4.1. Poisoning—Major Global Health Problem

Uncontrolled use of poisons in both developing and developed countries has resulted in significant human fatalities every year.\(^{(11, 12, 14, 124-129)}\) Poisoning has been influenced by numerous region-specific, socio-economic, health, cultural diversity, and poison-related factors.\(^{(13, 90, 98, 111, 130-136)}\) Poisoning has emerged as one of the major global health problems. Poisoning has been causing a significant mortality and morbidity worldwide.\(^{(13, 90, 98, 111, 130-136)}\) As per the WHO global estimation, 300,000 deaths occur every year due to pesticide poisoning.\(^{(17, 26, 77, 125, 137-140)}\) 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.\(^{(13, 90, 98, 111, 130-136)}\)

Acute poisoning accounted for an estimated 45,000 deaths annually in children and young people under the age of 20 years.\(^{(17, 26, 77, 125, 137-140)}\) 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.\(^{(26, 77, 125, 137-140)}\) Low-income (e.g., Africa) and middle-income (Europe, and the Western Pacific region) countries have higher poisoning death rates than high-income countries.\(^{(141)}\) 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.\(^{(28, 142-144)}\)
The data reported from various countries show varied mortality rate amongst the different regions, 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%.(145) In India, the reported figures for fatal poisonings ranged between 0.6% and 11.6%, while in Vietnam the reported case fatality rate was 3.3%.(32, 141)

4.2. Types of Poisoning/Reasons for Poisoning

There are several types of poisoning or reasons for poisoning. These include: a) suicidal poisoning (an intentional act resulting in death); b) accidental poisoning (an exposure to a poison by an accidental action and is common in young children, but may occur in adults in the home, workplace, or as a result of fire or transport accident); c) deliberate poisoning (this forms part of the spectrum of disorders now classified as deliberate self-harm); d) occupational poisoning (occurs in the context of employment); and e) environmental poisoning (refers to exposure resulting from presence of a chemical either in the air, in food or water and animal and insects bites/stings).

4.3. Types of Poisoning Agents

“All things are poison and nothing is without poison, only the dose permits something not to be poisonous”.

The nature of poison varies in different parts of the world and may vary even in different parts of the same country. Data from poison control centres and hospitals indicate that the most common agents involved in both developed and developing...
countries are medicines, household products, pesticides and animal or insect bites (Table 1).(1-54, 64-73, 79-86, 91-101, 105, 106, 108, 109, 111, 113, 115, 117-122, 124-126, 128-134, 137-143, 145-281)

**Table 1.** Types of common agents involved in poisoning across the world

<table>
<thead>
<tr>
<th>Type of Poisoning Agent</th>
<th>Range</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides</td>
<td>32% - 65%</td>
<td>Pesticides, insecticides, rodenticides and herbicides</td>
</tr>
<tr>
<td>Medicines</td>
<td>23% - 48%</td>
<td>Anti-inflammatory, sedative, iron supplementary, antihistamine, antidepressant, antipyretic and antiepileptic drugs</td>
</tr>
<tr>
<td>Household products</td>
<td>11% - 39%</td>
<td>Bleach, kerosene, disinfectants, detergents, cleaning agents, cosmetics and vinegar</td>
</tr>
<tr>
<td>Animal or insect bites</td>
<td>5% - 12%</td>
<td>Snake bite, spider bite, bees sting and wasp sting, fish sting/bite</td>
</tr>
</tbody>
</table>

### 4.4. Epidemiology of Poisoning

The pattern of poisoning has been varying according to the geographical location. In developing countries with developing economies, poisoning by pesticides and herbicides is often common. Patterns of habitation and work may also expose the population in warmer countries to toxins from snakes or spiders. In these countries, self-harm often involves agents that are available and may reflect local tradition. For example, in Sri Lanka oleander poisoning is a frequently encountered problem, in China and India herbicides and pesticides, and in the United Kingdom (UK) paracetamol (acetaminophen) are the most frequent poisons taken deliberately.(138, 282, 283)
4.4.1. Global Epidemiology

The epidemiology and the mortality rate are often found to be higher in low and middle-income countries. The epidemiology of acute poisoning in a rural Sri Lankan district was studied by a prospective assessment. The prospective study was conducted from September 2008 to January 2010 in all hospitals with inpatient facilities in Anuradhapura district of North Central Province of Sri Lanka. Acute poisoning data was extracted from patient charts. Selected data were compared with the data collected from a 2005 study in 28 hospitals. There were 3813 poisoned patients admitted to the hospitals in the Anuradhapura district over a period of 17 months. The annual population incidence was 447 poisoning cases per 100,000 population. The total number of male and female patients was almost similar, but the age distribution differed by gender. There was a very high incidence of poisoning in females aged 15-19, with an estimated cumulative incidence of 6% over these five years. Although, pesticides were still the most common type of poison, medicinal drug poisonings were 21% of the total and have increased 1.6 fold since 2005. Acute poisoning remains a major public health problem in rural Sri Lanka and pesticide poisoning remains the most important poison. However, recently a dramatic increase in cases of medicinal drug poisoning is observed. Youth in these rural communities remain very vulnerable to acute poisoning and the problem is so common that school-based primary prevention programs may be worthwhile.

Organophosphorus (OP) compounds are used as pesticides, herbicides, and chemical warfare agents in the form of nerve gases. Acute poisoning by these agents is a major global problem with thousands of deaths occurring every year.
Most of the OP pesticides poisoning and subsequent death occur in developing countries following a deliberate self ingestion particularly in young, productive age group, as highly toxic pesticides are readily available at the moment of stress due to family problem, failure in love and exam phobia. Poisoning has been a common cause of medical admissions and deaths in Nepalese hospitals. An epidemiological and medicolegal analysis was conducted in Nepal. This prospective cohort study involved 171 cases of OP intoxication in the Narayani zone of Central region of Nepal. Patients with OP intoxication admitted to emergency department of two hospitals during January 2010 to December 2011 were enrolled in the study. Poisoning is more common in the mean age of 28 years. Most of the admitted cases were of suicidal as well as accidental in nature and women were the main victims than man. Suicidal deaths due to ingestion of OP compound have been found to be very common in Nepal, especially in women. The reason may be the increasing stress in the family and economic constraints. Accidental deaths due to occupational exposure or inhalation of OP compounds are reported but in these cases mortality rate is less than that of suicidal poisoning.

Self-poisoning accounts for a substantial proportion of acute hospital presentations, but has been poorly characterized in older adults. A retrospective observational study was conducted in United Kingdom between 2004 and 2007 to determine the agents ingested by older adults presenting to hospital after drug overdose, and to compare clinical outcomes to younger patients. During the study period, there were 8,059 admissions, including 4,632 women (57.5%). This included a subgroup of 361 patients
(4.5%) who were >60 years of age. Older adults who presented to hospital after drug overdose had ingested different drugs than younger patients, possibly due to different prescribing patterns, and had a poorer outcome. The use of drugs associated with significant toxicity should be avoided in older patients at risk of self-harm.

The Danish Poison Information Centre (DPIC) provides information to the public and healthcare professionals on acute poisonings. A study was conducted at DPIC to classify all substance exposures and obtain the trends in poisonings. A total of 41,139 calls were divided into 18 substance categories, each consisting of 3-11 subgroups. The number of enquires/year increased by 70% from 2007 to 2009. For all groups, except drugs of abuse, the data showed an increase in the actual number of exposures from 2008 to 2009. Pharmaceuticals represent 1/3 of substance exposures, and analgesics constitute a third of these poisonings. A relative increase in contacts concerning household substances, plants and vitamins was observed.

