Acute pesticide poisoning: a proposed classification tool

Josef G Thundiyil,[a] Judy Stober,[b] Nida Besbelli[c] & Jenny Pronczuk[d]

Abstract Cases of acute pesticide poisoning (APP) account for significant morbidity and mortality worldwide. Developing countries are particularly susceptible due to poorer regulation, lack of surveillance systems, less enforcement, lack of training and inadequate access to information systems. Previous research has demonstrated wide variability in incidence rates for APP. This is possibly due to inconsistent reporting methodology and exclusion of occupational and non-intentional poisonings. The purpose of this document is to create a standard case definition to facilitate the identification and diagnosis of all causes of APP, especially at the field level, rural clinics and primary health-care systems. This document is a synthesis of existing literature and case definitions that have been previously proposed by other authors around the world. It provides a standardized case definition and classification scheme for APP into categories of probable, possible and unlikely/unknown cases. Its use is intended to be applicable worldwide to contribute to identification of the scope of existing problems and thus promote action for improved management and prevention. By enabling a field diagnosis for APP, this standardized case definition may facilitate immediate medical management of pesticide poisoning and aid in estimating its incidence.

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Une traduction en français de ce résumé figure à la fin de l'article. *Al final del artículo se facilita una traducción al español.* الترجمة العربية لهذه الخلاصة في نهاية النص الكامل لهذه المقالة.

Background

Cases of acute pesticide poisoning (APP) account for significant morbidity and mortality worldwide, especially in developing countries.[1,2] There are no reliable estimates as to how many people per year suffer from pesticide-related health effects. This is due to several reasons including a lack of standardized case definition. The purpose of this document is to create a standard case definition to facilitate the identification and diagnosis of APP, especially at the field level, in rural clinics and primary health-care systems. The case definition is inclusive of all circumstances of poisoning including suicide, homicide, non-intentional (accidental exposure) and occupational.

Studies in developed countries have demonstrated the annual incidence rates of APP in agricultural workers to be as much as 18.2 per 100 000 full time workers[3] and 7.4 per million among schoolchildren.[4] Yet, cases of APP may be the result of various causes in different regions of the world. In developing countries, where there is insufficient regulation, lack of surveillance systems, less enforcement, lack of training, inadequate access to information systems, poorly maintained or nonexistent personal protective equipment, and larger agriculturally-based populations, the incidences are expected to be higher.[5] The use of pesticides banned in industrialized countries, in particular, highly toxic pesticides as classified by WHO,[6] obsolete stockpiles and improper storage techniques may provide unique risks in the developing world.[7,8] In some countries, such as China and Sri Lanka,[9] self-poisoning with pesticides is a particular problem. Studies from Sri Lanka regarding self poisoning reveal an APP incidence rate of approximately 180 per 100 000.[10]

Studies from developing areas in Central America (El Salvador and Nicaragua) have indicated an overall incidence rate of 35 per 100 000 for APP in the general population[11] and 17.8 per 100 000 occupationally-related APP in Thailand.[12] In Belize, it has been estimated that 17 pesticide poisonings per 100 000 residents and 4142 preventable poisonings occur each year.[13] Previous research has demonstrated that reported occupational and non-intentional causes vary from 10% to 50% in developing countries.[14] The reason for this variation is unclear, but is likely contributed to by inconsistent recording methodology and lack of a standard case definition for an APP.[14] These variations may result in an underestimation of the true incidence of APP.

Since occupational and non-intentional pesticide poisoning require a specific set of prevention and control measures separate from those required for suicidal exposures, it is important to accurately determine the magnitude of the problem through better estimates and identification of cases and deaths resulting from APP. Several challenges

[a] Department of Emergency Medicine, Orlando Regional Medical Center, Orlando, FL, United States of America.
[b] Intergovernmental Forum on Chemical Safety (IFCS), World Health Organization, Geneva, Switzerland.
[c] European Centre for Environment and Health, WHO, Bonn, Germany.
[d] WHO, Geneva, Switzerland.
Correspondence to Josef G Thundiyil (e-mail: joseft@mindspring.com).
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exist in attempting to determine the scope of the problem: misdiagnosis by health-care providers, lack of readily accessible health care in rural populations, exclusion of non-hospitalized cases, resigned acceptance by workers that adverse health effects are expected,[15] and the fact that less severe cases of APP may not seek health care. Additionally, suicidal ingestions of pesticides account for the most severe cases of poisoning and consequently hospital-based studies may underestimate the overall (occupational/non-intentional) incidence of APP.[16] Further, many developing countries lack the resources to establish and maintain the necessary surveillance programmes and to obtain confirmatory laboratory testing for all possible cases of APP; therefore, the ability to identify a poisoning may differ between developing and developed countries. A standardized case definition will provide a practical tool for more accurately estimating the incidence of acute pesticide poisoning and identifying where problems exist to stimulate better management and control actions.

