

ORIGINAL ARTICLES

Non-intentional asphyxiation deaths due to upper airway interference in children 0 to 14 years

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Abstract

Objective—This study was undertaken to identify avoidable, contributing factors associated with non-intentional asphyxiation deaths due to upper airway interference in children 0 to 14 years.

Design—Historical population based incidence study.

Methods—All postneonatal and childhood deaths by asphyxiation from 1985 to 1994, using appropriate ICD-9-CM codes, were compiled from the Victorian government legislated paediatric mortality surveillance system. Recent cases were identified from the State Coroner's Office. Case definition included children under 15 years who died from upper airway interference such as facial occlusion, head and neck entrapment, rope or cord strangulation, or foreign body.

Results—Of the identified 42 deaths, eight (19%) were caused by a foreign body in the airway, five (12%) were due to facial occlusion, 16 (38%) were due to ropes and similar material (seven were homemade rope swings), and 13 (31%) were caused by entrapment (seven were in cots or beds). The average annual rate for asphyxiation deaths by all causes for children 0 to 14 years was 4.7/million. Infants under 1 year had a rate of 20.1/million, while the rate for 10 to 14 year olds dropped to 2.0/million.

Conclusion—Rope swings and rope material are inherently dangerous and frequently prove fatal, especially for older children. For infants, environmental factors are important; in particular food and bedding. Prevention strategies need to be developed that include obligatory standards for the design and manufacture of products for children, appropriate labelling and warnings, and education for children, their carers, and health care professionals.

(*Injury Prevention* 1995; 1: 76-80)

Keywords: asphyxia, suffocation, mortality, epidemiology.

Accidents, or non-intentional injury, are a major cause of paediatric mortality and premature years of life lost. In 1992, in Victoria, Australia there were 69 non-intentional

injury deaths in a total of 308 postneonatal infant and childhood deaths (29 days to 14 years). In the main categories of death, injuries ranked fourth after birth related deaths (94), acquired disease (75), and cot deaths (70), although injuries were the leading cause of death after 1 year. Of the injury deaths there were 32 due to motor vehicles, 16 drownings, 11 fire related, two train accidents, and five (7.2%), due to accidental asphyxiation.¹

In Australia in 1992 there were 380 deaths due to non-intentional injury in the 0 to 14 year age group.² Of these 11 (2.9%) and four (1.0%) were due to asphyxiation by food and other objects respectively, and 14 (3.7%) were due to suffocation, giving a total of 7.6% due to these types of asphyxiation.²

During routine prospective statewide surveillance of injury related deaths in Victorian children a cluster of rope related asphyxiations was noted. As a result it was decided to review all such and similar asphyxiation deaths in children over the 9.5 years that the surveillance system has been active.

Although non-intentional asphyxiation is a relatively rare cause of death, there have been 47 fatalities in children from this cause in the last 9.5 years in Victoria. In this study only the asphyxiation deaths due to upper airway interference were included. These were divided into four mechanism groups as follows: facial occlusion, entrapment of the neck, strangulation from any type of rope material or clothing, and foreign body aspiration. Deaths from involvement of the lower airway were excluded, such as chest compression or drowning. Although many of these 'accidents' may appear to be random mishaps, closer inspection reveals several consistent mechanisms and predictable outcomes.

Subjects and methods

Since 1985, a statewide government legislated paediatric mortality surveillance system has existed in Victoria, Australia under the auspices of the Consultative Council on Obstetric and Paediatric Mortality and Morbidity. The council is notified of every death in the state under the age of 15 years directly from the Victorian registry of births, deaths, and marriages. The council compiles confidential case histories from a variety of sources which are then reviewed by specialist committees so that any potentially avoidable factors can be identified.

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The council's records on accidental post-neonatal infancy and child deaths (29 days to 14 years) were searched. All deaths by asphyxiation from 1985 to June 1994 were drawn using the *International Classification of Diseases*, 9th revision, clinical modification (ICD-9-CM). The codes used were: 994.7—suffocation by bedclothes, cave in, constriction, mechanical, plastic, pressure, and strangulation; 933-934—foreign body in pharynx, larynx, trachea, bronchus, and lung; E911-912—inhalation or ingestion of food or other object causing obstruction of the respiratory tract or suffocation; and E913—accidental mechanical suffocation: in bed/cradle, by plastic bag, by falling earth or other substance, by accidental hanging, due to lack of air (in closed space), or by unspecified means.

The Coroner's Act 1985 in Victoria states that certain deaths must be reported. These include those that were unexpected, unnatural, or violent, that resulted from an accident or injury; that occurred during an anaesthetic; or where a person was held in care. Cases occurring in 1993 and the first half of 1994 were also searched for on the State Coroner's Office's computer system by age and cause of death.

All the cases were verified using information in the files on the investigations undertaken by the state coroner. The information reviewed for each case included: age, date of death, circumstances of the death, results of post-mortem examination if carried out, and identification, if possible, of any avoidable factors.

All cases due to lower airway interference were excluded. This included five asphyxial deaths caused by crushing or burying. Other asphyxial deaths excluded were those due to aspiration of vomit, drowning, fires, associated with motor vehicle accidents, suicides, homicides, and sudden infant death syndrome (SIDS). SIDS is classified by a combination of a centralised postmortem examination and a death scene investigation. These deaths are not classified as asphyxiation unless there is unequivocal evidence of such from the investigations.

The asphyxial deaths were divided into groups according to the anatomic level of upper airway involvement. The groups were: facial occlusion; entrapment of head of neck; rope or cord strangulation; and airway obstruction due to a foreign body (food or other object).

STATISTICAL ANALYSIS

Data on the Victorian population figures was obtained from the Australian Bureau of Statistics estimated resident population by sex and age from 1985 to 1993. Death rates were calculated by dividing the number of deaths observed by the number of children in the age group at risk. Because the annual number of deaths in each subgroup of asphyxiation was small, average annual rates were derived for the total study period (9.5 years).

Results

From 1985 to June 1994 there were 47 deaths due to non-intentional asphyxiation. Five due

to crushing or burying were excluded. The remaining 42 deaths are tabulated by the mechanism causing death (table 1).

Of the 42 deaths, eight (19%) were caused by a foreign body in the airway, six of which were due to food and two due to objects. Five (12%) were caused by facial occlusion, one of which involved plastic material.

Of the 29 strangulation deaths, 16 (38%) were due to ropes, cords, and other such material, and 13 (31%) were due to head or neck entrapment. Seven of the 13 deaths by entrapment were caused by cots or beds, seven of the 16 rope or cord associated deaths were due to homemade rope swings, and three were due to blind or curtain cords.

There were 12 deaths in infants under the age of 1 year. Of the four due to facial occlusion, two were related to couches and one involved plastic material. Another four became entrapped, two in the cot and one whose cardigan caught on the cot. One infant strangled on a rattle cord suspended over the cot and three inhaled a foreign body. Half were associated with an unsafe sleeping environment, for example, an inadequately sized mattress, inappropriate type of bed for the child's age, or objects attached to the cot.

The average annual rate for asphyxiation deaths by all causes in children 0 to 14 years was 4.7/million (table 2). However, the age group most at risk is that of infants under 1 year with a rate of 20.1/million/year. The rates then drop off with increasing age to a rate of 2.0/million year for the 10 to 14 year olds. In the infants, all mechanisms feature prominently except strangulation by ropes. In contrast, ropes are the most common cause of asphyxial death for children over 1 year of age.

Discussion

The results indicate two main risk groups for asphyxiation: infants, who were at risk from facial occlusion, neck entrapment, and foreign body aspiration and children over 1 year who were at risk from strangulation by ropes. The main mechanisms of asphyxiation are noticeably consistent and repetitive, and virtually all these deaths could have been prevented.

The excellent surveillance system in place in Victoria for paediatric mortality made it possible to identify the entire defined population in the selected time period. Although a preceding primary cause is not annotated on the death certificate (for example asphyxiation with anoxia resulting in cerebral palsy with death at a later date), misclassification would be unlikely due to statutory investigations undertaken on all paediatric deaths by the council. The coroner's records provided much additional information on intent and circumstances. After reviewing available evidence there were no indications to suspect suicide, for example, depression or prior disputes — in any of our cases. Due to the conservative classification of SIDS, and exclusion of these cases from the study, some underestimation of the true incidence of asphyxiation may have resulted.

The rate for asphyxiation deaths in Victoria over the study period, excluding deaths due to

Table 1 Non-intentional asphyxiation deaths in children 0 to 14 years, by mechanism of asphyxiation

Classification	Age	Description of circumstances	Comments and preventable factors	
Facial occlusion				
Plastic (n = 1)	4 m	Occlusive plastic dressing (shower cap), to scalp to treat seborrhoea. Cap dislodged to cover face leading to asphyxiation	Improper product usage	
	Other material (n = 4)	3 m	Left on couch during night after night feed by father. Suffocated between two couch cushions	Inappropriate sleeping environment
		3 m	Fell off couch during night, caught between mattress on floor and base of couch	Inappropriate sleeping environment
		1 y	Put into cot for afternoon sleep. Found face down in 1 m high, clothes filled, linen basket next to cot	Side rail of cot broken, remains set, half-way up, at about 2 feet above mattress
	7 m	Undetected intussusception of transverse colon during night. Suffocation by bedclothes		
Entrapment				
Cot/bed related (n = 7)	8 m	Put down for sleep, chest caught between bars and base of cot	Old cot with thin mattress causing unsafe sleeping environment	
	9 m	Arm of woollen cardigan caught on wingnut on top rail of cot, causing neck to be pulled tight, strangling infant	Unsafe cot with protruding screw on inside	
	13 m	Hospitalised for ear infection. Fell feet first between cot side and mattress (10 cm gap) entrapping face against mattress causing asphyxiation	Unsafe sleeping environment poorly fitting mattress	
	18 m	Playing with brothers. Head caught between notch in cot bedhead and ladder of bunk bed above	Unsafe placement of furniture	
	21 m	Found hanged as neck caught between top of cot and wooden rail nailed to cot to prevent child from getting out. Distance between top edge of cot and rail = 13.5 cm	Unsafe addition by parents to cot	
	4 y	Intellectually disabled child, epilepsy. Sleeping in protected bed, caught between guard rail and mattress (12 cm gap), hanged	Unsafe sleeping environment	
	8 y	Severe cerebral palsy. Head caught between protective bars of bed during night, neck compression	Unsafe sleeping environment	
Furniture and other objects (n = 8)	6 m	Put down for sleep in single bed. Fell through bars of bedhead into 20 cm gap between bedhead and wall. Throat constricted over edge of cardboard box under bed and in this gap	Inappropriate sleeping environment and unsafe placement of furniture	
	11 m	Head in toilet, heavy timber toilet seat came down trapping infant's neck against rim of toilet bowl		
	14 m	Early morning, parents in bed. Found with head caught between two tiers of a coffee table		
	22 m	Caught head in 11 cm gap between changing table and support bar while attempting to climb up and subsequently losing her footing	Unsafe width of bars on nursery furniture	
	8 y	Playing 'hide and seek'. Head caught between iron grill lid and edge of concrete pit in park, neck compression	Inadequate maintenance of park by local council	
	14 y	Epilepsy. Left alone after recovering from fit and had second fit unattended. Found wedged across kitchen floor, neck hyperextended against stove, airway obstruction	Very large child: 113 kg, 1.89 m tall. Unsupervised epileptic fit. Medication non-compliance	
Strangulation by ropes and cords				
Blind cord (n = 3)	16 m	Cord of venetian blind hanging down next to cot placed beside window. Found strangled with this cord around neck	Blind cord, cot placement	
	16 m	Head of cot beside window. Neck entangled in loop of curtain cord while in cot	Blind cord, cot placement	
	21 m	Found kneeling in bed with blind cord around neck. Bed beside window, parents claim to have tied cord up out of reach	Blind cord, cot placement	
Other string near cot (n = 2)	11 m	Elastic string with row of rattles attached across cot. Found face down with head entangled in the elastic	Cord string attached to cot, cord on toys	
	15 m	Bead necklace hanging on wardrobe handle 20 cm from end of cot. Put down for sleep. Found strangled by necklace around throat and still attached to wardrobe door handle	Strings and cords near cot and accessible to infants and children	
Rope swing (n = 7)	4 y	Rope swing in garden with tied loop in end 1.2 m off ground. Wooden step ladder climbed, knocked to ground. Neck caught in rope, hanged	Rope swing	
	4 y	Family visiting friend's house. Found hanging from looped rope used as a swing, end of loop 1 m off ground	Rope swing	
	6 y	Child made rope swing with knotted end of rotary clothes line. Found hanging beside chair, feet off ground	Rope swing. Flying-fox at school	
	6 y	Child attached rope to clothes line and tied in a loop as swing. Found hanged	Rope swing, ropes accessible to children	
	8 y	Playing with rope hanging from tree, two ends knotted, found hanging by older sister	Ropes and swings	
	13 y	Rope swing with loop in end in hayshed. Found hanging with loop over head	Rope swing	
	12 y	Child made rope swing in garden. Found hanging with noose around neck. Died 5 days later in hospital	Rope swing, rope accessible to children	
Unsafe play with ropes (n = 4)	4 y	Playing in lounge room with belt around neck as 'stethoscope'. Found suspended from door handle by belt, hanged	Unsafe play with ropes and cords	
	7 y	Child came home unsupervised from school. Found hanged by dressing gown cord from clothes hook behind bedroom door	Unsafe play with ropes and cords	
	11 y	History of overactivity, aggression, learning difficulties, attention deficit disorder, taking dexamphetamine. Found strangled by nylon cord tied to end of bed. Actions thought to be impulsive, reckless, and experimental behaviour rather than suicide	Unsafe play with ropes and cords	
	13 y	Playing on top bunk. Cord tied to guard rail, and around neck. Fell face downward from bunk, hanged	Training dog at home with choker, unsafe play with rope	
Foreign body in airway				
Food (n = 6)	8 m	Inhaled spaghetti meat sauce		
	8 m	Aspiration of biscuit fragments, unsupervised, may have been fed by sibling aged 2.5 years	Potential danger of infants being fed by older siblings	
	14 m	At children's party. Inhaled small frankfurter	Inappropriate food for child's age	
	4 y	Aspiration of chick peas when 22 m old causing tracheal obstruction at carina and subsequent severe cerebral damage. Remained in hospital 2.5 years until died	Inappropriate food for child's age	
	5 y	At children's party. Small frankfurter lodged in pharynx at tonsils	Obese child, tonsils very enlarged. Inappropriate food for child's age	
13 y	Down's syndrome. At restaurant, choked on cut up steak. Piece of meat found in larynx			
Other objects (n = 2)	10 m	Inhaled snail shell causing laryngeal damage and obstruction. Found with snails in hands		
	14 m	Fell over hitting face. Inhaled stone, presumably in mouth, causing obstruction at carina		

Table 2 Total No (%) and average annual rate* of asphyxiation deaths by cause and age group in children 0 to 14 years in Victoria, Australia, 1985–June 1994

Mechanism	0–14 years		<1 year		1–4 years		5–9 years		10–14 years	
	No (%)	Rate	No	Rate	No	Rate	No	Rate	No	Rate
Facial occlusion	5 (12)	1.7†	4	6.7	1	0.4	0	–	0	–
Entrapment	13 (31)	1.5	4	6.7	6	2.5	2	0.7	1	0.3
Ropes	16 (38)	1.8	1	1.7	7	3.0	4	1.4	4	1.3
Foreign body	8 (19)	0.9	3	5.0	3	1.3	1	0.3	1	0.3
All causes	42 (100)	4.7	12	20.1	17	7.2	7	2.4	6	2.0

*Average annual death rate/1 000 000/year. †Rate for 0–4 years.

foreign body inhalation was 3.8/million/year, with the Australian rate for suffocation, in 1992, comparable at 3.7/million/year.² A national analysis of childhood injury deaths in the USA, over a five year period, 1980–5, reported higher rates for childhood suffocation — 7/million/year population of children 0 to 14 years.³

A total of 17 deaths (40%) related to the child's own bed or bed furnishings, an inappropriate sleeping place for the child's age, or to furniture, cords, or other articles within close proximity of the cot. Despite the publicity and the design standards regarding infant cots, deaths continue to occur in this environment. The importance of using a cot with the appropriate design standards needs to be emphasised, along with using an appropriately fitting mattress. Design standards must also apply to special beds for the disabled.

The risk of death as a direct result of the sleeping environment, and in particular the infant cot, has been stressed by numerous authors.^{4–10} Regulations regarding infant cribs were first set in the USA in 1974, and reports since then have varied as to whether there has been a reduction in the number of associated crib deaths. Feldman and Simms quote a US Consumer Product Safety Commission (USC-PSC) report claiming that there was approximately a 50% reduction in the number of crib strangulations since the introduction of legislation.⁸ In contrast Kraus, after reviewing deaths in Californian children due to suffocation and strangulation from 1960 to 1981, found no evidence of a statistically significant decline.⁴ These differing findings may well be due to a lag time in discarding of old cribs after introduction of regulations.

Cots and beds should be placed firmly against the wall, and proximity to blind cords and other potentially dangerous articles avoided. Restraining devices fitted to the bed or cot are hazardous, as illustrated by one death that was a direct consequence of a bar over the cot. Although Australian standards on cots make provision against any protrusion into the cot, injuries are still likely to arise from broken or repaired cots that are outside the set safety standards. The death of a child in our series due to a cardigan catching on a wingnut in the cot was not an isolated incident.¹¹ These dangers of restraining devices, protrusions, and repairs were emphasised by Bergeson *et al* 18 years ago.⁶

A couch is not a safe sleeping environment for infants because of its inability to prevent

facial smothering due to poor head control. There were no deaths in our series associated with waterbeds, sheepskin rugs, or polystyrene bead filled cushions, each of which have been noted to pose a risk to infants.⁹ The importance of age appropriate bedding cannot be over-emphasised.

The largest cause of death in our series was strangulation due to ropes and cords, in children aged 11 months to 13 years, the majority of whom were male. For infants who are not mobile, the risk of strangulation was from cords on objects, both within and outside the cot — for example, strings attached to toys, harnesses, and clothing that can pull tight around the neck. The danger of infant strangulation due to cords has been raised in several case reports and the avoidance of these is strictly advised.^{6,11}

Three toddlers were strangled by blind or curtain cords, and one by a necklace left hanging beside the cot. Two recent fatal case reports highlight these dangers — the first of a toddler by a corded light switch specifically designed for use by children,¹² and the second by a loose lamp flex during the night.¹³ Toddlers become increasingly mobile, lack a sense of danger, and are curious by nature and therefore are at risk from a variety of objects around the house and near the cot.

There were 11 deaths in children 3 years and over attributable to rope, belts, or cords. Play with ropes is inherently dangerous even if the child is thought old enough to be careful, as illustrated by the death of four children aged 11 to 13 years. Seven deaths were due to homemade rope swings of varying types, usually made with a loop at the end or with the two ends tied together. The risk of childhood strangulation due to unsafe play with such ropes must be stressed.^{8,11}

In Australia in 1992 the rate for non-intentional death due to asphyxiation by food was 2.9/million/year, and by other objects was 1.1/million/year in children 0 to 14 years.² The Victorian average annual rate was less, at 0.9/million/year for foreign body aspiration, food, and other objects together. USA national rates for aspiration of food and other material were 4 and 3/million/year respectively,³ similar to the Australian rates.

Six of the eight deaths due to foreign body inhalation were in children under the age of 5 years. Factors such as a younger age group, a more intense atmosphere, playing, laughing or shouting while eating, and lack of supervision during meals, may increase the risk of choking. These elements are likely to occur in the day care setting,¹⁴ or at children's parties.

Hotdogs have been cited as a major cause of fatal chokings in children.^{7,15,16} Two Victorian children died after choking on a party frankfurter. Although not immediately evident as a risky foodstuff, the innocent and well-loved frankfurter is inherently dangerous for small children due to its size, shape, and consistency.¹⁶ Measures such as age appropriate food, a supervised eating environment, and not allowing young siblings to feed an infant should be adopted, together with promotion of correct responses to aspiration emergencies.

The prevention of asphyxiation deaths needs tackling from a variety of angles. The failure of voluntary standards emphasises the need for more standards to be legislated.¹⁷ Australia has many voluntarily adopted standards that cover articles with which children will come into contact. However, legislation only exists regarding the size of toys for children under 3 years where the toy may represent an inhalation or ingestion risk.¹⁸ In the USA, after a USCPSC review of 126 crib related deaths,¹⁹ legislation was passed regulating the distance between crib slats and the space between the mattress and side rails.²⁰ Currently in Australia standards relating to cots are under review, and legislation is being contemplated.

There are no codes or regulations in Australia that cover the labelling of food regarding its age appropriateness, while these types of labelling requirements on prepackaged food for infants and children were introduced in 1979 in Sweden,²¹ and are also seen in other European countries. Labelling and warnings on products, in particular children's equipment, and hazardous foodstuffs need to be considered. All domestic market rope products, together with equipment that contains loose rope or cord (for example skipping ropes and clothes lines), should carry product warnings, preferably non-removable. Written warnings need to state the potential hazard, rather than an age below which the product is deemed inappropriate. Product labelling has the ability to reach members of the public not always targeted by preventative campaigns and therefore is an excellent mechanism for information dissemination.

Hazardous products for children are frequently those available and marketed to the general public. Education and anticipatory guidance can address this problem, along with the issue of access to age inappropriate food and toys when there are older children in the household. Parents, children, their carers, and health care professionals all need to be targeted.

Conclusion

Almost all the asphyxiation deaths reported here could have been prevented by education, supervision, or structural modification of equipment. Preventable strategies need to include obligatory manufacturing standards, product labelling and warnings, and specific

and targeted education of parents, child carers, and health care professionals. Special attention must be given firstly to ensuring a safe environment for infants, with respect in particular to bedding and food, and secondly to warnings and education about the dangers associated with ropes, in particular rope swings.

The authors wish to acknowledge the invaluable help of the Consultative Council on Obstetric and Paediatric Mortality and Morbidity and its staff, in particular Dr Bill Kitchen, and also the Victorian Coronial Service and its staff, especially the principal registrar Mr David Stephens.

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