In order to determine the pattern and severity of poisoning cases, a hospital-based study was conducted by enrolling the patients admitted to hospitals in Nepal during one-year duration. Various parameters were analyzed and compared with other studies. There were 137 cases during the one-year duration. Most common manner of poisoning was suicidal and the incidence was mainly during evening hours. Organophosphorus compounds were the most commonly abused substances. Most of the cases had reported/brought to the hospital after one hour of exposure and duration of hospital stay in many cases was less than four days. These findings strongly suggest the necessity
of preventive measures like restriction on sale of the poisons, establishment of poison information centres, and educational or awareness programs.

Unintentional poisoning is a major public health problem in the United States. Published literature that presents epidemiology of all forms of poisoning mortalities (i.e., unintentional, suicide, homicide) together is limited. An important study was conducted recently to summarize the evidence on poisoning mortality according to demographic and geographic characteristics, which described the burden of poisoning mortality and the differences among sub-populations in the United States for a 5-year period. (295) Using mortality data from the Centre for Disease Control and Prevention’s Web-based Injury Statistics Query and Reporting System, age-specific and age-adjusted unintentional and intentional (suicide, homicide) poisoning mortality rates by sex, age, race, and state of residence for the most recent years (2003-2007) has been presented. (295) Annual percentage changes in deaths and rates were calculated, and linear regression using natural log were used for time-trend analysis. There were 121,367 (rate = 8.18 per 100,000) unintentional poisoning deaths. Overall, the unintentional poisoning mortality rate increased by 46.9%, from 6.7 per 100,000 in 2003 to 9.8 per 100,000 in 2007, with the highest mortality rate among those aged 40-59 (rate = 15.36), males (rate = 11.02) and whites (rate = 8.68). New Mexico (rate = 18.2) had the highest rate. Unintentional poisoning mortality rate increased significantly among both sexes, and all racial groups except blacks (p<0.05 time-related trend for rate). Among a total of 29,469 (rate = 1.97) suicidal poisoning deaths, the rate increased by 9.9%, from 1.9 per 100,000 in 2003 to 2.1 per 100,000 in 2007, with the highest rate among those aged 40-59 (rate = 3.92), males
(rate = 2.20) and whites (rate = 2.24). Nevada (rate = 3.9) had the highest rate. Mortality rate increased significantly among females and whites only (p<0.05 time-related trend for rate). There were 463 (rate = 0.03) homicidal poisoning deaths and the rate remained the same during 2003-2007. The highest rates were among those aged 0-19 (rate = 0.05), males (rate = 0.04) and blacks (rate = 0.06).(295) It is apparent from this study that prevention efforts for poisoning mortalities, especially unintentional poisoning, should be developed, implemented and strengthened. Differences exist in poisoning mortality by age, sex, location, and these findings underscore the urgency of addressing this public health burden as this epidemic continues to grow in the United States.

4.4.2. Indian Epidemiology

A significant number of drugs and chemicals are being developed in India. Unfortunately, there are no stringent rules and regulations for their dispensing and use. Pesticides are the commonest cause of poisoning.(6, 24, 64, 94) According to World Health Organization estimates, approximately 3 million pesticide poisonings occur annually worldwide, causing more than 220,000 deaths.(9, 11, 12, 26, 125) Developing countries like Sri Lanka and India report high rates of toxicity and death. India accounts for one-third of pesticide poisoning cases in the world and the worst affected are farmers.(49, 57, 58, 72, 73, 75, 77, 78, 100) The reason could be attributed to the increasing number of toxic chemicals and their large-scale use without proper testing of their toxic properties.(6, 49, 55, 57, 90, 92, 100) Banned products also continue to flow into the market. Household agents like cleaning products or medicines have further widened the spectrum of toxic products to which people may be exposed.(2, 65, 66, 115)
The scale of the problem is enormous due to increased incidence of morbidity and mortality. Improvement in the preventive and management program can be brought about by identification of poisoning pattern, high-risk circumstances, susceptible groups within the population, chemical substances and commercial products involved in poisoning cases in the community. In India, literature reports providing such information are scant.

Deliberate self-harm is a challenging Indian public health issue. In order to understand the deliberate self-harm behavior, numerous studies have been conducted in eastern parts of India. One-year prospective study was conducted at 13 block primary healthcare centres of the Sundarban region to obtain the socio-demographic profile and clinical outcome of suicidal behavior. A total of 1614 deliberate self-harm patients (619 men, 995 women) were admitted during the year, among them 143 patients (62 men, 81 women) died. Although women, especially in the younger age groups, constituted the majority of subjects (61.6%), the fatality trend was higher among men than among women (10% vs. 8.1%). Poisoning was the commonest (98.4%) method of self-harm, particularly using pesticide. Easy availability of pesticides was one of the risk factors. Psychosocial stressors, such as conflict with spouse, guardian or in-laws, failed love affairs and economic distress, were the common underlying reasons. The majority of acts of deliberate self-harm (92.6%) were committed inside the home, especially by women. Only a small proportion of subjects had a past or family history of attempt at deliberate self-harm. The overall incidence of fatal and non-fatal deliberate self-harm was 5.98 and 61.51 per 100,000 population, respectively.
In another study, authors examined the clinical records of 1277 patients admitted due to deliberate self-harm behavior from 1999 to 2001. (296) It was found that 77.7% of the patients survived their attempt, 11.9% died and for 10.4% the outcome was not recorded. Women accounted for 65.2% of the deliberate self-harm admissions and 67.1% of the deaths. Pesticides were the most commonly used agents (88.7%). The case fatality of self-harm reported in these hospitals ranged from 6.0% to 50.0%. The age group 55-64 years was at highest risk of death, the age group 15-24 years at lowest risk. Higher lethality of pesticide ingestion compared to other methods was suggestive but not significant. Case fatality within the region varied but was high compared to industrialized nations. Case records and management of deliberate self-harm were poor. (296) The results of these studies strongly suggest that better surveillance at clinical facilities and patient counseling program are required to reduce the deliberate self-harm incidences.

Accidental poisoning among pediatric population is a common and preventable cause of morbidity and mortality. Introduction of wide range of chemicals in the form of pesticides, household cleaners, and medicines into Indian market has increased the risk of children’s exposure to these chemicals. However, with help of proper studies and preventive measures, the poisoning among children can be reduced. Numerous studies have been conducted in Northern India to understand the trend of poisoning and potential causes. (71, 297)

A retrospective analysis of the poisoning calls received by the National Poisons Information Centre (NPIC) showed a total of 2,720 calls during a period of three years
Poisoning in children was reported in 995 calls (36.6%). The age ranged from less than 1 year to 18 years and the age groups involved were divided into four categories (0-6, >6-12, >12-16, >16-18 years). The most vulnerable age group included children from less than one year to 6 years old. Males outnumbered females (M = 628, F = 367). Although the accidental mode was the commonest (79.7%), intentional attempts were also noticed (20.2%) in the >12-16 years and >16-18 years age groups. In the majority of cases, the route was oral (96.8%) followed by dermal exposure (3.2%) comprising bites and stings. Various types of agents belonged to classes of household products (47.0%), drugs (21.8%), industrial chemicals (7.9%), agricultural pesticides (9.1%), bites and stings (3.2%), plants (1.5%), miscellaneous products (5.3%) and unknown products (4.0%). The incidence of poisoning was highest due to household products comprising mainly pyrethroids, thermometer mercury, rodenticides, phenyl, detergents and corrosives, etc. Poisoning due to drugs mainly included anticonvulsants, thyroid hormones, benzodiazepines, analgesics and oral contraceptives. Among the agricultural pesticides, aluminium phosphide was the most commonly consumed, followed by organochlorines and organophosphates, etc. Paint thinners were common among industrial chemicals. The results of other studies were consistent with findings of the study summarized above.(71, 298) The results of these studies indicate that a strong emphasis is required on prevention such as educating people on poisoning agents, safe storage and first aid.

Pesticides comprise a wide range of compounds including insecticides, herbicides, fungicides and others. About 1,000 active substances have been incorporated in
approximately 35,000 preparations of pesticides used in agriculture. (10, 24, 73) Pesticides are also used in other sectors for numerous purposes (Table 2). Organophosphate compounds (OPCs) are the most commonly used agents in agriculture and have been contributing significantly in accidental and suicidal poisoning.

Table 2. Usage of pesticides in India

<table>
<thead>
<tr>
<th>Sector</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>For control of pests, weeds, rodents, etc.</td>
</tr>
<tr>
<td>Public health</td>
<td>For control of malaria, filariasis, dengue, japanese encephalitis, cholera and louse-borne typhus</td>
</tr>
<tr>
<td>Industrial</td>
<td>Control of vegetation in forests and factory sites; fumigation of buildings and ships</td>
</tr>
<tr>
<td>Domestic</td>
<td>Household and garden spray; control of ecto-parasites in animals and birds</td>
</tr>
<tr>
<td>Personal</td>
<td>Application of clothing and skin; control of ecto-parasites (fleas, lice)</td>
</tr>
<tr>
<td>Material building</td>
<td>Incorporation of paints, timber, glues, plastic protection, sheeting, foundation of buildings, etc.</td>
</tr>
</tbody>
</table>

In India, the first report of poisoning due to pesticides was from Kerala in 1958, where over 100 people died after consuming wheat flour contaminated with parathion. (299) The chemical used was ethyl parathion known as Folidol E 605. (299) In Indore, out of the 35 cases of malathion (diazole) poisoning reported during 1967-1968, five died. (299) Numerous studies have been conducted to obtain the epidemiology of pesticides poisoning. (1-3, 6, 10, 24, 47, 49, 64, 65, 73, 77, 94, 95, 98, 100, 296)

One study was conducted to correlate the incidence of acute OP poisoning with the type of pesticides, its clinical characteristics and type of management provided with
subsequent outcomes in the patients. During the study period, 100 patients admitted in the emergency ward with acute OP poisoning were followed. The most predominant of the affected age groups was 21-30 years (60.5%). The most common reason for poisoning was attempted suicide (98%). The most common OP compounds exposed were methyl parathion and quinolophos. The most frequent clinical signs were salivation, miosis, fasciculations, respiratory system findings, tachycardia and hypertension. The total mortality rate of the study population was found to be 25%. Medical management mainly involved administration of pralidoxime and atropine along with supportive management. It was found that there was a correlation with type of compound, pre-hospitalization period and the type of management. These findings can be basis for preventing the mortality rate.

A retrospective hospital record-based study was conducted in a tertiary care hospital to obtain the patterns and outcome of poisoning cases. Incidence was more common among males (75.4%) compared to females (24.3). Most cases of acute poisoning presented among 20-29 years age group (31.2%), followed by 12-19 years age group (30.2%). A majority of poisoning cases (36.0%) were due to OPCs. Total mortality was found to be 15.4%. Mortality rate due to corrosives was significantly high compared to OPCs poisoning. Of the 56 patients of OPCs and carbamate poisoning, 13 patients (23.2%) had respiratory arrest and required respiratory support. Time lapse had a significant role on the mortality in cases of acute poisoning. It can be emphasized that poisoning was more common among young males and the overall mortality was
substantially high due to self-poisoning with insecticides and corrosives. Efforts are required to improve the quality of early care at tertiary care centres.

The frequency, distribution, and assessment of quality of management and subsequent outcomes from pesticide poisoning in Southern India was determined by a well-designed pilot study. Authors reviewed data on all patients admitted with pesticide poisoning to a district government hospital during 1997 to 2002. During these six years, 8040 patients were admitted to the hospital with pesticide poisoning. The overall case fatality ratio was 22.6%. More detailed data from 2002 reveals two thirds of the patients were less than 30 years old, 57% were male and 96% had intentionally poisoned themselves. Pesticides that were responsible for majority of deaths were monocrotophos and endosulfan. Low fixed dose regimens were used in the majority of cases for the most commonly used antidotes (atropine and pralidoxime). Inappropriate antidotes were also used in some patients. It is apparent from this study that better medical management and restrictions on the most toxic pesticides are required to reduce the incidence and mortality.

To further understand the patterns, social factors and the clinical outcomes of OP poisoning, another pilot study was conducted at hospital located in different region of South India. The study involved 148 cases of OP poisoning cases (female cases = 52.8%). A majority of cases came from urban areas (56.75%). A majority of poisoning cases were in the age group of 21 to 30 years (46.62%). The commonest motive was suicide (95.94%). The mean time interval for the hospital admission was 4.27 hours, with
a mean hospital stay of 5.17 days. Winter was commonest season for the poisoning, with 41 cases being observed in winter. The mortality rate was 4.72%. The factors such as easy availability of pesticides and personal reasons (e.g., inability to handle stress and problems) were attributed for poisoning incidences, indicating again that appropriate preventive measures are required to reduce the incidences.

Rural areas are more prone to accidental and intentional pesticide poisoning compared to urban areas. Studies were required to understand the poisoning trend in rural areas. A retrospective study was conducted to understand this trend. Acute poisoning was the leading cause of unnatural deaths and third common cause of emergency hospitalizations in this rural part of India. Of all fatal cases, 67% were males, 63% married, 83% with rural residence and 63.4% suicides. Responsible poison could not be ascertained in 16% of clinical and 9.9% of fatal cases. Insecticides were responsible for 35% of clinical and 55.4% of fatal cases. Young married males having rural background with agricultural occupation and failure of monsoon were some of the risk factors associated with poisoning cases.

Extensive literature survey conducted on Indian epidemiological studies demonstrated that the patterns of poisoning varies widely according to time, region, age group, sex, and socio-economic status. Multiple approaches are required to reduce mortality and morbidity associated with poisoning. Since different factors and poisoning agents contribute to the poisoning, region-specific studies and preventive measures are required to reduce the poisoning incidences and mortality. Banning or enforcing regulations on the
sale of pesticides and medicines would be one approach. However, it is difficult to predict long-term outcome. Long-term improvements may come from reducing the incidence of harmful behavior and appropriate medical management. It would be best to focus equally on treating and preventing the probable causes and recurrence for the acts of self-harm/intentional and accidental poisoning, and on changing people’s knowledge, beliefs, and attitudes about poisoning agent’s (mainly pesticides) use and storage practices and by increasing public awareness of the suicide risk associated with poisoning agent availability. Educating and encouraging farmers to use an integrated pest management approach may reduce the use of pesticides, thereby preventing the incidence of acute pesticide poisoning. Improved medical management approach has shown to reduce worldwide deaths in OP poisoning. By educating the public on proper storage and handling of poisonous substances, one can prevent accidental poisoning.