Methods

The work was conducted at the Intergovernmental Forum on Chemical Safety (IFCS) which is hosted by the WHO. The IFCS is a mechanism for cooperation among governments, intergovernmental organizations and non-governmental organizations for promotion of chemical risk assessment and the environmentally sound management of chemicals. An extensive worldwide literature review was conducted to obtain all relevant materials regarding pesticide-poisoning surveillance, pesticide intoxication, pesticide-related exposures, definition of pesticide poisoning, and determination of incidence and prevalence of pesticide poisoning. The WHO Pesticide Project Surveillance Working Group (2001–2003)[17] definition was used as a starting point. Additionally, all previous attempts to create a standardized definition of pesticide poisoning were obtained including those from the Environmental Protection Agency of the United States of America, the Pan American Health Organization, the Thai Food and Drug Administration, and the United States National Institute of Occupational Safety and Health.

These definitions were integrated into a single matrix definition which can be used across varying demographics, economies and settings. This initial definition matrix was sent to over thirty worldwide experts in the field of pesticide poisoning, pesticide surveillance, and members of industry on six different continents. The feedback was incorporated and the revised definition matrix was presented for further input to a workshop of health professionals from developing countries at the International Conference on Pesticide Use in Developing Countries in Arusha, United Republic of Tanzania, in October 2006. The case definition matrix presented here is the culmination of the review process.

Challenges

Classification strategies for APP must take into account the level of certainty of exposure, diversity of health effects, and plausibility that there is a causal link. Although, laboratory, biologic or environmental sampling may provide high specificity in detection of APP cases, sole reliance on these methods will result in a large proportion of missed cases. Further, while inpatient hospital records, suicide registries, forensic evidence and personal interviews may provide the strongest support for causation, these modes are too narrow and fail to provide adequate surveillance. Conversely, a case definition which is too broad may lack specificity and overestimate the true incidence of APP.

Due to the wide range of pesticides and their toxicities, clinical presentations can vary significantly. Additionally, it can be difficult to determine whether nonspecific symptoms are actually due to the pesticide exposure or other common environmental factors such as heat illness. Pesticides are defined as any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest.[8] Examples include herbicides, insecticides, rodenticides, fungicides, fumigants and wood treatment products. Pesticide exposure can occur via ingestion, inhalation, dermal absorption or ocular contact. It is important to identify whether signs and symptoms of pesticide poisoning are due to the active ingredient (the pesticide itself), inactive ingredients, solvents or additives which may vary by region, country, manufacturer or individual preference. Table 1 (available at: http://www.who.int/bulletin/volumes/86/07/041814/en/index.html) gives examples of pesticide classes and clinical presentations of possible adverse health effects resulting from unsafe exposure. The severity and likelihood of effects from APP can vary according to specific agent, dose, underlying physiologic reserve, comorbidities, route of exposure, organ system, age, poverty,[18,19] education[20] and other factors. Table 2 (available at: http://www.who.int/bulletin/volumes/86/07/041814/en/index.html) provides a guideline for assessing severity of APP signs and symptoms.

Case definition matrix for APP

An acute pesticide poisoning is any illness or health effect resulting from suspected or confirmed exposure to a pesticide within 48 hours. Warfarins, superwarfarins and coumarins are an exception to this rule as the onset of laboratory findings or symptoms may be delayed greater than 48 hours. This includes APP resulting from suicide, homicide, occupational and non-intentional exposures. Health effects may be local (dermal and ocular) and/or systemic. This includes respiratory, neurotoxic, cardiovascular, endocrine, gastrointestinal, nephrotoxic and allergic reactions. The definition of a case can be classified as: probable, possible or unlikely/unknown.[11,21–24] These categories were chosen to provide simple delineations, ease of initial identification of cases and to provide a meaningful tool for quantifying the magnitude of problems in specific situations.

