

# Epidemiological Surveillance System for Acute Pesticide Poisoning

## Introduction

Surveillance in public health requires the systematic and continuous collection, analysis, and interpretation of data on health events. These data are then used in the planning, execution and evaluation of health interventions. A surveillance system requires developing the functional ability to compile, analyze, and disseminate data in a timely fashion to those able to undertake effective prevention and control actions.

In public health, it is imperative to direct surveillance actions not only to health problems of infectious or chronic origin, but also those caused by external agents. These agents can be closely related to the environment, which has been deteriorating at an increased pace over the last decades.

In the case of pesticides, the Pan American Health Organization (PAHO) established as a priority promoting better methods for collecting data related to acute pesticide poisoning (APP) in member countries. The aim is to better understand health problems caused by pesticides, the magnitude of which are still not known with precision. This document presents some preliminary guidelines proposed and adopted by PAHO on this subject.

An APP surveillance system makes it possible to determine how poisoning is affecting the population's health, population groups most affected, types and characteristics of high risk exposures, main pesticides involved, and other determining factors. This information is used to direct prevention and control actions to reduce the negative health effects of chemical substances in places where cases are identified (i.e. in practical terms, an epidemiological blockade).

Furthermore, if surveillance system data are cross-checked with complementary information from other sources, surveillance can facilitate the identification of pesticide use patterns and evaluation of contaminated soils, water and pesticide residues in food.

## 1. Objectives of the surveillance system

- Determine the number of cases and deaths by APP according to time, place, and person (in populations and regions of greater risk, with trends over time) and their principal determining factors, to implement timely prevention and control measures. This makes it possible to calculate the APP morbidity and mortality incidence.
- After an outbreak of cases is identified, investigate the origin and develop training activities aimed at avoiding new cases (epidemiological blockade).
- Define high-risk populations.
- Detect situations of alert where effective and timely actions are required to minimize the negative public health effects of poisoning.

- Characterize pesticide exposures that pose the greatest risks for the population.
- Determine the causes of poisoning and death in the population.
- Identify pesticides more frequently related to APP.
- Focus the design of prevention and control strategies towards these problems in the population.
- Facilitate the evaluation of environmental conditions that create risk situations, in order to propose control measures.
- Direct research proposals to determine the public health implications of pesticide use and the effectiveness of prevention and control actions.

## 2. Case Definition

A case of APP is defined as any person who, after having been exposed to one or more pesticides, presents clinical manifestations of poisoning, or specific laboratory test results compatible with poisoning, in the first 24 hours after contact.

Manifestations of the diseases caused by APP are often not very specific. One source of information that contains a list of the most important signs and symptoms is a manual from the United States Environmental Protection Agency (EPA): Recognition and Management of Pesticide Poisonings. Fifth edition, 1999; USA. This manual is available in electronic format at the following Internet address: <http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm>.

At the state level in the United States, a monitoring index is used to assign a level of severity to different diseases due to APP. Table 1 shows the signs and symptoms according to severity categories (Original table available at: [www.cdc.gov/niosh/pestsurg/pdfs/pest-sitablev6.pdf](http://www.cdc.gov/niosh/pestsurg/pdfs/pest-sitablev6.pdf)).

## Case classification

### *Suspected Case*

A case that suggests acute pesticide poisoning by presenting a symptomatology compatible with poisoning (systemic or localized) and/or is suspected to have been exposed to pesticides.

### *Confirmed Case*

A case in which at least one of the following criteria is established:

- Epidemiological visit where the background of exposure to the toxic substance, the means of exposure, the agent, the mechanism, and their relation in time are identified and, additionally, presenting clinical manifestations of poisoning.
- History of exposure to the toxic substance and altered

**Table 1: Signs and Symptoms of Acute Pesticide Poisoning by Severity Category**

| Organ System                   | Fatal | Severity Category   |  |   |
|--------------------------------|-------|---|--|---|
|                                |       | High<br>Severe and life-threatening signs   | Moderate<br>Pronounced or Prolonged Signs and Symptoms   | Low<br>Mild, transient, and/or spontaneously resolving symptoms   |
| <b>Gastrointestinal System</b> | Death | <ul style="list-style-type: none"> <li>Massive hemorrhage/perforation of gut</li> </ul>   | <ul style="list-style-type: none"> <li>Diarrhea</li> <li>Melena</li> <li>Vomiting</li> </ul>   | <ul style="list-style-type: none"> <li>Abdominal pain, cramping</li> <li>Anorexia</li> <li>Constipation</li> <li>Diarrhea</li> <li>Nausea</li> <li>Vomiting</li> </ul>        |
| <b>Respiratory System</b>      | Death | <ul style="list-style-type: none"> <li>Cyanosis + Respiratory depression</li> <li>Pulmonary edema</li> <li>Respiratory arrest</li> </ul>  | <ul style="list-style-type: none"> <li>Abnormal pulmonary x-ray</li> <li>Pleuritic chest pain/pain on deep breathing</li> <li>Respiratory depression</li> <li>Wheezing</li> <li>Dyspnea, shortness of breath</li> </ul>  | <ul style="list-style-type: none"> <li>Cough</li> <li>Upper respiratory pain, irritation</li> <li>Dyspnea, shortness of breath</li> </ul>                                     |
| <b>Nervous System</b>          | Death | <ul style="list-style-type: none"> <li>Coma</li> <li>Paralysis, generalized</li> <li>Seizure</li> </ul>   | <ul style="list-style-type: none"> <li>Confusion</li> <li>Hallucinations</li> <li>Miosis with blurred vision</li> <li>Seizure</li> <li>Ataxia</li> <li>Slurred speech</li> <li>Syncope (fainting)</li> <li>Peripheral neuropathy</li> </ul>  | <ul style="list-style-type: none"> <li>Hyperactivity</li> <li>Headache</li> <li>Profuse sweating</li> <li>Dizziness</li> <li>Ataxia</li> <li>Peripheral neuropathy</li> </ul> |
| <b>Cardiovascular System</b>   | Death | <ul style="list-style-type: none"> <li>Bradycardia/heart rate &lt;40 for adults, &lt;60 infants and children, &lt;80 neonates</li> <li>Tachycardia/heart rate &gt;180 for adults, &gt;190 infants/children, &gt;200 in neonates</li> <li>Cardia arrest</li> </ul> | <ul style="list-style-type: none"> <li>Bradycardia/heart rate 40-50 in adults, 60-80 in infants/children, 80-90 in neonates</li> <li>Tachycardia/heart rate=140-180 in adults, 160-190 infants/children, 160-200 in neonates</li> <li>Chest pain + hyperventilation, tachypnea</li> <li>Conduction disturbance</li> <li>Hypertension</li> <li>Hypotension</li> </ul> |   |
| <b>Metabolism</b>              | Death | <ul style="list-style-type: none"> <li>Acid Base disturbance (pH&lt;7,15 or &gt;7,70)</li> </ul>  | <ul style="list-style-type: none"> <li>Acid Base disturbance (pH = 7,15-7,24 or 7,60-7,69)</li> <li>Elevated anion gap</li> </ul>  | <ul style="list-style-type: none"> <li>Fever</li> </ul>   |
| <b>Renal System</b>            | Death | <ul style="list-style-type: none"> <li>Anuria</li> <li>Renal failure</li> </ul>   | <ul style="list-style-type: none"> <li>Hematuria</li> <li>Oliguria</li> <li>Proteinuria</li> </ul>   | <ul style="list-style-type: none"> <li>Polyuria</li> </ul>  |
| <b>Muscular System</b>         | Death | <ul style="list-style-type: none"> <li>Muscle rigidity + elevated urinary myoglobin + elevated creatinine</li> </ul>  | <ul style="list-style-type: none"> <li>Fasciculations</li> <li>Muscle rigidity</li> <li>Muscle weakness</li> </ul>   | <ul style="list-style-type: none"> <li>Muscle weakness</li> <li>Muscle pain</li> </ul>  |
| <b>Local effects on skin</b>   | Death | <ul style="list-style-type: none"> <li>Burns, second degree (involving &gt;50% of body surface area)</li> <li>Burns, third degree (involving &gt;2% of body surface area)</li> </ul>  | <ul style="list-style-type: none"> <li>Bullae</li> <li>Burns, second degree (involving &lt;50% of body surface area)</li> <li>Burns, third degree (involving &lt;2% of body surface area)</li> </ul>   | <ul style="list-style-type: none"> <li>Skin edema/swelling, erythema, rash, irritation/pain, pruritis</li> <li>Hives/urticaria</li> </ul>                                     |
| <b>Local effects on eye</b>    | Death | <ul style="list-style-type: none"> <li>Corneal ulcer/perforation</li> </ul>   | <ul style="list-style-type: none"> <li>Corneal abrasion</li> <li>Ocular burn</li> </ul>  | <ul style="list-style-type: none"> <li>Lacrimation</li> <li>Mydriasis</li> <li>Miosis</li> <li>Ocular pain/irritation/inflammation (diagnosis of conjunctivitis)</li> </ul>   |
| <b>Other effects</b>           | Death |   |  | <ul style="list-style-type: none"> <li>Fatigue</li> <li>Malaise</li> </ul>  |

Source: Adapted from "Signs and symptoms [for pesticide active ingredients] by severity category" from SENSOR (Sentinel Event Notification System for Occupational Risk) Case Definition and Severity, National Institute for Occupational Safety and Health, United States.

biological indicators of exposure or effect in accordance with the pesticide, and presence or no presence of clinical manifestations.

- In case of death, confirmation with medical-legal procedures.

*According to the circumstance of the exposure:*

- Occupational: Exposure to pesticides during the industrial processes of manufacture, storage, transportation, application, and final disposal.
- Accidental: Unintentional and unexpected exposure to pesticides. This includes food poisoning.
- Intentional: Exposure to pesticides with the intention of causing harm. This includes suicide attempts, suicides, and homicides.

*According to characteristics of the pesticide:*

- Chemical Group:

- Bipyridyls
- Carbamates
- Arsenical compounds
- Copper compounds
- Organochlorine compounds
- Organotin compounds
- Organophosphate compounds
- Organomercury compounds
- Derivatives of phenoxyacetic acid
- Coumarins and Indandiones
- Derivatives of hydrocarbons, halocarbons, oxides, and aldehydes, composed of sulfur, composed of phosphorus, composed of nitrogen (all as fumigants)
- Nitrophenolics and Nitrocresolic
- Pyrethrins and Pyrethroids
- Thio- and dithiocarbamates
- Triazines
- Others

- Organisms to control:

- Insecticides
- Herbicides
- Fungicides
- Rodenticides
- Nematicides
- Acaricides
- Bactericides
- Others

- Toxicological Classification of Pesticides/WHO \*

- Ia: Extremely hazardous
- Ib: Highly hazardous

\* This classification is available at the following address: [http://www.who.int/pcs/pcs\\_act.htm](http://www.who.int/pcs/pcs_act.htm) (select WHO Recommended Classification of Pesticides by hazard and Guidelines to Classification).

- II: Moderately hazardous
- III: Slightly hazardous

### Definition of Alerts

A set of events related to pesticide poisoning which, according to epidemiological criteria, demand immediate intervention. They include:

- Death
- Poisoning in pregnant or lactating women
- Poisoning in children (minors as defined by each country legislation)
- Severe poisoning
- Two or more cases in a week, in the same place
- Two or more cases on a given day or cases on consecutive days in the same place
- Poisoning with unregistered or prohibited pesticides
- Alerts that the local pesticide monitoring commission consider should be investigated
- Emergencies where pesticides are involved such as: leaks, spills, natural disasters, technological disasters and others

### 3. Operational organization of the surveillance system

#### Surveillance Types

Through *passive surveillance* the background of pesticide exposure is sought in persons attended by health services personnel who present compatible signs and symptoms.

Notification of APP cases is made on a periodic basis. Reports are made immediately at the local level, weekly at the national level, and quarterly at the level of international agencies. These reports are integrated into the established notification system within the local public health surveillance system or pesticide prevention and control program when applicable.

In specific cases, surveillance can be carried out to monitor occupational risks with evaluation of environmental conditions and/or utilization of biological markers (*active surveillance*). Some biological markers can identify early alterations due to pesticide exposure.

In the case of an *alert* situation as previously defined, notification to the local health authority should be immediate and a compulsory epidemiological investigation should be conducted for every case.

#### Data collection

##### Data Sources

*Morbidity:* APP case notification forms; notifications by Local Pesticides Commissions; community notifications. If resources are adequate, it is possible to use registries of medical consultations and emergencies, clinical histories of patients and hospital discharge information to confirm that there were no additional cases.

Research findings and laboratory results can be used to actively look for active cases of pesticide poisoning in high-risk groups.

Consolidated monthly reports of data summarizing the epidemiological behavior of APP.

*Mortality:* individual death certificates, hospital or emergency mortality records, vital statistics and community medical and legal records.

*Field investigations:* reports of epidemiologic field studies carried out due to the presence of alert situations such as poisoning outbreaks or cases of special importance.

*Other registries (when resources are available):* reports of occupational injuries and labor absenteeism; registries of companies and of the Ministry of Labor; press reports and results of special research, for example on evaluation of underreporting.

*Environment:* Soil and water monitoring reports and reports of pesticide residues in food. Classification of pesticides used; hygiene and safety conditions and use of personal protection against pesticides.

### Minimum data recommended

For each case of APP:

*Socio-demographic variables:* age, sex, origin (urban / rural), education, occupation.

*Exposure variables:* place and activity at time of exposure, date, hour of exposure, means of exposure, cause of the poisoning (occupational, accidental, intentional).

*Variables related to the clinical manifestations:* date and hour of onset of symptoms, type of clinical manifestations, severity of clinical manifestations, condition of discharged patient (alive / dead).

*Variables related to the implicated pesticide(s):* type of pesticide, generic name, brand name, classification according to chemical group and according to type of organism controlled; type of crop.

**Note:** These data are included in the notification form at time of patient admission or subsequently based on clinical history data.

Data consolidated periodically (monthly or yearly):

- Total number of poisonings
- Number of poisonings by sex
- Number of poisonings by 5-year age groups
- Number of poisonings in children (minors as defined by the legislation of each country)
- Number of poisoning by cause: occupational, accidental, intentional
- Number of deaths from poisoning
- Number of deaths from poisoning by age and sex
- Number of deaths from poisoning in children (minors as defined by the legislation of each country)

- Number of deaths from poisoning by cause: occupational, accidental, intentional
- Number of occupational poisonings by type of crop
- Total poisonings per month
- Total weight of pesticides imported annually by country (in kg): by chemical group, type of organism to control and by toxicological classification
- Number and type of alert situations
- Number and type of prevention and control measures carried out (inspection visits, active search of new cases, hygiene and safety conditions improvement, education, compliance with legislation, follow-up of previous activities, others)
- Cases by place of occurrence (company, neighborhood, city)

### Instrument

The form for Report of Acute Pesticide Poisoning should be used for every person that is attended by health services, or who dies and meets the criteria established in the Case Definition.

### Additional sources

*The following information will be needed to analyze the data provided by the surveillance system.*

- Socio-demographic information (total population, population of economically active age, proportion of economically active population working in agriculture, distribution of the population by age and sex, by urban/ rural origin and by level (local, regional or national).
- Imports of pesticides by chemical group, by type of organism to control, and according to toxicological classification.
- Types, areas, and seasons of crops. Technologies used for these crops.
- Pesticide waste inventory.
- Monitoring of pesticide residues in food.
- Environmental impact assessments. Contamination of water and soil.
- Census of job sites by Municipality.
- Directory of organizations and institutions which work with pesticides that may have resources available.
- Available legal framework (laws, regulations, technical standards)
- Laboratory capacity at local and national level.
- Investigations and studies in the area.

## 4. Data analysis

### Epidemiological Indicators

*Incidence rate of acute poisoning:*

Number of new cases of APP in a period / Population at mid-period x 100,000

*Mortality from acute poisoning:*

Number of deaths by APP in a period / Population at mid-period x 100,000

### *Case-fatality:*

Number of deaths by APP in a period / Number of cases of APP in a period x 100

### *Rate or in case of not having data for denominators, proportional distributions:*

Proportion of cases by sex

Proportion of cases by age group

Proportion of cases in children (minors as defined by each country legislation)

Proportion of cases according to type of pesticide (chemical group, organism to control and WHO toxicological classification)

Proportion of cases according to cause of poisoning (occupational, accidental, intentional)

Proportion of cases of occupational poisoning by type of agriculture

Proportion of cases by place or company

### Indicators regarding the importation of pesticides

- Kilograms of Imported Active Ingredients\* / Number of inhabitants in the country
- Kilograms of Imported Active Ingredients\* / Population economically active in agriculture.
- Kilograms of Imported Active Ingredients\* / Hectares cultivated

In the analysis of these epidemiological indicators, monthly or yearly trends can be calculated. These trends can be analyzed for different localities, regions or countries. Behavior by sex, age group, cause of poisoning, type of pesticide according to chemical group, and type of organism to control also can be analyzed in time.

To present this information, trend graphs are used to illustrate rates and pie or bar graphs to represent the proportional distributions of the proposed variables. Maps are also useful to geographically locate where cases occur and define high-risk areas in a locality.

## **5. Dissemination of Information**

It is of vital importance that information from a surveillance system reach the people and institutions responsible for decision-making in a timely fashion. With this information, decision-makers will be able to effectively direct timely prevention and control actions.

In situations where APP is involved, information needs to be shared not only among health authorities but other organizations as well. These situations require the involvement and commitment of regulatory agencies, occupational health programs, local pesticide commissions, and the community.

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\* These calculations should be carried out taking into account that 85% of the imported active ingredients are used in agriculture.

Dissemination of information can be carried out through bulletins which include epidemiological analysis of APP using proposed indicators. Also, the mass media can be used to strengthen education related to the proper use of pesticides.

## **Uses of data for decision-making**

### *Surveillance:*

- Analyze the epidemiological behavior of APP and related mortality.
- Estimate the magnitude of the problem by using incidence rates of APP and mortality in the population, by locality and year.
- Monitor the characteristics of APP cases and deaths by sex, age, and specifically in children, using incidence and mortality rates.
- Characterize APP according to cause (occupational, accidental, intentional) through proportional distributions of cases by place and year.
- Describe the pesticides responsible for APP cases and deaths through a classification list according to chemical group, organism to control, and toxicological classification.
- Identify and characterize alert situations according to year, place, source of poisoning, type of pesticide, number of affected people, number of deaths, cause, and prevention and control actions.

### *Investigation:*

- Characterize the changes in APP frequency by time and place
- Identify populations at risk through periodic monitoring
- Characterize importation and utilization of pesticides in different places
- Identify the impact of specific pesticides on public health for the purpose of regulating their use
- Develop and strengthen enforcement of legislation in the area
- