail store unless there was printed on such bag, in clear, legible type, the admonition "Caution—keep away from small children, the thin film may cling to nose and mouth" (12). The law was amended in 1961 to specify size and type of lettering for the warning and further to restrict cartoons, pictures, or caricatures that might encourage the use of such bags as toys (22).

Figure 6 shows incidence rates for suffocations per million children by plastic garment bags and by

Table 3. Number of suffocation events involving 1, 2, or 3 children, 0–14 years, by cause, California, 1960–81

Cause	Number of events		
	1 death	2 deaths	3 deaths
Entrapment:			
Refrigerator or freezer ...	37	19	3
Washer or dryer	3	1	1
Inhumation:			
Construction site	24	17	1
Nonconstruction site	43	14	0
Other:			
Covered over	7	1	0

¹ Includes 1 event with child over age 14 as an additional fatality.

Figure 2. Percentage distribution of children suffocated in refrigerators or freezers and population at risk, aged 0–14 years, California, 1960–81

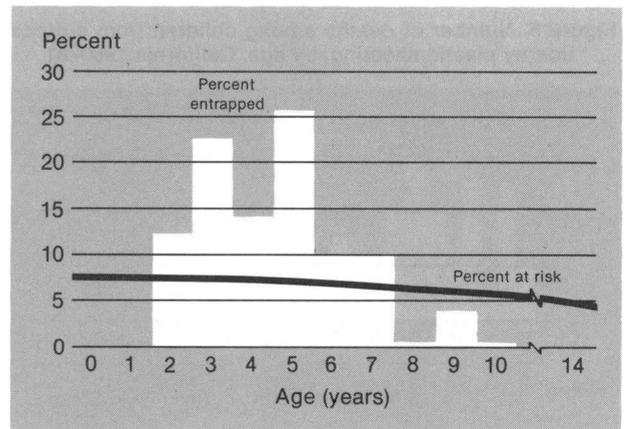


Figure 3. Rate of suffocation deaths in refrigerators or freezers per million children and ratio of fatal entrapment events per million units sold, California, 1960–81

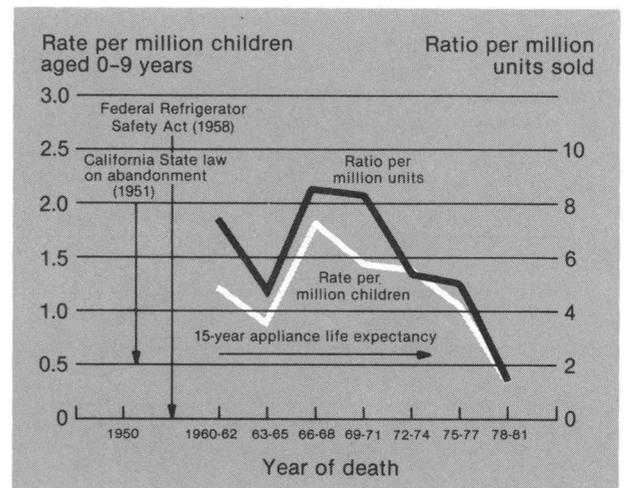


Figure 4. Number of deaths of children from suffocation by plastic garment bags, by age, California, 1960-81

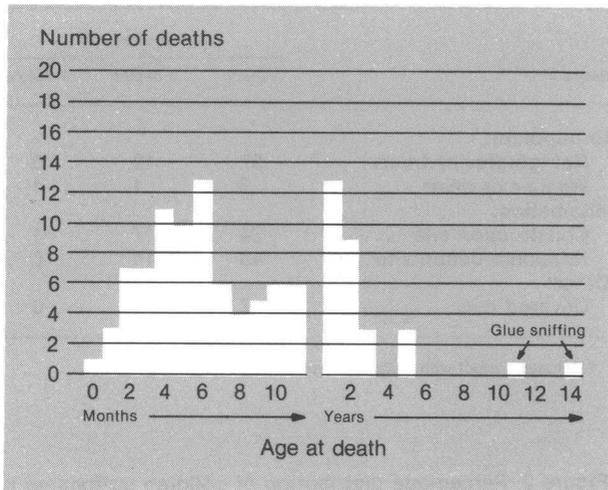


Figure 5. Number of deaths among children from suffocation by plastic sheeting, by age, California, 1960-81