Table 3 presents the case definition matrix for APP proposed as a classification tool. The distinction between the "probable" and "possible" cases is arrived at by the requirement that the case meet one criteria in *each* of the categories (exposure, health effects and causality). A probable case refers to a case that is presumptive, substantiated or "more likely than not" caused by exposure to a pesticide. The "unlikely/unknown" case definition represents cases for which there is unlikely or unknown causality or exposure. This category is arrived at by the requirement that the case meet only one criteria in *any* of the categories. Clinical evaluation, carried out by a health-care provider or trained personnel with some

Table 3. **Case definition matrix for acute pesticide poisoning**

Category	*Probable* case (meets at least one criterion in *each* category)	*Possible* case (meets at least one criterion in *each* category)	*Unlikely/unknown* case (meets at least one criterion in *any*[a] category)
Exposure	• Observation of pesticide residue, odour or other contamination by a health-care provider or trained personnel • A plausible description of exposure based on report by patient, witness or written record of pesticides used • Biological monitoring demonstrating evidence of the pesticide in the body (e.g. blood, serum, urine, sweat levels of specific chemicals) or evidence of a physiologic response to pesticide exposure (e.g. depressed cholinesterase levels after organophosphate exposure, prolonged prothrombin time after coumarin exposure) • Environmental sampling confirming presence of the chemical in the soil, clothing, air or water • Clinical response to administration of a treatment or antidote for pesticide poisoning (e.g. atropine, vitamin K)	• Observation of pesticide residue, odour or other contamination by a health-care provider or trained personnel • A plausible description of exposure based on report by patient, witness or written record of pesticides used • Biological monitoring suggesting presence (but not excess) of the pesticide in the body (e.g. blood, serum, urine, sweat levels of specific chemicals) • Environmental sampling confirming presence of the chemical in the soil, clothing, air or water	• No evidence of exposure • Evidence of no exposure
Health effects	Documentation by a health-care provider or trained personnel of: • a characteristic toxidrome or health effect from the pesticide • a physical sign[b] consistent with pesticide exposure and not easily explained by another condition • a laboratory test consistent with pesticide exposure and not easily explained by another condition • three or more symptoms[b] (not verifiable by objective means) compatible with pesticide exposure • autopsy evidence of pesticide poisoning	Documentation by a health-care provider or trained personnel of: • a health effect from the pesticide exposure even in the absence of a specific toxidrome • an exacerbation of a pre-existing illness (e.g. triggering asthma) • two or more subjective symptoms reported by the patient without objective evidence of physical findings or laboratory evidence	• No documented signs or symptoms:[b] • only one subjective symptom[b] (not verifiable by objective means) • insufficient information on health effects
Causality	• Temporal cause-effect relationship between exposure and health effect consistent with the known toxicology of the pesticide	• Temporal cause–effect relationship between exposure and health effect consistent with the known toxicology of the pesticide • Temporal cause–effect relationship between exposure and health effect(s) consistent with published case reports of the health effects of the pesticide • Temporal relationship between exposure and health effect(s) that have not yet been observed provided there is no other likely explanation for the effects and the effects do not contradict present knowledge of the toxicology of the pesticide	• Implausible temporal cause–effect relationship between exposure and health effects • Health effects are not consistent with known toxicology or case reports of the pesticide • Insufficient causality information

[a] Note that the other classifications require meeting criteria in *each* category as opposed to *any*.

[b] A distinction is to be made between signs and symptoms. A physical sign is an objective finding that can be described by a health-care provider or trained personnel (e.g. diaphoresis, tachycardia, vomiting). A symptom is a subjective complaint reported by a patient (e.g. nausea, headache, dizziness).

knowledge of the health effects caused by exposure to pesticides, is advised when making a determination about health effects. A distinction is to be made between signs and symptoms. A physical sign is an objective finding that can be described by a health-care provider (e.g. diaphoresis, tachycardia, vomiting). A symptom is a subjective complaint reported by a patient (e.g. nausea, headache, dizziness). The information in Table 1 and Table 2 provides guidance for the determination of health effects. It is important to keep in mind that since all the possible toxic effects of each pesticide are not entirely known, the possibility may still exist that certain symptoms represent new, as yet undocumented, health effects from a pesticide.