Depression and substance abuse are well-recognized risk factors in India contributing for suicide in both adults and adolescents. However, practice guidelines designed for specialists, such as child and adolescent psychiatrists, to assess and treat risk factors (e.g., depression) would not be practicable in developing countries. Ganju reported that there are about 1500 psychiatrists and 500 clinical psychologists in India,(91) where the population is over a billion. Promotion of training and education of qualified mental health professionals, including child and adolescent psychiatrists, is justified considering the size of the public-health problems that can lead to suicide.
4.4.3. Limitations of Epidemiological 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, data on the type of toxic agents that result in poisoning and death are limited.\(^{11, 141, 283}\) There is substantial under-recording and under-reporting of poisoning incidents due to several reasons.\(^{11, 141, 283}\) In addition, poisoning is not generally a notifiable condition, so few countries maintain records of poisonings. Even where surveillance systems exist, 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 diagnosed, the healthcare professional or caregiver may not recognize the toxic agent that is responsible.

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. 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.(13, 16, 32, 61, 70, 71, 104, 133, 134, 136, 145, 161, 168, 178, 185, 196, 219, 234, 246-249, 252, 285, 301-303)

Obtaining estimates of the numbers of poisonings resulting from pesticide and agrochemicals is extremely difficult since data collection in developing countries is inconsistent, and probably only the most severe poisonings are treated in hospital.(24, 26, 33, 178, 268, 304) Nevertheless populations suffering such exposures are likely to run into the millions worldwide.

Information from poison information centres may overestimate actual poisoning incidents, because many calls relate to patients who have been exposed, but not poisoned.(15, 17, 46, 60, 78, 81, 97, 142, 144, 149, 152, 154, 157, 158, 161, 179, 191, 216, 222, 232, 233, 239, 244, 250, 264, 277, 301, 305-308) These data should, therefore, be interpreted with caution.

4.5. Risk Factors

As with other injuries, the risk of general public being poisoned is affected by personal, poisoning agent and environmental factors. These factors are interrelated and are highly dependent on the context (Table 3). An understanding of these factors is important for the development of interventions to prevent and, where necessary, treat cases of poisoning.
4.5.1. Personal Factors

These are the human factors such as age, gender and socioeconomic status that may contribute to the incidence and severity of poisoning.

4.5.1.1. Age

Age has a strong association with poisoning as it determines the behavior, size and physiology of the individual, thus influencing types of exposure and outcome. (145, 168, 234, 248) For example, infants and small children tend to put their hands and small objects into their mouths more when compared to older children. As a result they are at increased risk of exposure to toxins or chemicals. 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 poisonous substances. (16, 32, 71, 104, 134, 145, 168, 178, 219, 234, 248, 301, 303) Young children are particularly susceptible to the unintentional ingestion of poisons, especially liquid ones. (16, 32, 61, 104, 136, 145, 178, 196, 234, 248, 249, 252, 298, 303)

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. Fatality rates in adolescents are higher than younger children when the poisoning is caused by alcohol misuse or the use of other recreational drugs. (70, 301) Young adults are vulnerable to suicidal behavior/attempt due to their inability to handle several problems including love failure, failure in education, and financial troubles.
Table 3. Risk factors for poisoning

<table>
<thead>
<tr>
<th></th>
<th>Personal</th>
<th>Poisoning Agent</th>
<th>Physical Environment</th>
<th>Socioeconomic Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-event</td>
<td>Age and developmental factors (e.g., curiosity, judgment); gender; parental supervision; health condition; other issues.</td>
<td>Ease of availability and opening package; attractiveness of substance; inadequate labeling; poor storage.</td>
<td>Cupboards within easy reach of children; absence of locking devices on cabinets; exposure to agents.</td>
<td>Lack of regulations and standards for toxic products and packaging; poverty; lack of awareness of toxicity and poisoning risks.</td>
</tr>
<tr>
<td>Event</td>
<td>Poor knowledge about ingestion; parent not noticing unusual behavior.</td>
<td>Toxicity of chemical; dose consumed; ease with which substance can be consumed.</td>
<td>Places where child or other individual can ingest substances without being seen.</td>
<td>Lack of awareness handling the crisis; lack of appropriate and timely decontamination by healthcare workers.</td>
</tr>
<tr>
<td>Post-event</td>
<td>Inability to communicate incident; lack of access to PIC.</td>
<td>Chemical agent without an antidote.</td>
<td>Lack of adequate pre-hospital care, acute care and rehabilitation.</td>
<td>No PICs or lack of information on how to contact centre; lack of access to emergency medical care.</td>
</tr>
</tbody>
</table>

4.5.1.2. Gender

Gender also played an important role in poisoning. For example, male population was found to be at consistently higher risk of poisoning than females.\(^{(61, 145, 309-312)}\) In contrast, some studies have shown no difference between male and female population. The discrepancy in these findings may be explained by gender differences in socialization between different countries. In some cultures, females are expected not to engage in outdoor activities or to adopt risk-taking behaviors.
4.5.1.3. Socioeconomic status

Socioeconomic status is strongly associated with injury and deaths from poisoning, not only between countries but also within countries. (21, 67, 133, 162, 163, 218, 274, 305, 313, 314) Studies from India and other developing countries show that the risk of dying due to poisoning from poor backgrounds is higher than the risk for wealthy people. (21, 67, 133, 162, 163, 218, 274, 305, 313-315) Therefore, socioeconomic status is the strongest risk factor in India for poisonings. In India, socioeconomic status is a strong predictor for household fuel consumption, itself linked to an increased exposure to paraffin or kerosene. At the same time, poverty drives children into work that is usually poorly paid but with high risk of injury. Poor people tend to live with inadequate sanitary facilities—for washing, sewerage, 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. The ability to withstand toxic effects depends upon other factors such other health problems and nutritional 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 critical and best healthcare.
4.5.2. Poisoning Agent Factors

There are two important factors from poisoning agent perspective factors that may contribute to incidence and severity of poisoning. These include: characteristics, storage and access of poisons.

4.5.2.1. Poison characteristics

The toxicity of chemicals varies considerably. The more concentrated or more potent the toxic agent, the greater the risk of severe morbidity and mortality. The nature of the substance also plays an important role in poisoning. Higher incidence of injury is often associated with liquid agents than solid compounds.(13, 16, 32, 61, 70, 71, 104, 133, 134, 136, 145, 161, 168, 178, 185, 196, 219, 234, 246-249, 252, 285, 297, 298, 301-303, 309-311, 315) 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. Unlike powdered preparations, liquid preparations usually do not produce a burning sensation, thereby influencing the quantity consumed.(56, 61, 309, 311, 312) 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, color and texture may attract or deter a child from handling and ingesting a substance. Studies have shown that liquids rather than solids, clear liquids rather than dark colored
ones, and small solids rather than large solids have more appeal to young children and are therefore more likely to be ingested by them. (316) Bright colors in solid medications may also make them more attractive to children.

4.5.2.2. 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 or other individual. Dispensing substances such as paraffin and medications in unlabeled or incorrectly labeled containers without child-resistant closures also increases the risk of poisoning. (317-319) Paraffin oil is frequently stored in bottles or other containers meant for cold drinks, milk or fruit juice, which children associate with beverages. (56, 61, 309, 311, 312, 320) In some places, tablets are poured into unsealed envelopes or ziplock bags, and liquids into non-distinctive, poorly labeled containers. Children may also drink from containers, such as cups, which have previously been used for refilling heating or lighting appliances. 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. (321)

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. (322) Some studies have found carelessness, overcrowding or limited space to be the cause of incorrect storage. (319, 320) 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. (321, 323) 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. (324) Even safe packaging cannot compensate for unsafe storage.