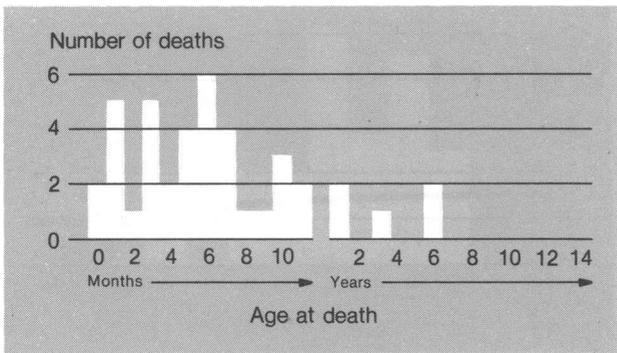
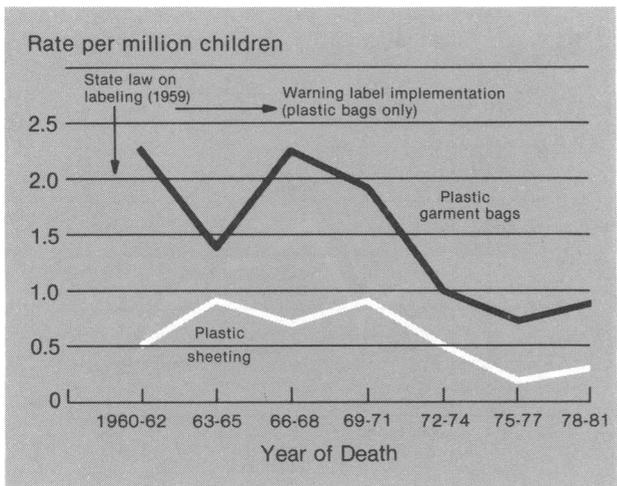


Figure 6. Incidence of suffocation by plastic garment bags and plastic sheeting among children aged 0-9 years, California, 1960-81



plastic sheeting. There was a significant decline in rates of suffocation by plastic bags between 1969-71 and 1975-77 ($P = .005$) and a statistically insignificant decline, during the same period, for rates of suffocation by plastic sheeting.

Inhumations. Cave-ins involving children result almost exclusively from collapse of tunnels in earth or sand. In California, efforts to reduce or eliminate this hazard have been dependent upon local action, if any.

Approximately two-thirds of most inhumation incidents occurred at nonconstruction sites such as vacant lots, beaches, or remote areas. Most of the children were aged 10-15 years, and the ratio of deaths of boys to that of deaths of girls was 20 to 1 ($P < .001$). One-third of the deaths occurred at construction or excavation sites, and one-quarter of the incidents were multiple-death events (table 3).

At construction sites, there is legal basis for contractor culpability for deaths and injuries caused by an "attractive nuisance." Although no statewide statute exists, many communities have enacted ordinances requiring barriers around construction sites (18). Even without such ordinances, many contractors erect fences to reduce loss from theft or vandalism and, in so doing, reduce their culpability for the attractive nuisance represented by the construction activity. The use of barriers, such as wire fences, has been introduced slowly over the past 10 to 15 years.

Children between the ages of 8 and 12 years are particularly at risk of inhumation (fig. 7), and seven times as many boys as girls are involved ($P < .001$). There appears to have been, since the mid 1960s, a reduction in the rate of inhumation deaths at construction sites. A similar pattern is seen in the ratio of inhumation suffocations per million building permits (fig. 8). The rates and ratios have not declined, however, below the level found in the early 1960s.

Crib wedging. Hearings conducted by the National Commission on Product Safety in 1969 clearly identified the extent of the problem of infant strangulations because of crib design, and suggestions of measures to reduce or eliminate the problem were made to industry. No further governmental action was taken until 1973, when the Consumer Product Safety Commission enacted a regulation on design standards (including spacing of slats) for cribs (11).

Figure 9 show that infants between 6 and 8 months of age are at highest risk of crib strangula-

tions. Male infants are more frequently involved than females (ratio of 1.4 to 1; $P = .05$).

There is a fluctuating pattern in mortality rates from these strangulations through 1981 (fig. 10). Rates per million children aged 0–4 years and ratios per million sales of full-sized cribs have not shown any significant changes since 1973, when the standard became effective. It appears that between the peak in incidence in the period 1969–71 and introduction of the current standard, the rates were declining.