Discussion

This paper provides a standard definition and classification scheme for APP to enable its identification and diagnosis, especially at the field level,

rural clinics, and primary health-care systems. The case matrix definition is a synthesis of existing case definitions that have been previously proposed by other authors.[12,13,21–24] The lack of a standardized definition and classification scheme has hindered identification and quantification of APP cases which in many situations results in a failure to establish adequate prevention and control measures.[16]

It is intended to provide a case definition for acute pesticide poisoning and consequently does not account for chronic effects (e.g. carcinogenesis, neurological effects, reproductive effects and developmental abnormalities). While these potential effects have significant public health importance, the scope of this definition does not allow for assessment of chronic poisoning.

The case definition is designed to account for the wide range of clinical practice, methods of diagnosis and observational epidemiological/surveillance methods that exist across the world. Such information collected can substantively contribute to identification of existing problems and thus promote action for improved management and prevention.[21] Based on the proposed criteria, laboratory confirmation is not absolutely necessary to meet the standard of a *probable* APP. Notwithstanding, thorough clinical evaluation, carried out by a health-care provider or trained personnel with some knowledge of the health effects caused by unsafe exposure to pesticides, is required. Hospitalization is not a precondition for using the case definition to classify an incident.

Finally, due to the complexity of this public health problem, the use of this definition has its limitations. Many individuals and workers who experience health effects from APP may never present to a health-care provider due to distance from a medical facility, lack of resources, economic factors, fear of job loss or other reasons.[25,26] Some health-care providers may be unaware of the relationship between pesticide and illnesses and fail to diagnose or report the incident properly. Additionally, some pesticides may not be properly mixed, prepared, applied, labelled or registered,[27–29] making the determination of the agent of exposure difficult. Although this definition provides a framework for further epidemiologic study, it does not serve as a substitute for a national registry of pesticide use and illness. By enabling a field identification of APP, this standardized case definition may facilitate immediate medical management of pesticide poisoning and aid in estimating its incidence. As this case definition is used in different countries and situations, it will be kept under review and updated on the basis of lessons learned. The information provided from its use will provide guidance for future research projects and the implementation of exposure prevention and management programmes. ■

Competing interests: None declared.

Résumé

Intoxication aiguë par les pesticides : proposition d'un outil de classification

Les cas d'intoxication aiguë par un pesticide (IAP) représentent une morbidité et une mortalité conséquentes dans l'ensemble du monde. Les pays en développement sont particulièrement vulnérables en raison d'un manque de réglementation, de systèmes de surveillance, d'application des règles et de formation et d'une insuffisance de l'accès aux systèmes d'information. Des études antérieures ont mis en évidence une grande variabilité des taux d'incidence de ces intoxications aiguës. Il est possible que cette variabilité résulte d'un manque de consistance dans la méthodologie de notification et de l'exclusion des intoxications professionnelles et involontaires. L'objectif de ce document est d'élaborer une définition de cas standard pour faciliter l'identification et le diagnostic de toutes les causes d'IAP, notamment sur le terrain, dans les dispensaires ruraux et dans le cadre des systèmes de soins de santé primaire. Il présente une synthèse de la littérature existante et des définitions de cas déjà proposées par d'autres auteurs de part le monde. Il propose également une définition de cas standardisée et un schéma de classification des IAP en catégories de cas :, potentiels ou improbables/indéterminés. L'une et l'autre sont destinés à être appliqués dans le monde entier pour faciliter l'évaluation de l'ampleur des problèmes existants et promouvoir des actions pour améliorer la prise en charge et la prévention. En permettant un diagnostic sur le terrain des IAP, cette définition de cas standardisée peut faciliter une prise en charge médicale immédiate des intoxications et aider à estimer leur incidence.