In developed countries, many products are required by law to be distributed in child-resistant packaging. (145, 168, 309-311, 317, 323) 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. (145, 168, 309-311, 317, 323)

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. (325)

4.5.3. Environmental Factors

Environmental factors can also influence the incidence and severity of poisoning. Such factors include: season and climate and socioeconomic environment.
4.5.3.1. 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.(311, 320) 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.(326)

4.5.3.2. Socioeconomic environment

Several case-control studies in low-income and middle-income countries have highlighted social and demographic risk factors in the poisoning. Some of these factors include the presence of young parents, residential mobility and limited adult supervision.(327-329) In case of children’s poisoning, incidence occurs despite the presence of parents or caregivers due to their involvement in other household duties or personal needs. Poor living conditions, local beliefs and customs and ignorance of the dangers of chemicals are other risk factors associated with acute poisoning.(319) Previous poisoning may also be a risk factor.(310)

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, labeling, distribution, storage and disposal of toxic
substances place people particularly 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. 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.

4.5.4. 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, in India many places do not have such a system in place.
The availability of health-care facilities and the ability to access such facilities rapidly affects the outcome of poisoning injuries. One would expect poisonings in more remote areas to have more serious outcomes due to poor health facilities and lower quality. Certainly, fatality rates in places with limited health-care facilities are higher than rates in more developed areas. Once a patient 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.

4.6. Interventions/Management and Preventive Approaches

Interventions or any management or preventive approaches are usually based on risk factors that are amenable to change and that are targeted at high-risk populations. In addition, specific need or regional limitations/factors are also considered when designing and using appropriate approaches. The approaches or interventions that have been found to be beneficial in the management of poisoning and minimizing poisoning incidences are discussed below.

4.6.1. Management of Poisoning

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

4.6.1.1. Acute management of poisoning

The general principles governing the management of all cases of acute poisoning are outlined in Table 4. Early and accurate diagnosis and management of
poisoning decrease the risk of morbidity and mortality. It is therefore vital that people seek help from a poison information centre or healthcare professionals. 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. Numerous analytical tests and procedures are available to determine the severity of poisoning.

Traditional diagnosis relies heavily on history of possible exposure and physical signs and symptoms consistent with exposure. However, the onset of symptoms may take some time to develop, by then the toxicity might become irreversible or even fatal.(332) In addition, subjective evaluation of clinical status by individual clinicians may differ in measurement of severity. Assessment of severity of poisoning requires adequate laboratory and instrumental facilities. For example, OPs concentrations and serum cholinesterase levels in plasma or urine needs to be determined to assess the severity and correlate with the mortality rate.(116) Unfortunately, these laboratory methods are not available in all the Indian healthcare centres. In such places, various descriptive and prognostic evaluation scales (scoring systems) can be used to predict the severity and mortality rates.(332) Scoring systems are simple, less time-consuming, and effective in an emergency situation, thereby allowing more intensive monitoring and treatment.
Table 4. Managing acute poisoning—the general principles.(36, 180, 312, 331)

<table>
<thead>
<tr>
<th>What to do?</th>
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<tr>
<td>1 Take/remove the person from the source of exposure and decontaminate as described below if the poison has been inhaled or absorbed through the skin or mucous membranes. Contaminated clothing, shoes and socks, and jewelry should be removed. If the toxins have been inhaled, the person should be removed to an environment of fresh air.</td>
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<td>2 Assess 1) what agent/agents and doses are involved, 2) the time since ingestion, c) current clinical status, and 4) other factors related to the person 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.</td>
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<td>3 Stabilize the patient. The general approach to acute poisoning involves giving priority to the airway, breathing and circulation—as for any emergency.</td>
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<tr>
<td>4 Decontaminate the patient as 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.</td>
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<td><strong>Topical decontamination.</strong> 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.</td>
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<td><strong>Activated charcoal</strong> 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.</td>
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<td><strong>Gastric emptying</strong> 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.</td>
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<td><strong>Catharsis</strong> 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.</td>
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<td><strong>Whole bowel irrigation</strong> 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.</td>
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<td><strong>Alkaline diuresis</strong> enhances elimination of some acidic substances. An example is bicarbonate administered to enhance the elimination of aspirin.</td>
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<td><strong>Dialysis</strong> including haemodialysis, peritoneal dialysis, haemofiltration and haemoperfusion—may be used in specific circumstances to clear certain water-soluble poisons from the circulation.</td>
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<td><strong>Antidotes.</strong> Envenomations should be treated with antivenom, most commonly for snake bite and scorpion stings, and also for some spiders’ bites. Atropine is used for carbamates; atropine and pralidoxime for organophosphorous pesticide poisoning; naloxone for opioids; acetyl-cysteine for paracetamol overdoses; and chelating agents for some heavy metals.</td>
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<td>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.</td>
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Glasgow coma scale (GCS), poisoning severity score (PSS), acute physiology and chronic health evaluation (APACHE) II score, and simplified acute physiology score (SAPS) II have been used to predict the severity and mortality in poisonings. GCS is a widely accepted prediction model and commonly employed in emergency services for the assessment of the consciousness of patients. PSS measures the severity of the illness after the acute poisoning. APACHE II and SAPS II are relatively advanced scoring systems and used to evaluate the general condition of patients during the first 24 hours. The suitability and effectiveness of these scoring systems have been evaluated both in India and other countries. The summary of key studies related to this aspect is given below.

Deshpande et al. assessed the applicability of the GCS and the QT interval (QTc) to predict the outcome of OP poisoning. QTc and GCS were monitored for each patient upon admission. Patients with respiratory failure were compared with patients without these complications, and mortality was compared between groups. It was found that the group with complications had a significantly longer QTc and a lower GCS score, a higher number of intubations, and worse outcomes. GCS score and QTc were shown to be equally effective in predicting respiratory failure and hospital mortality in patients with OP poisoning.

A prospective descriptive survey was carried out to assess the effectiveness of severity scales in predicting the outcome of OP and carbamate poisoning. The GCS scores, APACHE II scores, predicted mortality rate (PMR) and PSS were estimated
within 24 hours of admission. The clinical characteristics, severity and outcome following hospitalization were assessed. The clinical indices, GCS, APACHE II score, and PMR significantly correlated with PSS scores thereby indicating their usefulness to predict severity. The mean hospitalization period and outcome of poisoning were significantly influenced by the PSS scores but not by the APACHE II or GCS scores. The findings of this study highlights the usefulness of few clinical indices like GCS, APACHE II, PMR and poisoning severity scoring systems for predicting severity which in turn can be used to predict outcome of poisoning in patients especially during triage. Identification of severity at an early stage followed by prompt treatment can prevent the late respiratory and cardiac failures associated with OP poisoning.

In Turkey, the effectiveness of the PSS, GCS, and QTc interval in predicting outcomes in acute OP poisoning was evaluated. Over a period of 2 years, 62 patients with OP poisoning were admitted to emergency department. GCS and PSS were calculated for each patient. Twenty-six patients had a prolonged QTc interval. Mean PSS of men and women was 1.8 ± 1.0. No statistically significant correlation was found between the PSS and QTc intervals of the cases. A significant correlation was determined between the GCS and PSS of grade 3 and grade 4 cases. However, electrocardiogram (ECG) findings, such as prolonged QTc interval, were ineffective in determination of short-term prognosis and showed poor correlation with PSS.