Discussion

The findings of this report should be interpreted with caution for the following reasons:

- The findings relate to only one State, California.
- Although the findings encompass the period 1960–81, some of the numbers were small; thus, the rates derived are subject to variability.
- The data reported were obtained from coroners' reports and death certificates and are, of course, subject to the usual sources of error in data recording.
- The data were not experimentally obtained; that is, all information used for the analysis was from preexisting sources.

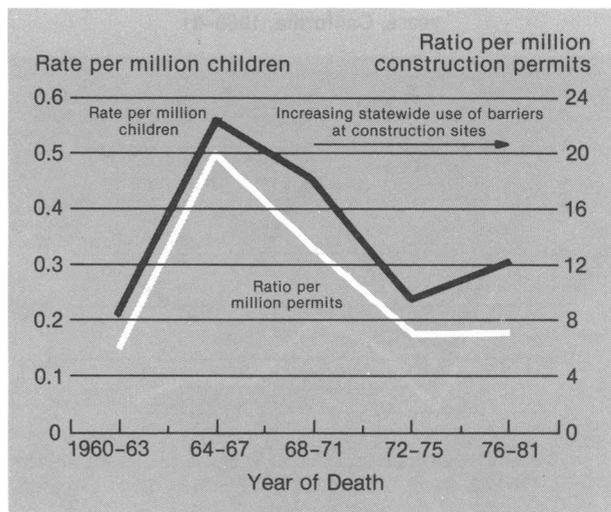
One underlying cause of death—"crib death" or sudden infant death syndrome (SIDS)—was a possible source of misclassification in this study. Before 1973, a number of different diagnoses—including suffocation and strangulation—were recorded (and coded) on death certificates in SIDS cases. With the introduction of a new rubric for SIDS in 1973, most of the deaths previously assigned strangulation or suffocation diagnoses by California coroners were called "SIDS." To minimize any problem because of this change in classification, all certificates after 1973 with a notation of "crib death" or SIDS were excluded from consideration in this study. Coroners' reports for a small sample of 25 certificates, filed before 1973 and listing suffocation or strangulation diagnoses, were reviewed for evidence that the cause of death might actually have been "crib death" or SIDS. No such evidence was found, and there did not appear to be a shift in terminology.

Refrigerator entrapments. It is uncertain whether the decline observed in such entrapments was due to the refrigerator and freezer design standard introduced in 1958, more aggressive enforcement of

Figure 7. Number of suffocation deaths among children from inhumation at construction sites, by age, California, 1960–81



Figure 8. Incidence of suffocation deaths from inhumation at construction sites among children aged 0–14 years, California, 1960–81



the California statute on refrigerator abandonment, changes in behavior of children, more intensive supervision by parents, or some combination of these and other factors. It is noteworthy, however, that not one entrapment event from 1972 through 1981 involved a refrigerator manufactured after implementation of the U.S. Refrigerator Safety Act of 1958, although an informal survey in fall 1983, in one large disposal dump site in Los Angeles County, identified several post-1958 models.

The refrigerator and freezer design standard also has implications for other sources of entrapment. During the 22-year study period, 31 other infants in California were suffocated because of entrapment in such devices as dryers, washers, portable coolers, and cold boxes in motorhomes or campers. De-

Figure 9. Number of suffocation or strangulation deaths among children from wedging in cribs or beds, by age, California, 1960-81

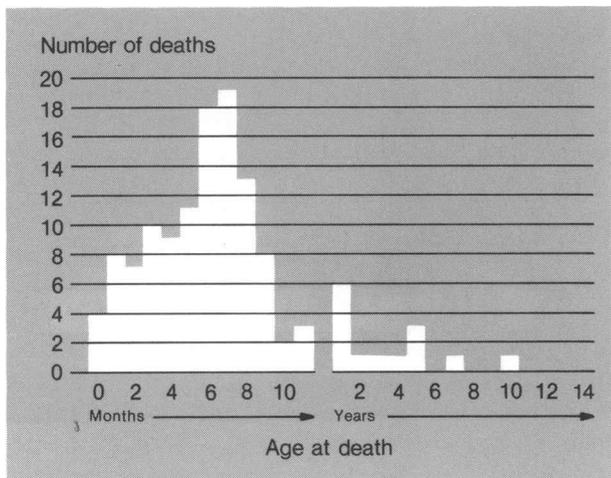
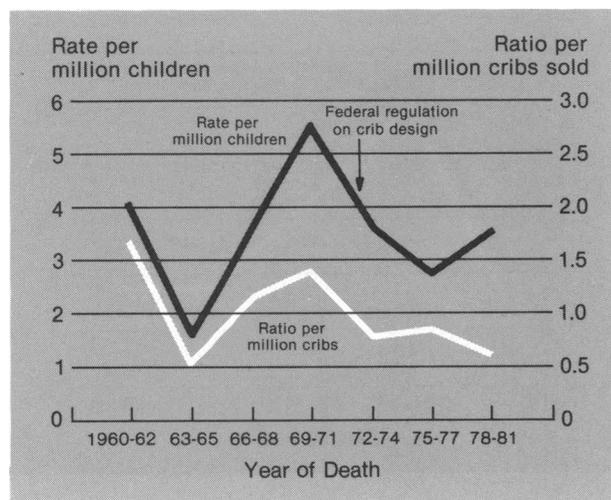


Figure 10. Incidence of suffocation or strangulation deaths from wedging in cribs or beds among children aged 0-4 years, California, 1960-81



signers and manufacturers of air-sealed storage units of any type should consider the eventual possibility of entrapment and suffocation of children.

In recent years, the incidence of refrigerator and freezer entrapment deaths has declined, and the cause of this decline would appear to be a passive countermeasure (that is, design changes in units manufactured since 1958). Although other countermeasures that required active behavioral change were introduced in the 1950s, no significant change in the incidence of entrapments was noted until recently. Reliance on the design standard should be guarded, however. As reported by Bain and associates (13) and pointed out later by Haddon and

coworkers (23), the standard specified a minimum of 15 pounds of internal pressure necessary to open the door, but exertion of such a force was unfortunately not within the capability of a significant proportion of the children tested by Bain and colleagues.

The finding on age at which the highest incidence of entrapment occurred (5 years, fig. 2), is consistent with the evidence cited by Bain and associates (13) in 1958. Data on the numbers of boys and girls exposed to *actual* risk (exploration or play in or around refrigerators or freezers) are not available. Thus, the 2-to-1 ratio of boys to girls involved in cases of entrapment may be due to differential exposure or to differences in susceptibility—for example, differences in hazard recognition. The latter explanation has some support in the findings reported by Rivara and coworkers (24) that gender differences in injury rates were not completely explained by differences in exposure to risk.

Plastic bags. The introduction of thin polyethylene plastic bags and sheeting for packaging has not been without hazard. Early cases of infant and childhood suffocations were documented in 1959 by Conley in the United States (25) and Jeffrey in Canada (26). As the use of such bags has expanded, so has the hazard. A 1982 report (27) described, for the first time, a near-fatal asphyxiation of a 2½-year-old boy by a toy plastic shopping bag.

The countermeasure employed in California and in many other States has been educational and legal: the bags are not supposed to be sold without imprinted warnings. Popular admonition to prevent this type of suffocation is decidedly behavioral, as seen in the prescription by Blackbourne (28) when commenting on the hazard from plastic dry-cleaning bags. In his view, "this problem can be eliminated by immediately removing the plastic bag from the clothing when it is brought into a home with an infant or small child, and by tying ten to twelve knots in the bag before discarding it in the garbage." Unfortunately, most people do not discard such bags but keep them to cover the garments until needed or use them for other purposes. Blackbourne's advice is typical of a countermeasure that is completely dependent on active human behavior, which—as expressed by Kelley (29)—"is dependent on the individual's continuing awareness of the nature of the hazard and the countermeasure. . ."

The incidence of suffocations by plastic bags has declined significantly in recent years; however, suffocations by plastic sheeting used in cribs continue

to occur at the rate of about 30–50 in the United States each year. Passive countermeasures, while mentioned in the European literature (30), evidently have not been employed in the United States. One approach might be to perforate the plastic material with small holes to render it nonairtight. Another might be to treat the plastic with an antistatic material to prevent its clinging to the face because of electrical-charge buildup.

Inhumation. Most suffocations of children by inhumation are caused by cave-ins of earth, sand, or other materials, occurring at widely separated and diverse locations such as beaches, vacant lots, and open areas. Multiple-death cave-ins are common, and deaths of boys exceed deaths of girls at these locations by a ratio of 20 to 1 (at construction sites, by a ratio of 7 to 1). The number of children, by gender, who are at risk is unknown, but the ratio of deaths among boys to that of deaths among girls is not inconsistent with current observations of exploratory behavior at play by children aged 10–15 years. Many of the younger children involved in multiple-death inhumations were younger siblings of an older child who was also inhumed. Except at construction sites, no passive countermeasure for inhumations is currently feasible, short of use of widespread barriers at all formal and informal recreational facilities. Hence, the only practical approach today is educational, directed to the child through school, parent, and community.

The rate of deaths from inhumation at construction and excavation sites has declined significantly since reaching a peak in the mid-1960s. While the current practice of erecting fences or wooden barriers seems to have had some impact in reducing these deaths, the barriers are constructed primarily for security and to reduce legal liability for all types of injuries at these sites. For whatever reason, this passive countermeasure appears to be successful, and its application to some other sources of inhumations should be explored. A careful study of the circumstances of inhumation deaths among children, the locations, and the risk factors of those involved seems overdue.

Crib wedging. Mechanical strangulation from wedging of the head or neck in parts of the crib has received considerable attention in the literature in the past 10 years (9,24,31–36). This literature is noteworthy, since it has documented crib suffocation deaths well *past* introduction of the regulation on crib design standards. Even new designs have strangulation hazards, as pointed out by Baker (9).

In certain crib models, even though the slat-spacing standard requirement was met, deaths occurred when young children stood up, leaned their heads into a grooved slot, and then could not extricate themselves.

Our data provide no evidence of a statistically significant decline in strangulation crib deaths since introduction of the passive countermeasure in 1974. This finding is contrary to that noted by Waller (37), who quotes a report by the U.S. Consumer Product Safety Commission claiming that the 1974 standard on crib-slat widths has brought about a 40 percent reduction in injuries and deaths. The findings reported here do not support that claim, at least as far as fatalities are concerned. This may be due to the long lag time needed before the older, hazardous cribs are discarded. Newer models may retain hazards (9) or may have broken slats, defeating the purpose of the standard—or, as in the case of portable mesh cribs, may introduce new hazards (35).

The hoped-for reduction in crib-wedging deaths may need more time before the countermeasure becomes effective. Efforts that encourage discarding of older, pre-1974 cribs may not have much success, and educational efforts to encourage active approaches among parents appear to be ineffective (38). Since 13 percent of all infant suffocations and strangulations in California involve a crib, it is important to accelerate the removal or remodeling of older cribs. A manufacturer's rebate incentive might be considered for this purpose.

Although an experimental evaluation to test conclusively the effectiveness of countermeasures now in use in California was not possible, the evidence from this report suggests that preventive measures introduced or widely adopted in the 1960s may have been responsible for the noticeable reduction in some types of suffocation and strangulation deaths. Nonetheless, further assessment of these and other measures is warranted to determine how they might be more widely used for other injury problems in the U.S. society.

References

1. National Center for Health Statistics: Advance report—final mortality statistics, 1980. Monthly Vital Statistics Report, Vol. 32, No. 4, supp. DHHS Publication No. (PHS) 83-1120. Hyattsville, MD, August 1983.
2. National Center for Health Statistics: Vital statistics of the United States, 1978, Vol. II, Part A. DHHS Publication No. (PHS) 83-1101. U.S. Government Printing Office, Washington, DC, 1982.
3. Haddon, W., and Goddard, J. L.: An analysis of highway safety strategies. In Passenger car design and highway safety: proceedings of a conference on research. Associa-

- tion for the Aid of Crippled Children and the Consumers Union of U.S., Inc., New York, 1962, pp. 6-11.
4. Haddon, W. J.: Strategy in preventive medicine: passive vs. active approaches to reducing human wastage. *J Trauma* 14: 353-354 (1974).
 5. Klein, D., and Waller, J. A.: Causation, culpability, and deterrence in highway crashes. Department of Transportation, Automobile Insurance and Compensation Study. U.S. Government Printing Office, Washington, DC, July 1970.
 6. Baker, S. P.: Injury control. *In Preventive medicine and public health*, edited by P. Sartwell. Ed. 10. Appleton-Century-Crofts, New York, 1973, pp. 987-1005.
 7. Wigglesworth, E. C.: Towards a conceptual framework for trauma. *Br J Clin Pract* 2: 373-376 (1974).
 8. Barry, P. Z.: Individual versus community orientation in prevention of injuries. *Prev Med* 4: 47-56 (1975).
 9. Baker, S. P.: Childhood injuries: the community approach to prevention. *J Public Health Policy* 2: 235-246 (1981).
 10. U.S. Consumer Product Safety Commission: Compilation of laws administered by CPSC. Refrigerator Safety Act (Public Law 84-930), 70 Stat. 953, August 2, 1956. Washington, DC, April 1959.
 11. Code of Federal Regulations. Commercial practices. Part 1000 to end, Hazardous Substances Act Regulations. Vol. 16. U.S. Government Printing Office, Washington, DC, 1980, pp. 361-366.
 12. State of California: Business and Professions Code. Chap. 13, Sec. 22200, Div. 8. Polyethylene plastic materials. July 1959.
 13. Bain, K., Faegre, M. L., and Wyly, R. S.: Behavior of young children under conditions simulating entrapment in refrigerators. *Pediatrics* 22: 628-647 (1958).
 14. Nelson, T.: Hazard analysis of injuries relating to cribs. U.S. Consumer Product Safety Commission, Washington, DC, 1975.
 15. Blackbourne, B. D.: Crib or coffin. *Forensic Science Gazette* 1: 1-3 (1970).
 16. Blackbourne, B. D.: Statement for the National Commission on Product Safety. New York Hearings, NCPS, Dec. 17, 1968, Vol. 2. National Commission on Product Safety, Washington, DC, p. 53.
 17. Highway Research Institute: Selected infant anthropometry, crib slat sub-study. University of Michigan, Ann Arbor, December 1972.
 18. Standard specifications for public work constructions. Building News, Inc., Los Angeles. Published yearly.
 19. State of California: Penal Code, Chap. 1658, Sec. 402b. July 1951.
 20. State of California: Penal Code, Chap. 631, Amendment to Sec. 402b, May 1953.
 21. State of California: Penal Code, Chap. 232, Amendment to Sec. 402c, 1968.
 22. State of California: Business and Professions Code, Chap. 197, Amendment to Sec. 22202 and addition to Sec. 22203, April 1961.
 23. Haddon, W., Suchman, E. A., and Klein, D.: Accident research, methods and approaches. Harper & Row, New York, 1964, pp. 617-630.
 24. Rivara, F. P., Bergman, A. B., LoGerfo, J. P., and Weiss, N. S.: Epidemiology of childhood injuries. 11 sex differences in injury rates. *Am J Dis Child* 36: 502-506 (1982).
 25. Conley, B. C.: Danger of suffocation from plastic bags. *JAMA* 170: 1667 (1959).
 26. Jeffrey, F. W.: Deaths from plastic films. *Can Med Assoc J* 81: 687 (1959).
 27. Bulugahapitya, D. T. D., Beck, P. R., and Lobo, S.: Near-fatal asphyxia by a toy shopping bag. *Br Med J* 285: 263 (1982).
 28. Blackbourne, B. D.: Accidental injuries in children: clinical proceedings. *Children's Hospital Medical Center* 30: 83-88 (1974).
 29. Kelley, A. B.: Passive vs. active = life vs. death. Paper presented at the Automotive Engineering Congress and Exposition, Detroit, February 24-28, 1975.
 30. Polson, C. J., and Gee, D. G.: Plastic bag suffocation. *J Leg Med (Germany)* 70: 184-190 (1972).
 31. Sturner, W. Q., Spruill, F. G., Smith, R. A., and Zene, W. G.: Accidental asphyxial deaths involving infants and young children. *J Forensic Sci* 21: 483-487 (1976).
 32. Bergeson, P. S., Herrried, L. S., and Sonntag, P. L.: Infant strangulation. *Pediatrics* 59 (supp.): 1043-1046 (1977).
 33. Boss, M.: Asphyxial crib death. *N Engl J Med* 296: 555-556 (1977).
 34. Smialek, J. E., Smialek, P. Z., and Spitz, W. V.: Accidental bed deaths in infants due to unsafe sleeping conditions. *Clin Pediatr (Phila)* 16: 1031-1036 (1977).
 35. Sinal, S. H., and Stanton, W. A.: Infant strangulation in a mesh portable crib. *Pediatrics* 63: 669-670 (1979).
 36. Feldman, F. W., and Simms, R. J.: Strangulation in childhood: epidemiology and clinical course. *Pediatrics* 65: 1079-1085 (1980).
 37. Waller, J. A.: Injury as a public health problem. *In Public health and preventive medicine*, edited by J. Last. Ed. 11. Appleton-Century-Crofts, New York, 1981, pp. 1549-1591.
 38. Draper, B. T., and Klarm, K. K.: Consumer education, pre- and post-test. Program on the Toy and Crib Safety Campaigns. Education and Development Corp., Report on Contract CPSC-C-71-10 for Consumer Product Safety Commission, Washington, DC, 1974.