Resumen

Intoxicación aguda por plaguicidas: propuesta de instrumento de clasificación

Los casos de intoxicación aguda por plaguicidas (IAP) son una causa importante de morbilidad y mortalidad a nivel mundial. Los países en desarrollo son particularmente vulnerables, pues en ellos coinciden una escasa regulación de esos productos, la falta de sistemas de vigilancia, un menor cumplimiento de las normas y un acceso insuficiente a los sistemas de información. Investigaciones anteriores han puesto de relieve una gran variabilidad de las tasas de incidencia de IAP. Ello se debe posiblemente a unos métodos de notificación incongruentes y a la exclusión de las intoxicaciones laborales y no intencionales. La finalidad de este artículo es crear una definición de caso estándar que facilite la identificación y el diagnóstico de todas las causas de IAP, especialmente sobre el terreno, en los consultorios rurales y en los centros de atención primaria. Se hace una síntesis de la bibliografía existente y de las definiciones de caso propuestas anteriormente por otros autores en todo el mundo, y se proporciona una definición de caso normalizada y un sistema de clasificación de las IAP en tres categorías: probable, posible e improbable/origen desconocido. Esos criterios se han concebido de manera que puedan aplicarse en todo el mundo para facilitar la determinación de la magnitud de los problemas existentes y promover así la adopción de medidas que mejoren el tratamiento y la prevención. Posibilitando el diagnóstico sobre el terreno de las IAP, esa definición de caso normalizada puede facilitar el tratamiento médico inmediato de la intoxicación por plaguicidas y la estimación de su incidencia.

ملخص

التسمُّم الحاد بمبيدات الهوام؛ أداة مقترحة للتصنيف

تعد حالات التسمُّم الحاد بمبيدات الهوام مسؤولة عن قسط كبير من المراضة والوفيات في جميع أنحاء العالم. وتعاني البلدان النامية من التعرُّض للتسمُّم الحاد بمبيدات الهوام أكثر من غيرها بسبب ضعف التشريعات لديها، وبسبب غياب نُظُم الترصُّد، ولأن إنفاذ النُظُم فيها أقل مما في سواها، وبسبب افتقادها للتدريب وقلة إتاحة نُظُم المعلومات فيها. وقد أوضحت البحوث السابقة اختلافاً كبيراً في معدلات حدوث التسمُّم الحاد بمبيدات الهوام، وقد يعود ذلك إلى عدم الاتساق في المنهجيات المتَّبعة في الإبلاغ وإلى استبعاد حالات التسمُّم المهني وغير المتعمَّد: وتهدف هذه الوثيقة إلى إنشاء تعريف معياري للحالات يسهِّل التعرُّف على جميع أسباب التسمُّم الحاد بمبيدات الهوام وتشخيصها؛ ولاسيَّما على المستوى الميداني وفي العيادات الريفية وفي نُظُم الرعاية الصحية الأولية. وقد جمعت هذه الوثيقة من تركيب للأدبيات المنشورة والموجودة حالياً إلى جانب تعريف الحالات الذي سبق اقتراحه من قِبَل مؤلفين آخرين من جميع أنحاء العالم. وتقدِّم هذه الوثيقة تعريفاً معيارياً للحالات ونظاماً تصنيفياً للتسمُّم الحاد بمبيدات الهوام في شكل فئات محتملة، وأخرى ممكنة، وثالثة غير محتملة/غير معروفة. ومن المستهدف أن يطبَّق استخدام هذا التعريف في أنحاء العالم كافة ليسهم في التعرف على نطاق المشكلات الموجودة حالياً ويعزِّز الأنشطة التي تحسِّن تدبير واتِّقاء التسمُّم. ويمكن للتعريف المعياري لحالات التسمم الحاد بمبيدات الهوام أن يسهِّل التدبير الطبي الفوري للتسمُّم بمبيدات الحشرات وأن يساعد في تقدير معدلات حدوثه، وذلك من خلال تعزيز التشخيص الميداني له.

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Table 1. **Adverse health effects caused by selected classes of pesticides**[a]

