POISONING

HARRISON'S STORY

Harrison is the youngest of five children in an Australian family. One day, Lisa, his mother, changed her usual morning routine. Instead of going directly to the kitchen, checking that the cupboard doors were locked and preparing breakfast, she put on a video for Harrison's older sister. In that brief period, 18-month-old Harrison opened a cupboard, removed the cap from a container of dishwasher detergent and swallowed the powder.

Lisa heard his cry and ran to the kitchen to find him vomiting blood. An ambulance rushed Harrison to hospital where doctors were unsure if he would survive.

The container Harrison had managed to open had a cap that looked like a child-resistant closure. To secure this closure, the cap had to click twice. Instructions to this effect, though, were not displayed on the packaging and Lisa mistakenly thought the container was securely closed when she felt the first click.

Harrison survived, but his injuries changed his life and the lives of his family. Lisa publicized his case, which was then actively taken up by the media. Harrison's story, and the details of other small children who had sustained similar injuries, became first local and then national news. While Australian laws stipulated that all dishwasher gels and liquids with a pH value greater than 11.5 be supplied in containers with child-resistant closures, with specific warnings as to the caustic nature of the contents, powders were exempt from this regulation. The powder swallowed by Harrison was extremely alkaline – with a pH of 13.4.

The manufacturer of the dishwasher detergent was contacted. Faced with the evidence, the company placed warning labels on all its containers informing consumers of the "double-click mechanism" to engage the child-resistant closure. The company then redesigned the container itself, incorporating a device to limit the flow of powder and changing the closure to a "single-click" mechanism. Unfortunately, this was only one product of many on the supermarket shelves, leaving other manufacturers' products unchanged.

Government agencies and nongovernmental organizations lobbied for a change to the law, which was eventually amended. Dishwasher powder must now be distributed in child-resistant containers with specific warning labels if the pH exceeds 11.5. Furthermore, detergents with a pH greater than 12.5 have been removed from the domestic market. In addition, the performance standard for the child-resistant closure is also under review. The aim is to ensure that if a closure *appears* to be child-resistant, then it must function as such. There cannot be different stages of functionality, such as the "single-click" and "double-click" stages that Lisa's container incorporated.

Chapter 6
Poisoning

Introduction

"All things are poison and nothing is without poison, only the dose permits something not to be poisonous" – Paracelsus (*1*).

The home and its surroundings can be dangerous places for children, particularly for the possibility of unintentional poisoning. Children are naturally curious, exploring in and around the home. As a result, each year millions of calls are made to poison control centres (also called poison information centres). Thousands of children are admitted to emergency departments because they have inadvertently consumed some type of household product, medicine or pesticide. Most of these "accidental" poisonings could have been prevented.

This chapter focuses on cases of acute poisoning among children – predominantly unintentional ones. It covers the extent and nature of poisonings, the risk factors and the intervention measures that can be employed to prevent poisonings or to mitigate the consequences. The chapter does not deal with chronic poisoning issues related to lead, with indoor air pollution or with other effects of repeated or prolonged exposure to toxic agents. Also excluded are allergic reactions to food or poisoning stemming from infectious agents. The issue of snake bites, a major problem in some parts of the world, is addressed in the form of a box.

"Poisoning" refers to an injury that results from being exposed to an exogenous substance that causes cellular injury or death. Poisons can be inhaled, ingested, injected or absorbed. Poisoning may also be acquired in utero. The exposure may be acute or chronic and the clinical presentation will vary accordingly. The factors determining the severity of poisoning and its outcome in a child are interrelated. They include:
– the type of poison;
– the dose;
– the formulation;
– the route of exposure;
– the age of the child;
– the presence of other poisons;
– the state of nutrition of the child;
– the presence of other diseases or injuries.

The time interval between the exposure to poison and the appearance of clinical symptoms is an important window of opportunity. During this period, it is important to minimize absorption by removing or neutralizing the poison (in the case of ingestion), or to administer agents that prevent damage to the organs – such as the use of N-acetyl cysteine in cases of paracetamol poisoning. The longer the time interval, the greater is the chance of survival. In general, if poisons are ingested in solid doses, which have a slower onset of absorption, more time is available for interventions targeting the absorption process. For liquid poisons, on the other hand, absorption is usually too rapid to be easily prevented.

Poisoning with specific agents produces clinical syndromes that are frequently recognizable. All the same, the syndromes may be easily misdiagnosed or go unrecognized in a child. For this reason, treatment may be delayed, with serious consequences. Poisoning is therefore best prevented. Understanding the pattern of poisoning is helpful for reducing the risk of unintentional poisoning, as well as for preventing intentional poisoning (*2*).

Epidemiology of poisoning

According to the WHO Global Burden of Disease project, an estimated 345 814 people of all ages died worldwide as a result of "accidental" poisoning in 2004. Although the majority of these accidental poisonings were among adults, 13% occurred among children and young people under the age of 20 years (see Statistical Annex, Table A.1). Among 15–19-year-olds, poisoning ranks as the 13th leading cause of death (see Table 1.1). A survey of 16 middle-income and high-income countries revealed that, of the different external causes of unintentional injury death among children aged between 1 and 14 years, poisonings ranked fourth in 2000–01, after road traffic crashes, fires and drowning (*3*).

Mortality

Acute poisoning accounted for an estimated 45 000 deaths annually in children and young people under the age of 20 years (see Statistical Annex, Table A.1). The global death rate from poisonings for children younger than 20 years is 1.8 per 100 000 population. For high-income countries the rate is 0.5 per 100 000 while for low-income and middle-income countries it is four times higher, at 2.0 per 100 000. The map in Figure 6.1 shows the geographic distribution of fatal unintentional poisoning, by WHO region. Although mortality rates are generally low and do not exceed 4 per 100 000 population, Africa, the low-income and middle-income countries of Europe, and the Western Pacific region have the highest rates.

In general, low-income and middle-income countries have higher poisoning death rates than high-income

countries. The one exception is in the high-income countries of the Americas, where death rates are higher than in the middle-income and low-income countries, particularly in the 15–19-year age range (see Statistical Annex, Table A.1).

Reported mortality data from countries show higher rates than the estimated regional averages, but the trends are similar. For instance, in Sri Lanka, the case fatality rate from poisoning was found to be as high as 3.2% (*4*). In India, the reported figures for fatal poisonings ranged between 0.6% and 11.6%, while in Viet Nam the reported case fatality rate was 3.3% (*5, 6*).

Age

Children under the age of one year have the highest rates of fatal poisoning (see Figure 6.2), particularly those in low-income and middle-income countries. Generally, mortality rates are highest in infants and decrease with age until 14 years. After that, there is an increase again, almost everywhere, in children 15 years of age and older. In many settings, this increase may be due to substance use, or to unintentional or undetermined drug overdoses (*7*). In some places, the increase may be as a result of entry into the workplace, with its increased exposure to risks.
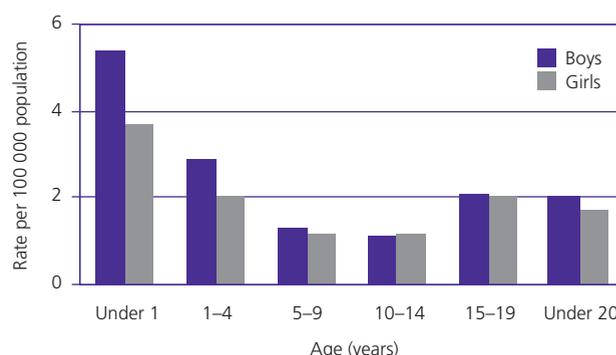
Gender

Boys have higher rates than girls in all regions of the world except the low-income and middle-income countries of the Western Pacific region (see Table 6.1). The poisoning rate for boys in the WHO African region is 5 per 100 000 population, while for girls in the high-income countries

FIGURE 6.1

Mortality rates due to poisoning per 100 000 children[a] by WHO region and country income level, 2004
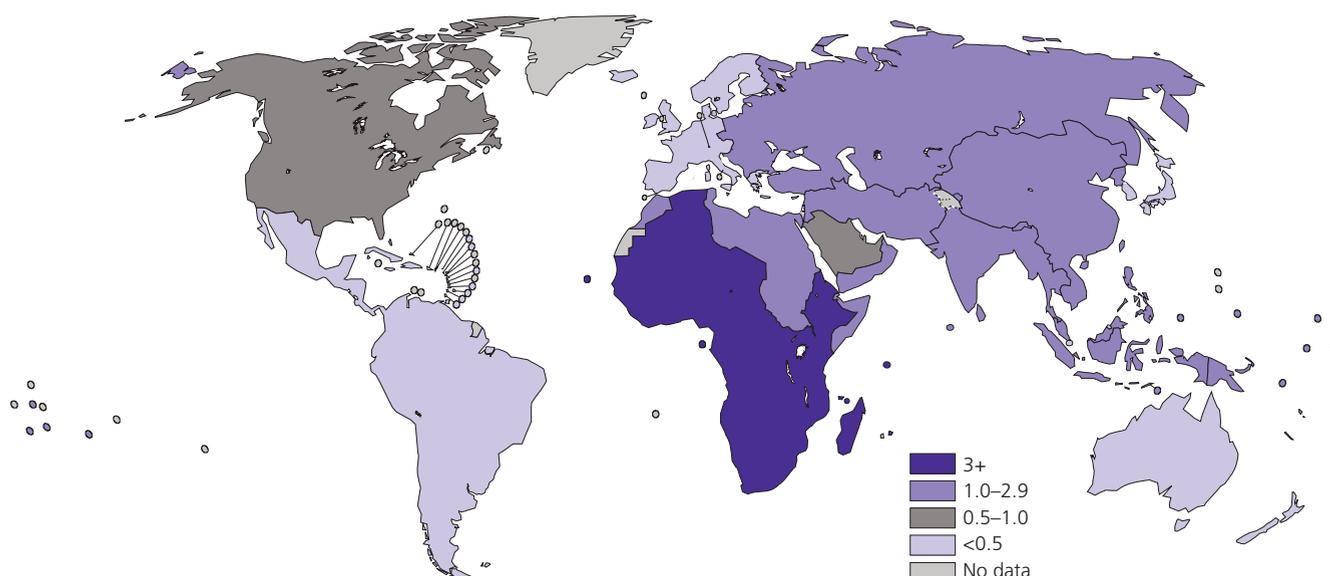
Africa	Americas		South-East Asia	Europe		Eastern Mediterranean		Western Pacific	
LMIC	HIC	LMIC	LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC
4.0	0.8	0.3	1.7	0.2	2.0	0.7	1.6	0.1	1.8

[a]   These data refer to those under 20 years of age.

HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

of the Eastern Mediterranean and Western Pacific regions the rate is as low as 0.1 per 100 000 population.

Morbidity

In contrast to data on mortality, global data on non-fatal outcomes of poisoning are not readily available. Data at country level, though, usually obtained through poison control centres, specialized surveillance systems (such as the National Poison Data System in the United States) or the general injury surveillance systems that exist in many countries, are available. Unfortunately, much of the country information is from high-income countries. Some low-income and middle-income countries, though, including South Africa and Sri Lanka, have established poison control centres and begun to conduct research on poisonings.

One difficulty when comparing poisoning incidence rates between countries is the variety of classification systems used.

- In Sweden, the annual rate of enquiries to the poison control centre concerning non-pharmaceutical chemicals – a category that could include natural toxins, or recreational drugs – was about 1400 per 100 000 children aged between 0 and 9 years (8).
- In Japan, the poison centre received 31 510 enquiries in 1995 about poisoning in children under 6 years of age. The product most frequently involved was tobacco (20%). Enquiries relating to children less than 1 year old made up 35.7% of these cases (9).
- Data from 2006 from the American Association of Poison Control Centers showed that the most common poisonings among children were due to pharmaceutical products. Enquiries relating to children less than 6 years old made up 50.9% of cases and 2.4% of the total reported fatalities (10).
- In the United States in 2004, there were over 1.25 million poison exposures involving children less than 6 years of age – 425 per 100 000 children – reported to the Toxic Exposure Surveillance System (11). The substances most frequently involved were cosmetics and personal care products, cleaning substances and analgesics.

Data from published hospital admissions are available for poisonings in a number of high-income countries. Comparability is a problem here again, since admission criteria differ between countries and between urban and rural settings. Child poisoning admission rates in Australia have been consistently higher in rural areas than urban areas over a number of years. This is probably due to the fact that children are more readily admitted to hospital in rural areas, as doctors in these areas may err on the side of caution and refer children to hospital even when this is unnecessary. The actual agents involved, though, vary little between urban and rural cases (12).

Hospital discharge data are a better indicator of morbidity, since they include a confirmed diagnosis. A two-year study based on hospital discharges and death certificates in California, United States, showed that children aged 15–17 months had the highest overall injury rate and that poisoning was the second leading cause of injury in this group. More than two thirds of the cases involved the ingestion of medicines (13).

Although poisoning death rates are highest in infants under 12 months of age, the incidence of poisoning cases – as reflected in calls to poison control centres and emergency department visits – is generally higher in other age groups (14, 15). Non-fatal poisoning, in fact, appears to be more common among children aged 1 to 4 years (9). In a recent hospital-based study in four low-income and middle-income countries, only 2% of poisonings occurred in children under 1 year of age, compared with 54% in the 1–4-year age group (16).

The fatality rate among older children admitted to hospital following an accidental poisoning is generally less than 1% (4, 17). The higher mortality rate in very young infants may be explained by the greater susceptibility of the infant body to damage by toxins.

Types of poison

The prevalence and types of poisoning vary considerably across the world and depend on socioeconomic status and cultural practices, as well as on local industrial and agricultural activities.

TABLE 6.1

Mortality rates due to poisoning per 100 000 children[a] by sex, country income level and WHO region, 2004

	Africa	Americas		South- East Asia	Europe		Eastern Mediterranean		Western Pacific	
	LMIC	HIC	LMIC	LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC
Boys	4.9	1.2	0.4	1.7	0.3	2.4	1.3	1.7	0.1	1.5
Girls	3.0	0.4	0.3	1.6	0.2	1.7	0.0	1.5	0.1	2.1

[a] These data refer to those under 20 years of age.

HIC = High-income countries; LMIC = low-income and middle-income countries.

Source: WHO (2008), Global Burden of Disease: 2004 update.

Data from poison control centres and hospitals (*4, 5, 18–24*) indicate that the most common agents involved in developed countries – as well as in some developing countries – are:

– medicines sold over the counter, such as paracetamol, cough and cold remedies, iron tablets, antihistamines and anti-inflammatory drugs;
– prescription medicines, such as antidepressants, narcotics and analgesics;
– recreational drugs, such as cannabis and cocaine;
– household products – such as bleach, disinfectants, detergents, cleaning agents, cosmetics and vinegar;
– pesticides – including insecticides, rodenticides and herbicides;
– poisonous plants;
– animal or insect bites.

The most common agents involved in childhood poisonings in low-income and middle-income countries are hydrocarbons used for fuel and lighting, such as paraffin oil (also known in some countries as kerosene) (*5, 25–31*).

A study conducted in Bangladesh, Colombia, Egypt and Pakistan showed that medications were responsible for 31% of poisonings in children under 12 years of age, followed by cleaning agents, which accounted for 20% (*16*).

Older children may be employed in the informal labour sector, in extractive metal industries that involve processing with toxic chemicals, or in agriculture, where pesticides are used. Children living in poverty may scavenge in dump sites containing toxic waste. In all these cases, there is a strong likelihood of exposure to toxic substances, including lead, mercury and organophosphates (*32*). Other children in the family, not directly involved in these activities, may come into contact with toxins brought into the home on the clothes or shoes of their siblings. Children may also be exposed to toxins leached into water or sprayed in the air.

Medicines

Medicinal drugs are the leading cause of non-fatal poisoning in children in middle-income and high-income countries.

- A hospital-based study from United Arab Emirates found that 55% of childhood poisonings were due to medicines. Analgesics, non-steroidal anti-inflammatory drugs and antihistamines were the most commonly ingested drugs in children in the 1–5-year age group (*21*).
- A study from Turkey reported that accidental ingestion of drugs was most common (57.7%) in children aged between 1 and 5 years and that the most frequent offending agent was analgesics (*33*).
- In the United States, in 2003, some 570 000 pharmaceutical exposures were reported in children

less than 6 years old (*34*). This figure represented 23.8% of all poisoning reports, with analgesics accounting for almost 100 000 cases. Additionally, more than 50 000 children under the age of 5 years were treated in emergency rooms for an unintentional exposure to medicinal drugs. Prescription medicines were more commonly implicated than over-the-counter drugs (*34*).

- In England and Wales, during the period 1968–2000, medications accounted for 12.8% of unintentional poisoning deaths in children aged less than 10 years (*23*).

Organic fuels and solvents

Ingestion of hydrocarbon fuel used for cooking, heating or lighting is a common cause of childhood poisoning in low-income countries (*25–29*). Paraffin oil is the leading cause of childhood poisonings in many countries, where it may account for up to 16% of all paediatric poisonings, mainly in children aged between 1 and 3 years (*2, 16, 30, 31, 35–38*).

Organic solvents (such as paint remover, glue and acetone), as well as diethylene glycol (a component of anti-freeze), have also been implicated in mass unintentional poisonings of children through contaminated medicines or toiletries. In 1998, 109 children in Haiti fell ill after consuming paracetamol (known as acetaminophen in the United States) contaminated with diethylene glycol, and 85 of them died (*39*). In similar incidents in Bangladesh, India, Nigeria and Panama, children were poisoned as a result of poorly regulated manufacturing processes (*39*).

In addition to the unintentional ingestion of organic fuels and solvents, intentional inhalation of volatile substances (such as "glue sniffing") by adolescents can result in sudden cardiac death, since inhaled hydrocarbons are about 140 times more toxic than when ingested (*40*).

Pesticides

Children living in agricultural communities are at risk of acute pesticide poisoning. In the Central American region, in 2000, about 12% of all acute pesticide poisoning occurred in children less than 15 years of age, with an incidence rate of 5.7 per 100 000 population (*41*). In poor communities, where there is often little separation between work and the home, children may be exposed to pesticide residues present in work clothes, in the air from spraying and in household dust (*42*). In Nicaragua, children living near cotton farms have been found to suffer poisoning from organophosphates (*43*).

Some of the factors contributing to fatal food poisonings are the inappropriate use and storage of pesticides; the handling of food, while or after working, without proper washing of hands; and the unsafe disposal or reuse of pesticide containers. An example was the food

contaminated with thallium, a rodent poison, that was eaten by children in the Peruvian Andes in 1999, causing 24 deaths (*44*).

In addition to these types of indirect exposure to pesticides, there are direct exposures. A study in China found that children had been exposed directly to rodenticides used in and around the home (*45*). The International Labour Organization estimates that there are approximately 250 million working children between the ages of 5 and 14 years and that some 40% of these are exposed to toxic substances in the rural areas of developing countries (*42*).

Household chemicals

Chemicals around the house to which children may have access contribute significantly to unintentional poisonings in childhood. In the United States in 2004, among children less than 6 years of age, there were over 120 000 exposures to household cleaning agents, such as ammonia, bleach and laundry detergents (*11*). While most exposures to cleaning agents result in mild poisoning, bleach, dishwasher detergents and ammonia can lead to severe tissue damage. These agents are found in most households in developed countries. Several other studies have confirmed the existence of similar household agents in childhood exposures to toxic substances (*3, 21, 22, 46*).

Carbon monoxide

In the United States, some 1600 children under 5 years of age are treated in emergency departments each year and 10 die as a result of unintentional non-fire-related exposure to carbon monoxide. This type of poisoning among children most commonly occurs from furnaces, motor vehicles, stoves, gas pipes and generators (*47*). In low-income countries, indoor cooking fires in homes with poor ventilation can lead to carbon monoxide being produced as a result of incomplete combustion. This in turn can result in respiratory disease in children – from long-term exposure, rather than acute toxicity (*32, 33, 48*).

Other substances

Inorganic substances – including arsenic and the heavy metals lead, copper and mercury – are also responsible for some childhood poisonings. The majority of poisonings due to heavy metals and other inorganic substances are the result of chronic exposure and are therefore excluded from this discussion. In rare instances, though, acute exposure to these agents can result in poisonings. As an example, acute lead encephalopathy with an 11% rate of mortality was reported in Oman, after a lead-containing local medication was given by parents to young infants (*49*).

Plant toxin poisoning – involving plants such as ackee, oleander, datura and cassava – is less frequently reported. Such poisoning can cause morbidity. Death from ingesting plant toxins, though, is rare. Two exceptions are the tragedy in Haiti in 2001, in which 65 children died after eating unripe ackee fruit (*50*); and the consumption of *C. occidentalis* beans, the cause of recurrent outbreaks of encephalopathy among young children in western Uttar Pradesh, India (*51*).

Animal envenomations (poisoning from bites or stings) from snakes (see Box 6.1), scorpions and spiders are a relatively common form of child poisoning in certain areas of the world. These include parts of Asia, the Pacific and South America, and the desert areas of North Africa, West Asia and North America. Envenomations, for instance, in Saudi Arabia account for as much as 30% of all poisonings among children aged 6–12 years (*22, 52, 53*).

Cost of poisoning-related injury

Few studies have been done on the cost of poisonings, especially those affecting children or those occurring in low-income or middle-income countries. One study conducted in South Africa estimated that the direct costs alone of hospitalization due to paraffin poisoning were at least US$ 1.4 million per year (*54*). The average cost of treatment per patient amounted to US$ 106.50 in urban Pretoria (*36*) and approximately US$ 75.58 in the Cape Peninsula (*55*).

Data from the United States confirm the South African findings that poisonings and their management are costly (*56*). Figures from 2000 show that, in children under 15 years of age, there were a total of 219 000 poisonings, of which 141 were fatal and 14 000 resulted in hospital stays. The lifetime cost of poisonings in children in this age group was almost US$ 400 million, with medical treatment accounting for nearly 9% of the costs. This produces a conservative estimate of US$ 1780, on average, for each case of poisoning – including medical costs, lost earnings and lost quality of life (*57*).

Limitations of data

The epidemiology of poisoning can be studied from hospital admissions and discharge records, mortality data, emergency department records and surveillance systems, as well as from enquiries to poison control centres. Globally, though, data on the type of toxic agents that result in child poisoning and death are limited. There is substantial under-recording and under-reporting of childhood poisoning incidents. In addition, poisoning is not generally a notifiable condition, so few countries maintain records of poisonings. Even where surveillance systems exist, child poisoning cases are not necessarily reported or counted. Cases may escape detection, especially if those affected do not seek treatment in a health-care facility. Furthermore, poisoning in children may be attributed to the wrong cause if the effects are similar to those of other conditions. Even where poisoning is correctly diagnosed, the health-care worker or caregiver may not recognize the toxic agent that is responsible.

BOX 6.1

Snakebites

Snakebite is an eminently treatable, but neglected, injury affecting predominantly tropical developing countries. As is also the case with dog bites, recent improvements in injury coding and surveillance, including community surveys in low-income and middle-income countries, have led to an increased understanding of the issue.

How great is the problem of snakebite?

The annual number of cases of snakebite worldwide is about 5 million, among which there are some 100 000 to 200 000 deaths (*53, 59*). In addition to the deaths, there are an estimated 400 000 snakebite-related amputations each year around the world (*60*). Children have both higher incidence rates and suffer more severe effects than do adults, as a result of their smaller body mass (*61, 62*). Snakebites are concentrated in mainly rural areas and vary considerably by season, with the peak incidence seen in the rainy and harvesting seasons (*63*).

Analysis of 2002 WHO mortality data suggests that snakebite contributes to 35% of all child deaths, globally, from venomous bites and stings, with boys about twice as likely to suffer as girls (*64*). Boys appear to have a higher risk, from a very early age, of more severe, upper limb bites (*65*). This type of injury is considerably more common in low-income and middle-income countries, largely in Asia (*53, 59*).

Unfortunately, although the specific antidotes for snakebites – antivenoms – are organic products, there is a worldwide shortage of this pharmaceutical (*59*). This has a severe impact on poor rural communities, who cannot afford the refined antivenoms used in high-income countries. As a consequence, many developing countries are driven to making crude sera that are both less safe and less effective. At the same time, those most at risk of snakebite, such as rice farmers and plantation workers and their families, are frequently far from medical care.

There are a number of snakebite studies in the published literature, but few report specifically on the impact on children – although fatality rates among children are generally higher (*63*). Furthermore, less than 10% of countries in WHO's South-East Asia Region, an area of high snakebite incidence, report paediatric snakebite mortality data. Nonetheless, the recent community health and injury surveys in Asia show that snakebite-related injury ranks as a leading cause of childhood morbidity and mortality in this region (*66*).

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Papua New Guinea has some of the highest snakebite rates in the world, with the country's rural central province recording an annual incidence of 561.9 cases per 100 000 population (*63*). Among paediatric snakebites treated at Port Moresby Hospital Intensive Care Unit, the fatality rate for 2003–2004 was 25.9%, compared to 14.5% for adults. Children also represent 36% of all snakebite-related ventilator bed-days in an intensive care unit, in which snakebite-related paralysis accounts for 60% of the ventilator bed-days (*63*).

Data from developed countries, on the other hand, reveal much lower snakebite-related injury and very low mortality rates.
• In Australia, 1512 snakebite hospitalizations were recorded between 2000 and 2002, resulting in a crude annual rate of 3.9 per 100 000 population. The highest rates – of 7.5 per 100 000 – were among boys aged 10–14 years (*61*).
• In the United States during the period 2001–2004, the estimated crude rate of snakebite presentations to emergency departments was 3.4 per 100 000 population, with an overall admission rate of 31%. The crude presentation rate was highest among children aged 10–14 years, at 5.5 per 100 000 population (*62*).

What can be done about snakebites?
Few studies have comprehensively examined this question for adults, and even fewer have looked at paediatric snakebite. The evidence is therefore somewhat anecdotal. Nevertheless, several general points can be made about why children are at particularly high risk of snakebite (*67*).
• Natural curiosity leads children to interact with animals in general, and in particular leads boys to interact with snakes.

- In rural areas in developing countries, children are often employed on the farm, thus incurring an increased risk of making contact with snakes.
- Children's small body weight means that a snakebite is likely to have a relatively great impact.

Hence children, especially boys, should be specifically targeted for snakebite prevention educational initiatives.

The primary avoidance of snakebite relies on minimizing children's interaction with snakes. Approaches here include:

– wearing appropriate protective clothing – such as shoes or boots – particularly at night and in rural areas;
– avoiding demonizing snakes, as deliberate aggressiveness towards them is more likely to result in a snakebite;
– keeping sheds and fodder storage areas clear of mice and rats, as these attract snakes;
– keeping grassy areas well cut.

Regarding secondary prevention, two recommendations should be made.

- Compartment syndrome – where excessive pressure impairs blood supply, leading to possible nerve damage and muscle death – is often associated with tourniquet use following a snakebite, and is the most common reason for amputation in children in many areas of Africa. The use of tourniquets as first aid following snakebite should therefore be discouraged, and vigilance maintained against pressure-induced cell death (*68*).
- Traditional healers, who often initially treat snakebite, should be specifically targeted so that modern principles of medical care can be incorporated into their traditional methods. This can help avoid delays before treatment can be given in a health-care facility, and thus minimize the frequent serious harm that results from late treatment of snakebite.

Snakebite is a widespread and previously poorly-documented global injury problem, in which children and young people are disproportionately represented. Low-income and middle-income countries, particularly the rural areas, are the most affected. Most deaths and serious consequences from snakebites are entirely preventable by existing means, including making antivenom much more widely available. Better surveillance and reporting are necessary to assess the extent of this forgotten injury and to improve prevention strategies.

Data on child poisonings are further affected by problems with coding. The use of the International Classification of Disease coding of external causes of death, for example, does not capture sufficient detail on the agent involved (*58*). In addition, there is frequently insufficient information on which to make a determination of intent, with the result that many poisoning cases are classified as being of undetermined intent. Accurate information regarding intent is vital for prevention strategies. Studies show that poisonings of children up to the age of 10 years tend to be unintentional, while those of adolescents tend to be intentional in terms of deliberate consumption of the agent, but not necessarily with the intent to cause injury (*7*).

Risk factors

As with other injuries, the risk of a child being poisoned is affected by factors related to the child, the agent and the environment. These factors are interrelated and are highly dependent on the context (see Table 6.2). An understanding of these factors is important for the development of interventions to prevent and, where necessary, treat cases of child poisoning.

Child-related factors

Age

Age has a strong association with poisoning as it determines the behaviour, size and physiology of the child, thus influencing types of exposure and outcome (*69*). Infants and small children are closer to the ground than older children and tend to put their hands and small objects into their mouths. As a result they are at increased risk of exposure to toxins found at low levels or in the soil or dust – such as rodenticides. Many studies have confirmed that poisoning rates increase dramatically at around 2 years of age, as young children become more mobile and have increased access to toxins (*16*). Young children are particularly susceptible to the unintentional

TABLE 6.2

Haddon Matrix applied to the risk factors for childhood poisoning

	Child	Agent	Physical environment	Socioeconomic environment
Pre-event	Age and developmental factors (such as curiosity, judgement); gender; parental supervision.	Ease of opening package; attractiveness of substance; inadequate labelling; poor storage.	Cupboards within easy reach of children; absence of locking devices on cabinets; exposure to agents.	Lack of regulations and standards for toxic products and packaging; poverty; lack of awareness of toxicity and poisoning risks among caregivers.
Event	Child's secrecy about ingestion; parent not noticing unusual behaviour.	Toxicity of chemical; dose consumed; ease with which substance can be consumed (for instance, as liquid rather than solid).	Places where child can ingest substances without being seen.	Lack of awareness by caregivers of how to react; lack of appropriate and timely decontamination by health-care workers.
Post-event	Child's inability to communicate incident; lack of access to poison control centre.	Chemical agent without an antidote.	Lack of adequate pre-hospital care, acute care and rehabilitation.	No poison control centre or lack of information on how to contact centre; lack of access to emergency medical care.

ingestion of poisons, especially liquid ones (*70*). The risk of poisoning among young children is exacerbated by their size and physiological development. Most substances increase in toxicity as the dose increases relative to body mass. Some toxins are eliminated by enzyme systems in the body that develop as the child grows older.

In adolescents, where poisoning can be caused by alcohol misuse or the use of other recreational drugs, fatality rates are higher than in younger children (*71*).

Gender

Boys appear to be at consistently higher risk of poisoning than girls (*4, 36, 72*). With specific regard to poisoning from the ingestion of paraffin, though, some studies have shown no difference between boys and girls, while others have shown a preponderance among boys (*25, 28, 37*). The discrepancy in these findings may be explained by gender differences in socialization between different countries. In some cultures, girls are expected not to engage in outdoor activities or to adopt risk-taking behaviours (*27*).

Poverty

Socioeconomic status is strongly associated with injury and deaths from poisoning, not only between countries but also within countries (*73*). Studies from the United Kingdom show that the risk of dying from poisoning among children from poor backgrounds is more than three times higher than the risk for children in affluent areas (*74*). One study in Greece, however, showed no association between social and demographic factors and child poisonings (*75*). Nonetheless, socioeconomic status may well be the strongest risk factor for poisonings in children as it affects exposure, is itself associated with several other risk factors (such as physical

underdevelopment in children) and is linked to poor outcomes of injury.

In developing countries, socioeconomic status is a strong predictor for household fuel consumption, itself linked to an increased exposure to paraffin. At the same time, poverty drives children into work that is usually poorly paid but with high risks of injury. Poor people tend to live with inadequate sanitary facilities – for washing, and sewerage and waste disposal – and limited storage space to keep harmful substances away from children. Poor dwellings are more likely to be close to areas sprayed with pesticides or to toxic dumps, or to draw their water from contaminated sources. Poverty and malnutrition can also place children at risk of poisoning by forcing them to consume unsafe but cheaply obtained foods – such as undercooked cassava or unripe ackee fruit, both of which are toxic.

The ability to withstand toxic effects depends, among other factors, on the nutritional and health status of the child. Children living in poverty are generally inadequately nourished and therefore more vulnerable to poisons than their healthier counterparts. In addition, conditions of poverty frequently prevent people from accessing health care.

Agent factors

Characteristics of the agent

The more concentrated or more potent the toxic agent, the greater the risk of severe morbidity and mortality. Chemical analyses of seven samples of paraffin from South African refineries found significant differences in their levels of toxicity (*76*).

The nature of the substance is also important. There is a higher incidence of injury associated with liquid agents than with solid compounds (*69*). Households

with children are more likely to have liquid medications. Liquid preparations are easier to swallow than powdered preparations, such as dishwasher detergents or tablets, because they do not stick to the mucosa of the mouth. Nor do they usually produce a burning sensation (which powdered preparations do) which would limit the amount consumed. Unfortunately, powdered chemicals are now being produced with an anti-caking agent, which increases the ease of flow of the powdered chemical, but which also makes ingestion easier.

The physical appearance of a toxic substance plays a large part in its attractiveness to children, while its chemical composition determines its effect. Features such as size, colour and texture may attract or deter a child from handling and ingesting a substance. Studies show that liquids rather than solids, clear liquids rather than dark coloured ones, and small solids rather than large solids have more appeal to young children and are therefore more likely to be ingested by them (77). Bright colours in solid medications may also make them more attractive to children.

Storage and access

The most obvious risk factor for ingestion of a substance is its presence in the domestic environment, within reach of the child. Dispensing substances – such as paraffin and medications – in unlabelled or incorrectly labelled containers without child-resistant closures also increases the risk of poisoning (14, 26). Paraffin oil is frequently stored in bottles or other containers meant for cold drinks, milk or fruit juice, which children associate with beverages (36, 66, 78). In some places, tablets are poured into unsealed envelopes or ziplock bags, and liquids into non-distinctive, poorly labelled containers. Children may also drink from containers, such as cups, which have previously been used for refilling heating or lighting appliances (79). White pesticide powders improperly stored close to food substances can be mistaken for flour, starch or milk, and have led to poisonings of entire families (80).

Even when dangerous products are stored in distinctive containers with visual warning labels – such as images of "skull and crossbones" – young children are unlikely to recognize the significance of these signs (81). Some studies have found carelessness, overcrowding or limited space to be the cause of incorrect storage (14, 36). Research in Australia has shown that many products leading to child poisoning incidents were recently purchased or else not kept in their usual place of storage (80, 82). Medicine and bathroom cabinets, and kitchen cupboards and drawers appeared to be the safest storage places, while handbags, refrigerators, shelves and bathroom ledges were the least safe (83). Even safe packaging cannot compensate for unsafe storage.

In developed countries, many products are required by law to be distributed in child-resistant packaging (84). This usually involves either a bottle with a child-resistant closure or a blister pack. Child-resistant closures make it more difficult for a child to open a container because they require a series of complex actions – such as squeezing and turning, or pushing downwards and turning. The standard for the testing of child-resistant closures adopted in most countries requires that at least 85% of children aged from 42 to 51 months must be unable to open the container within five minutes, and at least 80% must fail to open the container following a non-verbal demonstration (85).

No closure, though, is perfect. In the child testing, up to 20% of children aged between 42 and 51 months may be able to overcome the child-resistant closure. Many parents are unaware that young children may indeed be able to access the contents of child-resistant packaging. Child-resistant closures should therefore never take the place of good supervision (24).

Environmental factors

Season and climate

There are significant seasonal variations in the incidence of poisoning cases for different poisoning agents. Summer is the time of greatest risk for the ingestion of paraffin, medications and organophosphates and for bites from scorpions and snakes (25, 36). Several explanations have been put forward. Children on their summer holidays are more likely to be outdoors or to be left at home unattended or in the care of an older child or elderly relative (65, 86, 87). Children may also consume more fluids because of the warmer weather. Around national or religious holidays, parents or siblings may be less alert to hazards or children may exhibit more attention-seeking behaviour (88).

Although the incidence of poisoning is higher during the summer months, a few types of poisoning are more common in winter or during cold weather. These include carbon monoxide poisoning – from heating appliances – and poisoning through ingesting cough or cold medicines, as these are often considered harmless and left unattended (89).

Socioeconomic environment

Several case–control studies in low-income and middle-income countries have highlighted social and demographic risk factors in the poisoning of children. These factors include the presence of young parents, residential mobility and limited adult supervision (65, 90, 91). Although parents and caregivers may have been present at the time of the poisoning incident, studies confirm they were usually engaged in household duties or attending to personal needs. In a significant proportion of cases, poisoning occurred when a child was left in the care of another child or with a grandparent (65, 87, 91, 92).

Poor living conditions, local beliefs and customs and ignorance of the dangers of chemicals are other risk factors associated with acute poisoning (14). Previous poisoning may also be a risk factor (72).

The socioeconomic environment has an effect on the exposure to the risks of poisoning as well as on outcomes. The absence in many countries of policies, standards or laws governing the manufacture, labelling, distribution, storage and disposal of toxic substances place children at risk of poisoning. Poor quality control in the manufacture of medicines exposes children to toxic contaminants in these products. The unregulated packaging and distribution of medicines and other potentially toxic substances in sachets and containers that are not child-resistant increases the ease with which children can gain access to them. The uncontrolled storage and dumping of pesticides near homes and in water supplies expose children, especially those from poorer households, to toxins.

The toxicity of agents is also influenced by the political environment. In the United Kingdom during the 1970s, a significant proportion of child poisonings were attributed to medicines, such as aspirin, barbiturates and safapryn, a drug that was a dangerous combination of paracetamol and aspirin (*23*). Aspirin is no longer prescribed for children and barbiturates have been replaced by less toxic agents such as benzodiazepines. In addition, the chemical industry now produces less toxic pesticides. Economic forces, though, are responsible for the continuing use in developing countries of outdated agents, both pharmaceutical and non-pharmaceutical, that often carry high risks.

Lack of prompt treatment

In the event of a poisoning, quick and appropriate triage, diagnosis and treatment are vital. Poison control centres do an excellent job of advising the public when a poisoning is suspected, as they rely on regularly updated databases and standard management protocols. However, many countries do not have such a system in place. Even if they do, people may not have access to the centres.

The availability of health-care facilities and the ability to access such facilities rapidly affects the outcome of poisoning injuries. Although there are no data comparing fatality rates of poisonings in rural or remote areas – where health facilities are more likely to be scarce and of lower quality – one would expect poisonings in more remote areas to have more serious outcomes. Certainly, fatality rates in countries with limited health-care facilities are higher than rates in more developed areas. Once a child has been transported to a hospital, the prompt recognition of the signs and symptoms and treatment for the correct type of poison involve knowledge of the latest clinical developments and skill in toxicology analysis.

Interventions

Interventions are usually based on risk factors that are amenable to change and that are targeted at high-risk populations.

Engineering measures

Reduction of toxicity

Removing a poisonous substance effectively may not always be possible. An alternative approach is to lower the level of the toxicity of the offending agent or to neutralize it in some way. One way of doing this is to reduce the concentration of the active ingredient. In Saint Lucia, a policy of selling acetic acid only in diluted form led to a fall in the rate of childhood poisonings. Previously, concentrated vinegar had been easily available, and had been responsible for several poisoning deaths (*93*). Another example of lowering toxicity is the reformulation of methylated spirits as principally ethyl alcohol, rather than the more toxic methanol.

In a similar way, less toxic pesticides may be used to prevent cases of acute pesticide poisoning (*32*). However, safer pesticides are generally more expensive, so that financial incentives or subsidies are probably needed if they are to be used in poorer countries. Introducing organic pesticide management or an integrated vector management system (*94*) will also lead to a fall in the number of cases of acute pesticide poisoning. To operate such systems, though, requires scientific expertise (*41*).

Reducing the toxic effects of ingestible poisons by adding an antidote to the substance has also been attempted, but has not been proved to be effective. In the United Kingdom, paracetamol was manufactured with added methionine, an antidote to paracetamol overdose (*95*). This product, though, was withdrawn because it was more expensive than the paracetamol-only formulations that remained on the market. In addition, the use of oral methionine was questioned, as the substance was associated with allergic reactions.

Safer packaging and storage

The success in reducing unintentional child poisoning through safer packaging and storage over the past three decades has relied on:
– *education* of parents and caregivers – about the risks and how to protect against them;
– *legislation* – to prevent unsuitable containers (such as are normally used to store food or drinks) being used to store harmful substances; and to make packaging around harmful substances resistant to tampering by children.

In South Africa, paraffin oil is used for heat for cooking and is frequently stored in bottles previously used for storing beverages. A successful programme to tackle this dangerous practice involved the free distribution of containers with child-resistant closures (see Box 6.2). As a result, the annual incidence of poisoning fell, over a period of 14 months, from 104 per 100 000 to 54 per 100 000 (*80*).

In affluent countries, medicines stored in the home are more likely to be implicated in childhood poisoning than they are in poorer countries. In many places, tablets or capsules are emptied into cheap containers such as paper or plastic envelopes. In developed countries, commercially packaged medicines are sold in a variety of preparations and strengths – in standard screw-capped or clip-capped bottles, in bottles with child-resistant closures and in blister packs. To avoid errors of dosage, particularly among elderly people, some medications are dispensed in special boxes where multiple morning, lunchtime and evening doses are stored together.

Child-resistant packaging is one of the best-documented successes in preventing the unintentional poisoning of children (96). In England and Wales, unintentional poisoning deaths of children aged under the age of 10 years fell steadily from 151 per 100 000 in 1968 to 23 per 100 000 in 2000 (23). Similarly, in the United States, the annual rate of unintentional ingestion of 15 regulated substances in children younger than 5 years fell from 5.7 per 1000 in 1973 to 3.4 per 1000 children in 1978 – with nearly 200 000 unintentional ingestions prevented during that period (97). Both these reductions were largely as a result of the introduction of child-resistant packaging.

Safe storage of poisons in the home requires a secure location where a child cannot overcome barriers of locks or height. Although children will devise complex strategies to get hold of medicines, doing so takes time. The main reason, therefore, for storing poisons *out of reach of children* is that this is a delaying strategy – as indeed is child-resistant packaging.

Child-resistant packaging has been proved effective for medications, fuels, household chemicals and pesticides. The cost to manufacturers and distributors may be an obstacle, but this is likely to be outweighed by the large savings from treating children who have been unintentionally poisoned. The costs to households may be offset by government subsidies, such as the free distribution of such containers (91). Child-resistant packaging should be used on all drugs sold over the counter, to help prevent children consuming these potentially lethal products (98).

Reducing an agent's attractiveness

One study has shown that the appropriate design of packaging can be an effective means of reducing the attractiveness for children of harmful substances (99). Other studies, on the ingestion by children of paraffin, have recommended that containers be made of darkened material in which the contents are invisible (25). The reason for this is that, since paraffin may be easily mistaken for water, a non-transparent, dark container is less likely to be associated with a drinkable liquid than a transparent, light-coloured container. Another suggestion is to modify the taste and colour of paraffin as well as modifying the containers in which it is stored

(*27*). In Australia, changing the colour of paraffin to blue led to a decrease in the incidence of paraffin ingestion (*101*).

The addition of bitter agents is another method of stopping children from consuming significant quantities of harmful substances. Studies have shown that this approach may be useful, though it is possibly more appropriate for household products of mild to moderate toxicity rather than for pharmaceutical products (*102, 103*).

Labelling containers with warning stickers showed no deterrent effect on children at risk aged under 6 years (*81, 104*). The possible effectiveness of warning labels depends very heavily on their being understood by all, and assumes some degree of literacy. It has even been suggested that in some cases, warning labels may attract children (*81*).

Environmental measures

Studies show that 56% of unintentional poisonings in young children occur within the child's home, and another 17% occur in or around someone else's home (*16*). Reducing children's access to poisons in the home can be achieved in a number of ways.

Removing toxic agents

The most effective way to prevent children coming into contact with a poison is to remove the poison itself. An example of this is the Manchineel tree. The fruit of this tree looks like an edible green apple but the fruit, bark and sap are all toxic. Poisonings from the Manchineel tree, especially among children, used to be common in the Caribbean, despite warning signs and educational campaigns. Eventually, the trees were removed by the authorities from the beach areas where they were prevalent and replaced by coco plum trees, with a consequent fall in the number of poisoning cases.

Alternatively, toxic agents may be replaced by other substances with a lower toxicity. As examples, the following highly toxic substances have been largely replaced in many places by less toxic substances having a similar intended effect (*23*):
– barbiturates (a class of sedative-hypnotic drugs) by benzodiazepines;
– cresol (a preservative) by chlorocresol;
– aspirin by paracetamol;
– toxic anti-inflammatory drugs with less toxic non-steroidal anti-inflammatory drugs.

Sometimes the change from toxic to less toxic substances occurs as a side effect of economic development. The incidence of paraffin ingestion, for instance, has been found to fall when countries move from using individual fuel sources, such as bottled paraffin, to safer alternatives such as electricity and natural gas supplied by public utilities (*32*).

Laws and regulations

A comprehensive strategy to prevent childhood poisoning must include laws supported by enforcement. This has been shown in the case of child-resistant closures. The laws on child-resistant closures and a high degree of compliance by manufacturers have seen falls in mortality rates in several developed countries.

Child-resistant packaging

Standards and policies for child-resistant packaging currently only exist in a handful of high-income countries, such as Australia, Canada, New Zealand, the United States and the European Union. The absence of laws (or their lack of enforcement) and policies on manufacturing, storing, distributing and disposing of hazardous products has led to deaths of children as a result of contaminated medicines and toothpaste. In the Bhopal catastrophe, methyl isocyanate – a poisonous gas, heavier than air, that is used in the production of pesticides – was released into the atmosphere. In the absence of a strong local legislative framework, international standards and laws need to play a role in regulating global companies, currently often able to operate with lower levels of care than in their country of origin.

In 1970, the United States introduced child-resistant packaging in its Poisons Prevention Packaging Act. With rates of compliance among manufacturers of between 60% and 75%, the incidence of unintentional ingestion of baby aspirin was reduced by 45%–55% and of regular aspirin by 40%–45% in children less than 5 years old (*105*). Poisoning deaths among children under 5 years of age, resulting from the ingestion of substances regulated by the 1970 law, declined from 450 in 1962 to 216 in 1972 and 33 in 2005 (*106*).

The European Union has laws (*107*) mandating the storage of toxic substances in child-resistant containers that are:
– clearly and appropriately labelled;
– in places that are not within reach of children or near to foodstuff;
– labelled in such a way that the substances in question cannot be mistaken for food.

This clearly places the onus for protecting children from toxic substances on households as well as on manufacturers and distributors. These laws may account for the low rates of child poisoning seen in much of Europe.

Blister packs

Blister packs (non-reclosable packaging) for medicines in tablet or capsule form are increasingly being used for dispensing. Soon after they were introduced such packs were considered to be child-resistant, because of the time it takes to remove each individual tablet or capsule and led to some reductions in child poisoning (*108*). However,

as the use of blister packs has increased, it has become clear from poison centre data that young children can access medications from such packs. While removing and swallowing the tablets from a single strip of a blister pack may be less likely to be harmful than having access to a full bottle of the comparable liquid form, for many medicines even a few tablets can be a toxic or even a lethal dose for a young child. One advantage of blister packaging is that parents may better recall how many tablets had been used before the child swallowed some – thus being able to calculate the maximum number that may have been ingested. The disadvantage of blister packs is their transportability. Studies have shown that children often remove medications from handbags, particularly those belonging to the grandmother (*109*). This has prompted the development of a European standard for child-resistant blister packs, using a child test panel similar to the one for the reclosable child-resistant packaging standard.

Educational approaches

Although not an effective intervention strategy by itself, education on how to prevent poisoning has been shown to be a useful component of prevention programmes (*110–114*). Education on poisoning should aim to:
– raise awareness;
– increase knowledge and skills on poison prevention;
– change attitudes and behaviours;
– influence policy and legislation;
– create good practices within organizations.

Educational interventions should be used in combination with other interventions seeking to prevent poisoning.

Most poisonings in young children occur at home, with parents or caregivers nearby and engaged in household tasks. While continuous direct supervision (always within eyesight) would reduce the access of children to poisons, it is not practical to promote such a strategy. Continuous supervision is difficult to achieve even for caregivers in affluent households with few children. In poorer households, there are likely to be more children to be cared for and other competing household tasks to be performed. In such circumstances, passive measures are likely to be more effective.

The effectiveness of public awareness and general education campaigns in reducing the incidence of child poisoning cases is open to question. Educational campaigns in isolation have not had a significant impact on the ingestion of harmful substances (*110, 115*). One study in the state of Massachusetts in the United States showed no significant increase in compliance following a campaign of advice on how to prevent poisoning (*111*). Research has also shown that mothers and caregivers take fewer precautions against child poisonings if these precautions involve more effort, and especially if they involve changes in behaviour. Passive interventions, as already stated, are likely to be more successful and should be promoted (*112*).

It has been suggested that messages used in educational programmes directed at caregivers (including parents) may be more effective if they address the factors influencing the behaviour of the caregivers. Further, home visits by health-care workers to reinforce the messages of the educational programmes have been shown to be effective (*113*).

Educational programmes with a narrower, more specific aim may be more successful. Such programmes may include:
– point-of-sale warnings from pharmacists on the possible dangers of the medication being dispensed;
– public awareness campaigns that "child-resistant does not mean child-proof";
– messages to parents and caregivers reminding them to test child-resistant closures and to ensure that these closures have been properly re-engaged;
– messages to parents and caregivers that common household products may be dangerous for young children – even such "healthy" or "natural" products as iron tablets or essential oils.

A recent systematic review on the effect of home safety education and the provision of safety equipment on poisoning prevention practices revealed that although these interventions improve poison prevention strategies, their impact on poisoning prevention rates remains unclear (*116*).

Managing poisoning

Management of a poisoning requires immediate advice and first aid, followed by directed treatment where necessary.

Acute management of poisoning

Box 6.3 outlines the general principles governing the management of all cases of acute poisoning (*48, 117*).

Early and accurate diagnosis and management of poisoning decrease the risk of morbidity and mortality. It is therefore vital that caregivers seek help from a poison centre or a professional health-care worker. An assessment, including the previous history, should be made if possible, though this may be difficult with children. It is important to keep the airway clear, the breathing regular and the circulation flowing.

The agent is likely to be known, but the dosage may have to be estimated. Treatment should be based on the greatest exposure that could have occurred. There are many sophisticated tests and procedures, but their effectiveness has in some cases been questioned. Some of these tests may in any case not be possible to perform in most developing countries.

Managing acute poisoning: the general principles

1. **Remove the child** from the source of exposure and decontaminate the child, as described below, if the poison has been inhaled or absorbed through the skin or mucous membranes. Contaminated clothing, including shoes and socks, and jewellery should be removed. Where toxins have been inhaled, the child should be removed to an environment of fresh air.

2. **Assess** what agent, or agents, and doses are involved, the time since ingestion and the current clinical status – as well as other factors related to the child, such as age, gender and the presence of other illnesses. Toxic screening has limited value as it delays management and is seldom available in developing countries.

3. **Stabilize** the child. The general approach to acute poisoning involves giving priority to the airway, breathing and circulation – as for any emergency.

4. **Decontaminate** the child, if appropriate. It is important to limit the absorption of an ingested agent. Gastrointestinal decontamination is reserved for severe or life-threatening cases, where the poison is still in the gastrointestinal tract and can be removed. The airways must be secured and gut motility assured before embarking on gastrointestinal decontamination.

   Specific decontamination measures include the following.

   - *Topical decontamination*. Whatever the means of exposure, any body surface – including the eyes – that is exposed to a toxin should be flushed well with large amounts of water, saline or other fluids specific to the poison.
   - *Activated charcoal* may be used to absorb many organic poisons. It is ineffective, though, for hydrocarbons, caustics, alcohols and some heavy metals. Though not proved to achieve a better clinical outcome, activated charcoal does result in a decrease in absorption of the poison if it is used within one hour of ingestion. Complications associated with activated charcoal include aspiration and constipation.
   - *Gastric emptying* can be achieved in two ways.
     – One means of gastric emptying is through vomiting, but it is no longer a routinely used method as its effectiveness is in doubt. There may also be complications with vomiting and it is contraindicated in children less than six months of age, in children with unprotected airways or when the ingested substance is an organic solvent, such as petrol or paraffin oil, or a corrosive agent.
     – The second means is through gastric lavage. In this method, the stomach is washed out with small aliquots of normal saline until its contents are cleared. This procedure should only be performed if indicated and is not recommended for children less than six months of age.
   - *Catharsis* to increase gastrointestinal motility and hence hasten the expulsion of unabsorbed poison. There is little evidence, though, to support the use of catharsis as a means of reducing gastrointestinal absorption following an overdose, and the complications of fluid loss and electrolyte imbalance outweigh any benefits.
   - *Whole bowel irrigation* can be used to physically eliminate highly toxic substances not absorbed by charcoal. Its use is neither supported nor refuted if substances such as iron, lead and paraquat have been ingested. A non-absorbable liquid such as polyethylene glycol solution is used to induce a liquid stool until the rectal effluent clears. Complications include fluid and electrolyte imbalance, bloating and vomiting.
   - *Alkaline diuresis* enhances elimination of some acidic substances. An example is bicarbonate administered to enhance the elimination of aspirin.
   - *Dialysis* – including haemodialysis, peritoneal dialysis, haemofiltration and haemoperfusion – may be used in specific circumstances to clear certain water-soluble poisons from the circulation.
   - *Antidotes.* Envenomations should be treated with antivenom, most commonly for snakebite and scorpion stings, and also for some spiders' bites. Atropine is used for carbamates; atropine and pralidoxime for organophosphorus pesticide poisoning; naloxone for opioids; acetyl-cysteine for paracetamol overdoses; and chelating agents for some heavy metals.

5. **Provide supportive therapy**, including the treatment of complications. The main management in acute poisoning includes: airway stabilization; seizure control; correction of hypoglycaemia; correction of hyperthermia; treatment of shock and pain; and the use of antidotes.

Poison control centres

Poison control centres provide advice to individuals and health-care institutions. They direct first aid where appropriate, and refer more severe poisonings to a health-care facility. Poison control centres are responsible for less severe outcomes in cases of poisoning. They also eliminate much unnecessary contact with more expensive health-care services (*118*). They were initially set up in high-income countries and have since been established in many low-income and middle-income countries (see Box 6.4).

There are problems, though, in establishing poison control centres in less developed countries. Often, the need for such centres is not properly appreciated. There is likely to be a shortage of adequately trained staff, and poor clinical and laboratory toxicology services for further management of cases (*119*). In addition, the effectiveness of poison control centres depends on good telephone communications, which may in some places be limited, though this obstacle is likely to be overcome by the increasing use of mobile telephones (*120*).

It is estimated that for every dollar spent on a poison control centre contact there is a saving of nearly eight dollars, as more than 70% of cases are resolved over the telephone (*118*). If these centres did not exist, an estimated 600 000 additional possible poisoning cases would receive

treatment at a health-care facility each year, at an added cost of US$ 545 million.

Involving a range of sectors

There is a wide range of groups and sectors that need to be involved for the successful prevention of accidental poisoning of children. In addition to the health-care sector, parents and caregivers, there are: the education sector; the justice ministry; the departments of trade and industry; consumer groups; nongovernmental organizations concerned with child safety; producers and retailers of pharmaceuticals, agrochemicals and other toxic substances; and industries that handle toxic substances and in which children are employed.

In the Netherlands, a programme to prevent unintentional poisoning among children aged 0–4 years resulted in a 15% reduction in the number of poisoning cases and a 50% fall in the number of admissions to health-care facilities. The programme involved health-care workers, parents, kindergarten teachers, the mass media, nongovernmental organizations, and the pharmaceutical and chemical industries (including retailers and distributors) (*122*). Another example of a multisectoral collaboration to prevent poisonings is the establishment of poison control centres in developing countries (*120*).

Industry has an important role to play in reducing the number of toxic substances produced, both directly and as by-products. In developed countries, as demand for more environmentally-friendly products has increased, industry has responded by modifying products, with the increased cost met by concerned consumers. Products have in this way been modified to produce safer versions, not through planned interventions but as a result of independently occurring social changes. Financial incentives to industry, that have led to a reduction in carbon emissions, may also be effective in reducing the range of household poisons to which young children are exposed. Both legislation and a strong voluntary engagement of the corporate sector are likely to be required to ensure the safe storage and disposal of toxic products and by-products.

Evaluating interventions

Evaluation is vital in determining whether policies and programmes for poisoning prevention are effective. An essential element of evaluation is having an injury surveillance system or else the ability to collect data from health-care settings. In the Netherlands, surveillance data that had been gathered were used successfully to evaluate a range of interventions – from child-resistant closures to educational campaigns for safer storage (*123*).

Conclusions and recommendations

Despite reductions in the incidence of child poisoning following specific interventions, cases of poisoning still contribute towards a significant proportion of child injuries.

One of the greatest obstacles in the way of effective prevention and control of poisoning is the lack of reliable data. Few data collection systems exist and those that do are mainly in developed countries. As a result, it is difficult to estimate the scale of the problem precisely in those places where the incidence may be the greatest.

Several interventions have been tried, with varying levels of success (see Table 6.3) (*124–126*). Measures that have been found effective to some degree include poison control centres, child-resistant packaging, and

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> **BOX 6.4**
>
> ## The National Poisons Information Centre in Sri Lanka
>
> In Sri Lanka in 2005, poisoning accounted for almost 90 000 hospital admissions and 1785 deaths. Around a third of these cases were in children under the age of 18 years.
>
> The first poison control centre in the world was established in 1953 in the state of Illinois, United States, largely in response to the number of poisoning cases involving children. One of its aims was to instruct doctors on how to deal promptly with accidental overdoses, cases of chemical poisoning and animal bites or stings. More generally, the centre provided information on the toxic ingredients of substances and their chemical effects.
>
> In Sri Lanka, the National Poisons Information Centre was set up in 1988 – the first such centre in South Asia (*121*). Deaths from insecticide poisoning were of special concern, and three pesticides in particular – monocrotofos, methamidofos and endosulfan – were found to be killing agricultural workers and their children. As a result, the importation of these pesticides was banned in Sri Lanka.
>
> In the first 10 years of its existence the National Poisons Information Centre dealt with 4070 enquiries (*121*). Of these, 3671 were by telephone (about a third of them relating to children and young people under 20 years of age), 368 were personal visits to the centre, and 31 written enquiries. Over 90% of the telephone calls were from health-care personnel, most of the rest coming from members of the public. Around half the enquiries were in connection with suicide attempts, and a further third concerned unintentional poisoning incidents (*4*).
>
> The centre is staffed by three information officers covering the hours from 8:00 to 17:00 every day. Calls outside working hours are referred to the intensive care unit at the National Hospital of Sri Lanka (*4*).
>
> In 1993, again in response to a continuing problem with pesticides, several new measures were put in place to strengthen the National Poison Information Centre. These included:
> – a 24-hour service for health-care professionals and doctors;
> – a laboratory facility for analysing blood, urine and stomach contents;
> – the ability to supply antidotes to hospitals.
>
> As a result of these and other services provided by the centre, the incidence of morbidity and mortality from poisoning in Sri Lanka has fallen.

education (including training of parents and caregivers) combined with home visitations (*113, 116*). Many of the successful prevention interventions have been tested only in developed countries.

Recommendations

- Data collection systems need to be improved in ways appropriate to the setting. The data obtained will help to identify populations at risk and their specific risk factors, as well as facilitating the design and implementation of interventions.
- More research is needed on the ability to reproduce and transfer across cultural boundaries successful prevention interventions on childhood poisoning.
- Poison control centres, with well-trained personnel, should be set up as widely as possible. In places where they have operated, they have saved many lives and large amounts in health-care costs (*127*).
- Countries should set laws and standards relating to the manufacture, storage, distribution and disposal of potentially toxic substances.
- Countries should introduce laws mandating child-resistant packaging for medications, and for pesticides, rodenticides and other potentially toxic household items. The effectiveness of such packaging should be evaluated, particularly where blister packs are concerned.
- Industry needs to play a greater role in reducing the presence of toxins and in safely packaging items that are sold to households. Greater care needs to be taken in the production process itself, to ensure that by-products and waste do not contaminate the environment.

- Treatment protocols should be developed to assist with the initial assessment and management of potential child poisoning cases. These protocols should target the most frequently involved and most toxic pharmaceuticals (*128*).

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TABLE 6.3

Key strategies to prevent poisoning among children

Strategy	Effective	Promising	Insufficient evidence	Ineffective	Potentially harmful
Removing the toxic agent	■				
Legislating for (and enforcing) child-resistant packaging of medicines and poisons	■				
Packaging drugs in non-lethal quantities	■				
Establishing poison control centres	■				
Locking away medicines and other toxic substances		■			
Removing or regulating availability of toxic substances that are easily mistaken for edible items			■		
Teaching children to avoid poisonous substances			■		
Reducing the attractiveness of medications and poisonous products			■		
Providing home safety education and safety equipment			■		
Clearly labelling toxic products				■	
Introducing non-standardized, non-reclosable packaging for tablets					■

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