A similar multi centre cohort study was conducted in Sri Lanka to find out the usefulness of the PSS and GCS prospectively for predicting death in patients poisoned by
OP pesticides. Receiver operating characteristic (ROC) curves were calculated for the PSS and GCS on admission. The PSS and GCS had similar ROC area under the curves (AUC) and best cut points as determined by Youden’s index (AUC/sensitivity/specificity 0.81/0.78/0.79 for PSS ≥ grade 2 and 0.84/0.79/0.79 for GCS ≤13). The predictive value varied with the pesticide ingested, being more accurate for dimethoate poisoning and less accurate for fenthion poisoning (GCS AUC 0.91 compared with 0.69). These findings indicate that GCS and the PSS were similarly effective at predicting outcome. However, the identity of the organophosphate must be taken into account, since the half of all patients who died from fenthion poisoning only had mild symptoms at presentation.

Snake bite is an important preventable health hazard. Patients with snake envenomation present as emergencies with significant morbidity and mortality. In India, it is estimated that up to 20,000 people die annually from snake bites. Morbidity is also significant and there seems to have been little improvement in reducing the fatalities over the years in spite of now having good supplies of polyvalent anti snake venom (ASV) available in all population centres. The major reason for high mortality rate (about 5% to 10% of all those reporting bites) is the delay in getting the victim to a well equipped casualty treatment facility fast enough.

The severity of envenomation was assessed using the modified snake bite severity score (SSS). The severity grading was determined by the most severe symptom(s) or signs(s) observed. The severity was graded from 0 to 4 ranging from no envenomation...
to severe life threatening symptoms and death taking into consideration clinical signs/symptoms and/or laboratory data. The four levels represent as follows; grade 0 for no symptoms or signs, grade 1 for mild, transient and spontaneously resolving symptoms or signs, grade 2 for moderate, pronounced or prolonged symptoms or signs, grade 3 for severe or life threatening symptoms or signs, while grade 4 represents extremely severe envenomation leading to mortality. The factors that affect SSS like pre hospitalization period, demographical variables, type of snake bite and the outcome were evaluated. The mortality rate was 10.7% while 78.9% of patients improved with 8.2±8.3 day hospitalization period. Severity scores, complications and outcomes were significantly associated with type of snakes, age distribution and linearly correlated to the time elapsed between snake bite instance and hospitalization.(336) It is apparent that mortality and morbidity can be minimized by the early interventions following identification of snakes, associated signs, symptoms and severity.

Another study was conducted to validate the effectiveness of SSS by determining the correlation of the SSS with the clinical assessment of physicians experienced in the management of crotalid snake bite.(337) The correlation of the SSS and the physicians' consensus was determined with pointbiserial correlation. The SSS correlated well with the physicians' consensus at presentation and at the point at which the patient's condition was worst. The SSS also correlated highly with the physicians' assessment of change in the patient's condition.(337) Therefore, SSS provides a more objective instrument for the evaluation of severity and progression of envenomation in patients with crotalid snake bite.
Mixed drugs poisoning (MDP) is common in the emergency departments. Recognition of risk factors to divide the patients into different survival groups is necessary. Poisoning due to ingestion of different medications may have additive or antagonistic effects on different parameters included in the scoring systems. Therefore, studies have been conducted to compare applicability of the different scoring systems in prediction of outcome of patients admitted with MDP. (338, 339) Clinical and laboratory data conforming to the APACHE II, Modified APACHE II Score (MAS), Mainz Emergency Evaluation Scores (MEES) and GCS were recorded for all patients on admission (time-0) and 24 hours later (time-24). The outcome was recorded in two categories: survived with or without complication and not-survived. Discrimination was evaluated using receiver operating characteristic (ROC) curves and area under the ROC curve (AUC). Mean of each scoring system was statistically significant between time-0 and time-24 hours in the survivors. However, it was not significant in non-survivors. Discrimination was excellent for GCS-24, APACHE II-24, MAS-24 and APACHE II-0. (338, 339) Therefore, the GCS-24, APACHE II-24, MAS-24 and APACHE II-0 scoring systems were shown to predict the outcome in comatose patients due to MDP more accurately. GCS and Modified APACHE II Score may have superiority over the others because those are easy to perform and does not require laboratory data.

4.6.1.2. Poison information/control centres

Poison information centres (PICs) provide critical information and advice to general public and healthcare professionals. (65, 66) PICs advise first aid where appropriate, and refer more severe poisonings to a healthcare facility. PICs were initially set up in high-
income countries and have since been established in many middle-income and low-income countries. 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. 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. (65, 66)

Considering the magnitude of poisoning-related deaths in India, PICs are essential to provide the critical service and advise for both general public and healthcare professionals. The management of acute poisoning cases is difficult for physicians working in emergency departments due to lack of sufficient information related to poisoning agents and optimal treatments. (13, 17, 65, 66, 179, 340) This deficiency can influence the mortality rate and morbidity. In India, only four WHO-recognized centres are available for the poison information services. The first National Poison Information Centre was established in December 1994 at the All India Institute of Medical Sciences (AIIMS), New Delhi. The other centres were subsequently established at the National Institute of Occupational Health, Ahmedabad, Government General Hospital, Chennai and Amrita Institute of Medical Sciences and Research, Cochin. (17, 65, 66)

The ultimate motive of PIC is to prevent poisoning deaths due to accidental, intentional ingestion of poison in general public. (65, 66) Poison information centre aims
to assist general public and healthcare professionals with poison prevention and management (identification/assessing/availability of antidote and management) by providing immediate, up-to-date and relevant information about poisoning management.(17, 65, 66, 179, 217, 244, 245, 254, 340) Poison information centre conducts educational programs to healthcare professionals and public highlighting the services of poison information centre especially the identification of poisoning substance, first aid measures, management and prevention of poisoning cases. It can involve in developing strategy and responding to chemical disasters in association with other responsible organizations. The roles of PIC are given in Table 5.(17, 65, 66, 179, 217, 244, 245, 254, 340) There are benefits to the public and healthcare professionals by the services provided by the PIC. It ensures the healthcare benefits by reducing morbidity and mortality from poisoning and cost effective benefit by avoiding unnecessary visits to hospital in mild or less severe poisonings.

Table 5. Roles and functions of poison information centre

<table>
<thead>
<tr>
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<th>Provision of poison information services</th>
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<tr>
<td>2</td>
<td>Development of treatment protocols for poison management</td>
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<tr>
<td>3</td>
<td>Management of poisoning cases</td>
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<td>4</td>
<td>Toxicological analytical services</td>
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<tr>
<td>5</td>
<td>Toxicovigilance</td>
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<tr>
<td>6</td>
<td>Conducting education and awareness program for public regarding prevention of accidental poisoning</td>
</tr>
<tr>
<td>7</td>
<td>Conducting education and training of healthcare professionals</td>
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Several studies that have been conducted in India demonstrated the significance of PICs, PISs or analytical toxicology services of PICs. The summary of key studies on each of those aspects is given below.
Pillay et al. reported that of the biological samples analyzed for chemicals, drugs and toxins, the commonest toxicants were pesticides, pharmaceuticals, heavy metals and alcohols. Of the pesticides, organophosphates accounted for the maximum number, while most of the remaining comprised zinc phosphide, carbamates, pyrethroids, paraquat, phosphorus, and bromadiolone. This study showed the significance of analytical toxicology services, wherein it was helpful to determine the actual concentrations of poisoning agents in the blood. Based on the actual concentrations, a better management of poisoning can be envisaged.(341)

The quality of poison information services may influence the outcome of poisoning and associated treatment cost. It is important to ensure excellent quality service at all time. Continuous evaluation of the information services is essential to upgrade the quality of the poison information services provided. A retrospective study was conducted to evaluate the quality of all the poison information documented over a period of four years.(102) The quality of service was assessed according to DSE/WHO seminar guidelines. The quality of service was graded poor to excellent based on the scores (obtained from 100 point rating scale). The outcome of the service was evaluated by comparing the mortality rate for the cases in which the poison information service was provided, with the cases in which the Poison Information Centre was not consulted. Of the 210 poison information queries answered, 80% of queries were rated as excellent. The mortality rate was reduced in cases where the Poison Information Centre was consulted (0.9%) and it was lower compared to that of the cases where the Centre was not
consulted (12%)(102) This finding demonstrated the potential benefit of PICs in reducing the mortality rate.