Chemical/chemical class	Examples of pesticides	Clinical presentation	Route of exposure[b]
Arsenicals	Arsenic trioxide, CCA, sodium arsenate	Abdominal pain, nausea, vomiting, garlic odour, metallic taste, bloody diarrhoea, headache, dizziness, drowsiness, weakness, lethargy, delirium, shock, kidney insufficiency, neuropathy	O, R, D (rarely)
Borates (insecticide)	Boric acid, borax	Upper airway irritation, abdominal pain, nausea, vomiting, diarrhoea, headache, lethargy, tremor, kidney insufficiency	O, R, D (broken skin)
Carbamates (insecticide)	Carbaryl, thiram, aldicarb, mecarbam	Malaise, weakness, dizziness, sweating, headache, salivation, nausea, vomiting, diarrhoea, abdominal pain, confusion, dyspnea, dermatitis, pulmonary oedema	O, D
Chlorphenoxy compounds (herbicides)	Di/tri- chlorophenoxyacetic acid, MCPP	Upper airway and mucous membrane irritation, abdominal pain vomiting, diarrhoea, tachycardia, weakness, muscle spasm, coma, acidosis, hypotension, ataxia, hypertonia, seizures, dermal irritation, headache, confusion, acidosis, tachycardia	O, D
Calciferol (rodenticide)	Cholecalciferol, ergocalciferol	Fatigue, anorexia, weakness, headache, nausea, polyuria, polydipsia, renal injury, hypercalcemia	O
Chloralose	Chloralose	Vomiting, vertigo, tremor, myoclonus, fasciculations, confusion, convulsions	O
Copper compounds (fungicide)	Copper acetate, copper oleate	Abdominal pain, vomiting, skin/airway/mucous membrane irritation, renal dysfunction, coma	O, R, D
Coumarins (rodenticide)	Brodifacoum, warfarin, pindone	Echymoses, epistaxis, excessive bleeding, haematuria, prolonged prothrombin time, intracranial bleed, anaemia, fatigue, dyspnea	O, D (possible)
Diethyltoluamide (insect repellent)	DEET (N,N-diethyl-meta-toluamide)	Dermatitis, ocular irritation, headache, restlessness, ataxia, confusion, seizures, urticaria	O, D
Dipyridil (herbicide)	Paraquat, diquat	Mucous membrane and airway irritation, abdominal pain, diarrhoea, vomiting, gastrointestinal bleeding, pulmonary oedema, dermatitis, renal and hepatic damage, coma, seizures	O, D (via broken skin)
Phosphonates (herbicide)	Roundup, glyphosate	Airway, skin, and mucous membrane irritation, abdominal, pain, nausea, vomiting, shock, dyspnea, respiratory failure	O, R
Fluoroacetate (rodenticide)	Sodium fluoroacetate	Vomiting, paresthesias, tremors, seizures, hallucinations, coma, confusion, arrhythmias, hypertension, cardiac failure	O, D (possible)
Mercury, organic (fungicide)	Methyl mercury	Metallic taste, paresthesias, tremor, headache, weakness, delirium, ataxia, visual changes, dermatitis, renal dysfunction	O, R, D
Metal phosphides (rodenticide, fumigant)	Zinc-, aluminium-, magnesium- phosphide	Abdominal pain, diarrhoea, acidosis, shock, jaundice, paresthesias, ataxia, tremors, coma, pulmonary oedema, tetany, dermal irritation	O, R, D
Halocarbons (fumigant)	Cellfume, Methyl bromide	Skin/airway/mucous membrane irritant, cough, renal dysfunction, confusion, seizures, coma, pulmonary oedema	O, R, D
Nitrophenolic and nitrocresolic herbicides	Dinitrophenol, dinitrocresol, dinoseb, dinosarn	Sweating, fever, confusion, malaise, restlessness, tachycardia, yellow skin staining, seizures, coma, renal insufficiency, hepatic damage	O, R, D
Organochlorines (insecticide)	Aldrin, dieldrin HCB, endrin, lindane	Cyanosis, excitability, dizziness, headache, restlessness, tremors, convulsions, coma, paresthesias, nausea, vomiting, confusion, tremor, cardiac arrhythmias, acidosis	O, R, D

(Table 1, cont.)

Chemical/chemical class	Examples of pesticides	Clinical presentation	Route of exposure[b]
Organophosphates (insecticides)	Malathion, parathion, dichlorvos, chlorpyrifos	Headache, dizziness, bradycardia, weakness, anxiety, excessive sweating, fasciculations, vomiting, diarrhoea, abdominal cramps, dyspnea, miosis, paralysis, salivation, tearing, ataxia, pulmonary oedema, confusion, acetylcholinesterase inhibition	O, D
Organotin (fungicide)	Fentin acetate, fentin chloride	Airway, skin, and mucous membrane irritation, dermatitis, salivation, delirium, headache, vomiting, dizziness	O, R, D
Phenol derivatives (Fungicide, wood preservative)	Pentachlorophenol, dinitrophenol	Skin, airway, and mucous membrane irritation, contact dermatitis, dyspnea, diaphoreses, urticaria, tachycardia, headache, abdominal pain, fever, tremor	O, R, D
Pyrethrins, Pyrethroids	Allethrin, cyfluthrin, permethrin	Allergic reactions, anaphylaxis, dermatitis, paresthesias, wheezing, seizures, coma, pulmonary oedema, diarrhoea, abdominal pain	R, D
Strychnine (rodenticide)	Strychnine	Muscle rigidity, opisthotonus, rhabdomyolysis	O
Thallium (rodenticide)	Thallium sulfate	Abdominal pain, nausea, vomiting, bloody diarrhoea, headache, weakness, liver injury, hair loss, paresthesias, neuropathy, encephalopathy, cardiac failure	O
Triazines (herbicide)	Atrazine, prometryn	Mucous membrane, ocular and dermal irritation	O, R, D