Despite the impact that regional poison control centres have on reducing morbidity and mortality associated with poison exposures, PICs are facing a serious financial crisis today resulting in an increased emphasis on their economic justification. Using decision-analysis techniques, the cost-effectiveness of the treatment of poison exposures with the services of a regional poison control centre compared with treatment without access to any poison control centre has been evaluated.(342) The relative cost-effectiveness was modeled based on 2 outcomes (morbidity and mortality) for each of 4 typical poison exposures. Additionally, analyses were conducted to test the sensitivity of the cost-effectiveness ratios to outcome probability, average inpatient and emergency department costs, and proportion of poison exposures treated on site by the regional poison control centre. A societal perspective was adopted. The regional poison control centre was found to be substantially more cost-effective than the treatment of poison exposures without the services of a regional poison control centre for both outcomes (morbidity and mortality) in each of the poison exposures considered. The results of the sensitivity analyses demonstrated that the outcomes of the decision analyses do not change regardless of the type of poison exposure, outcome considered, clinical outcome probabilities, average inpatient and emergency department costs, and proportion of poison-exposure cases treated on site by a regional poison control centre.(342) The significant cost savings to society are realized for each additional successful outcome obtained with a regional poison control centre.
The impact of poison control centres on poisoning-related visits to emergency departments located in United States and associated cost was studied by Zaloshnja et al.(144) Using a log-normal regression model, the association between the number of human exposure calls per hospitalized poisoning patient and the number of non-hospitalized emergency department visits was assessed. A 1% higher poison control centre human exposure call rate for unintentional poisoning is associated, but not necessarily causally, with a 0.18% lower emergency department visit rate. If the observed association is causative, 15.5 PCC human poison exposure calls prevent one non admitted emergency department (ED) visit, yielding a $205 net cost saving and a benefit-cost ratio of 1.4. The savings ignore any reduction in hospital admissions. Increased PCC exposure calls appeared to reduce emergency department use for unintentional poisoning and net medical spending.(144)

The impact of PIC service on the length of hospitalization also has been studied. The aim was to investigate differences in length of hospital stay among poisoned patients, between those who received remote assistance from a poison control centre and those who did not.(191) One hundred and ninety-eight patients were included. Those who received remote assistance from a poison control centre stayed in hospital on an average for 3.43 days less than those without poison control centre assistance. There was no statistical difference in severity between the patients with and without poison control centre assistance. Patients with remote assistance from a poison control centre had a shorter length of stay than patients without this aid.(191) The poison control centre may have reduced the length of stay of the poisoned patients.
Another study that assessed the potential impact of poison control centres on hospitalization rates in rural areas reported that, a 1% higher poison control centre human poison exposure call rate was associated with a 0.19% lower hospitalization rate among people who visited emergency departments because of poisoning.(343) If the observed association is causative, then 43.3 calls would prevent 1 hospital admission, yielding $7321 in net cost savings and a return on investment of 5.9:1 (from the healthcare system perspective). These results demonstrate again the beneficial nature of PICs in rural areas.

A study that reviewed nine papers on economic evaluation of poison centres (PCs) comparing presence of PCs with a scenario of their absence reported that the cost-benefit ratios ranged from 0.76 to 7.67, which indicates that each United States Dollar (USD) spent on poison centres can save almost 8 USD on medical spending. A cost-effectiveness analysis showed that each successful outcome achieved by a PC avoids a minimum of 12,000 USD to 56,000 USD in other healthcare spending. It was apparent that PCs are economically viable and improve the efficiency of healthcare expenditure and contribute to the sustainability of the healthcare system. An investment in PCs is a rational public health policy approach that contrasts the current trend of reducing spending on PCs. (340)

The development of PICs has in general complied with the actual needs and conditions in the society, and a pragmatic approach and limited funds have been characteristic for these units. Successful operation of PIC demands (i) a well educated and specially trained staff and (ii) reliable, updated and easily manageable information.
resources. Once a poison information centre has started to operate, it must more or less instantly launch a process to develop and continuously check the standards and the quality of the service. The European Association of Poisons Centres and Clinical Toxicologists (EAPCCT) has for this purpose developed a self-assessment checklist, addressing and defining minimum and optimum standards to be considered when running a poison information centre.(344) Items covered are poison centre operations, direction and management, education and training of staff, location of poison centres, information sources, documentation of enquiries/cases, funding, publications and quality control.

4.6.2. Educational Approaches

Education on how to prevent poisoning has been shown to be a useful component of prevention programs.(87, 345, 346) Education on poisoning should aim to: a) raise awareness, b) increase knowledge and skills on poison prevention, c) change attitudes and behaviors, d) influence policy and legislation, and f) create good practices within organizations. Educational interventions should be used in combination with other interventions seeking to prevent poisoning.(73, 74, 87, 126, 168, 323, 345, 346) For example, continuous direct supervision of children (always within eyesight) along with educational program. 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. Improvement of public awareness and general education campaigns in reducing the incidence of poisoning cases is also critical.(168, 309, 323)
It has been suggested that messages used in educational programs directed at general public may be more effective if they address the factors influencing the poisoning. Further, home visits by healthcare professionals to reinforce the messages of the educational programs have been shown to be effective. The educational programs for the prevention of poisoning in children should include a narrower and more specific aim. Such programs may include: a) point-of-sale warnings from pharmacists on the possible dangers of the medication being dispensed; b) public awareness campaigns that “child-resistant does not mean child-proof”; c) messages to parents and caregivers reminding them to test child-resistant closures and to ensure that these closures have been properly re-engaged; and d) 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. The potential benefit of different educational programs in reducing the poisoning incidences has been investigated both in India and other countries. The summary of some of the studies, that provided the benefit of educational programs is given below.

The effect integrated pest management (IPM) educating program in reducing the poisoning among farmers has been investigated in in South India. Exposure to organophosphates is considered as a serious risk factor for occupational poisoning. The
adoption of IPM reduced the use of pesticides and halved the incidence of acute pesticide poisoning. Overall, the pesticide use spectrum shifted towards lower WHO Hazard Classes. A reduction of adverse health effects was attained through a reduction in exposure to toxic pesticides and behavioral changes. Given that other strategies to reduce the rate of acute poisoning have proven ineffective, interventions aiming to minimize pesticide poisoning in India and in other developing countries with similar rural conditions should focus on restricting the use of highly toxic compounds and educating farmers on IPM.

Occupational poisoning with pesticides is common in India because farmers are often under trained, illiterate and consider it impractical and expensive to use safety equipment, especially in tropical climates. Greater benefit of education programs on prevention can be obtained if initiated in areas having higher occurrence of poisoning. To test this hypothesis, one study evaluated occurrence of poisoning and effectiveness of educational interventions among pesticide handlers in areas having high occurrence of occupational poisoning. The impact of educational program was assessed using a knowledge attitude and practice (KAP) questionnaire. Education was provided using a structured individualized training program to pesticide handlers. Three point KAP assessments were carried out at baseline, immediately after training and after 1 month of training. Nonparametric Kruskal-Wallis tests and Friedmann tests were used to compare scores at different time intervals and between groups. Occurrence of occupation related poisoning was 33%. The average baseline KAP score of 30.88 ± 10.33 improved after education significantly ($P<0.001$) at first follow-up 45.03 ± 9.16 and at second follow-up 42.9 ±
9.54. A decline of score between the first and second follow-up was attributed to decline in knowledge retention, indicating the necessity of continued education. Demographics like gender, literacy and presence of children affected KAP score and there was no influence of geography, age or frequency of pesticide use.(346)

Intensive survey involving 1039 farmers belonging to 28 districts in 12 Indian states was carried out in regions where pesticide use was predominant to study the influence of awareness, education and practices related to pesticide use as well as IPM measures among farmers.(345) Data were collected through pre-tested schedules by trained field investigators and the data were analyzed by suitable statistical package. The results revealed that though overall consumption of pesticide decreased, the expenditure incurred on pesticides remained high. Most of the respondents in the surveyed area followed their own spraying schedules and pesticide doses to manage constantly increasing insect pests and disease problems. More than 50% of the respondents applied both single and cocktail pesticides to manage their crop pests. Greater number of the literate farmers had strong perception on the negative impacts of pesticides on soil, water, air and beneficial organisms. Only 20% of the respondents obtained their information on plant protection aspect from the agricultural extension officer and the rest of 80% of the farmers used unreliable information in crop production of surveyed areas. The respondents in the study regions were of the opinion that chemical methods of pest control are very effective in combating serious pest infestation. In the study area, it was observed that only 3% of the respondents followed organic farming successfully. The total area under organic farming in India is negligible. There is a tremendous scope for agricultural extension activity
through which stewardship can be achieved in these pesticide predominant regions. Nevertheless, costs on constantly increasing safety measures for pesticide applicators would be an additional burden which is to be considered seriously under resource poor small and medium holding systems in India.

Promoting general public on safe storage of pesticides is also a potential educational means to reduce the pesticides poisoning. A study was conducted in rural Sri Lanka to determine community perceptions and use of in-house safe storage boxes for pesticides. Boxes with a lock, to be used for the in-house safe storage of pesticides, were distributed to randomly selected farming households in two agricultural communities. A baseline survey determined pesticide storage practices and household characteristics prior to distribution. The selected households were encouraged to make use of the box at community meetings and during a single visit to each household one-month after distribution. No further encouragement was offered. A follow-up survey assessed storage practices seven months into the project. Following the distribution of the boxes the community identified a number of benefits including the protection of pesticide containers against exposure from the rain and sun and a reduced risk of theft. As expected, the distribution of boxes significantly reduced the number of households storing pesticides in the field, from 79 (46%) at baseline to 4 (2%) at follow-up. There was a significant increase in the number of households keeping pesticides safe from children between baseline (64%) and seven months after the distribution of boxes (89%). The same was true for adults although less pronounced with 51% at baseline and 66% at
follow-up. The farming community appreciated the storage boxes and made storage of pesticides safer, especially for children.(349)

4.6.3. Engineering Measures

With the help of some engineering measures (e.g., reduction of toxicity, safer packaging and storage, and reducing agent attractiveness), incidences of poisoning can be reduced. However, these measures require support from other organizations or departments to achieve the common social benefit.

4.6.3.1. 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.(350) Previously, concentrated vinegar was easily available, and had been responsible for several poisoning deaths.(350) Another example of lowering toxicity is the reformulation of methylated spirits as principally ethyl alcohol, rather than the more toxic methanol.(41, 42, 73-75, 126, 168, 214, 220, 221, 257, 309, 322, 323, 347, 348)

In a similar way, less toxic pesticides may be used to prevent cases of acute pesticide poisoning. 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 will also lead to a fall in the number of cases of acute pesticide poisoning. To operate such systems, though, requires scientific expertise. (351)

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. (352) 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.

4.6.3.2. Safer packaging and storage

The success in reducing unintentional poisoning through safer packaging and storage over the past three decades has relied on: a) education of general public—about the risks and how to protect against them; and b) 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. (168, 324, 353, 354)

In India and South Africa, paraffin oil is used as a source of energy for cooking and is frequently stored in bottles previously used for storing beverages. (168, 324) A successful program to tackle this dangerous practice involved the free distribution of containers with
child-resistant closures. 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. (321)

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. (36, 112, 127, 152) 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. (36, 112, 127, 152)

Child-resistant packaging is one of the best-documented successes in preventing the unintentional poisoning of children. (145, 168, 323, 348) 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. (330) 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. (353, 354) 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 or any individual with self-harm intention cannot overcome barriers of locks or height. Although children or a person with self-harm intention will devise complex strategies to get hold of medicines or pesticides, doing so takes time. The main reason, therefore, for storing poisons out of reach is that this is a delaying strategy—as indeed is child-resistant packaging.(324, 345, 354)

Child-resistant packaging has been proved effective for medications, fuels, household chemicals and pesticides.(324, 354) 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.(13, 90, 133, 136, 328) Child-resistant packaging should be used on all drugs sold over the counter, to help prevent children consuming these potentially lethal products.(13, 90, 133, 136, 328)

4.6.3.3. Reducing an agent’s attractiveness

A study has shown that the appropriate design of packaging can be an effective means of reducing the attractiveness for children of harmful substances.(355) Other studies on the ingestion by children of paraffin, have recommended that containers be made of darkened material in which the contents are invisible.(311) 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-colored container. Another suggestion is to modify the taste and color of paraffin as well as modifying the
containers in which it is stored. In Australia, changing the color of paraffin to blue led to a decrease in the incidence of paraffin ingestion. 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. Labeling containers with warning stickers showed no deterrent effect on children at risk aged under 6 years. 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.

4.6.4. Environmental Measures

Studies have shown 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. Reducing children’s access to poisons in the home can be achieved in a number of ways.

4.6.4.1. 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. For examples, numerous highly toxic substances have been largely replaced in many places by less toxic substances having a similar intended effect. These include: benzodiazepines in place of barbiturates (a class of sedative-hypnotic drugs); chlorocresol in place of cresol (a preservative); paracetamol in place of aspirin; non-steroidal anti-inflammatory drugs in place of toxic anti-inflammatory drugs.

Sometimes the change from highly 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.

4.6.5. Laws and Regulations

A comprehensive strategy to prevent poisoning must include laws supported by enforcement. More stringent laws and regulations should be implemented on sale and use of poisonous substances including pesticides, medicines and packaging of poisonous substances. 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. 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.

4.6.5.1. Child-resistant packaging

Standards and policies for child-resistant packaging currently exist only in a handful of high-income countries, such as Australia, Canada, New Zealand, the United States and the European Union. (324, 354, 355) 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 1970, the United States introduced child-resistant packaging in its Poisons Prevention Packaging Act. (324, 354, 355) 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. (324, 355) 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. (355) The European Union has laws mandating the storage of toxic substances in child-resistant containers that are: a) clearly and appropriately labeled; b) in places that are not within reach of children or near to foodstuff; c) labeled 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. (324, 345, 354, 355)

4.6.5.2. 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 had led to some reduction in child poisoning. (359) 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. (360) 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.

In summary, the extensive literature survey performed above signifies few important aspects. These include a) need for Regional Poison Information Centre, b) programs to
create awareness about management of crisis and preventive measures among general public and healthcare professionals, and c) analytical toxicology services for the better management of poisoning. It was also clear that the PICs require support from general public, healthcare professionals, government organizations, and other social welfare organizations to achieve the above mentioned common goals.