CCA, chromated copper arsenate; HCB, hexachlorobenzene; MCPP, methyl chlorphenoxy propionic acid.

[a] This list is an overview and is not meant to be a comprehensive list of all pesticide and pesticide classes. The health worker is encouraged to use other resources and clinical experience in establishing health effect and causality for acute pesticide poisoning. Suggested online references include: http://www.who.int/whopes/recommendations/IPCSPesticide_ok.pdf, http://npic.orst.edu/npicfact.htm, http://www.epa.gov/pesticides/safety/healthcare/handbook/handbook.pdf, http://www.cdc.gov/niosh/topics/pesticides/pdfs/pest-cd2app2v2.pdf, http://hazard.com/msds/, http://www.epa.gov/pesticides/reregistration/status.htm, http://pesticideinfo.org/, http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB, http://www.pesticideinfo.org/Search_Countries.jsp.

[b] Route of exposure key: O, oral/ingestion; R, respiratory/inhalation; D, dermal or ocular.

Based on references 22–24.

Table 2. **Signs and symptoms by organ system and severity category**

Organ system	Severity of symptoms			
	Fatal	High	Moderate	Low
Gastrointestinal	Death	Massive haemorrhage Gut perforation 2nd or 3rd degree burns Severe dysphagia	Diarrhoea Vomiting Bloody stools Jaundice	Abdominal cramping Loss of appetite Nausea Oral irritation Constipation
Respiratory	Death	Cyanosis and respiratory depression Pulmonary oedema Respiratory arrest	Diffuse radiographic abnormalities Pleuritic chest pain Respiratory depression Bronchospasm Dyspnoea	Cough Airway irritation Rhinitis Sneezing
Nervous	Death	Coma Paralysis Seizure Stupor Widespread neurologic impairment	Confusion Hallucinations Blurred vision Ataxia Slurred speech Syncope Hearing loss Localized neuropathy/ paraesthesias	Hyperactivity Headache Profuse sweating Dizziness Tremor Tinnitus Drowsiness
Cardiovascular	Death	Bradycardia: HR < 40 adults, < 60 children, < 80 neonates Tachycardia: HR > 180 adults, > 190 children, > 200 neonates Cardiac arrest Myocardial infarction Shock	Bradycardia: HR 40–50 adults, 60–80 children, 80–90 neonates Tachycardia: HR 140–180 adults, 160–190 children, 160–200 neonates Chest pain Conduction disturbance Hypertension Hypotension	Isolated extrasystoles Mild transient hypertension
Metabolism	Death	Acid/base disturbance (pH < 7.15 or > 7.7) Severe electrolyte imbalance	Elevated anion gap Acidosis (pH 7.15–7.30) Alkalosis (pH 7.60–7.69)	Fever of short duration Mild hyperglycaemia
Renal	Death	Anuria Renal failure	Haematuria Oliguria Proteinuria	Polyuria
Muscular	Death	Muscle rigidity and rhabdomyolysis Compartment syndrome	Fasciculations Rigidity Weakness	Muscle weakness Muscle pain
Dermatologic	Death	Burns: 2nd degree > 50% total BSA Burns: 3rd degree of > 2% BSA	Bullae Burns: 2nd degree < 50% BSA Burns: 3rd degree of < 2% BSA	Oedema, swelling, Erythema, irritation Urticaria
Ocular	Death	Corneal ulcer Corneal perforation Loss of vision	Corneal abrasion Ocular burn Visual changes	Lacrimation Mydriasis Miosis Pain/ conjunctivitis
Other	Death	–	–	Fatigue Malaise

BSA, body surface area; HR, heart rate.
Based on references 22 and 30.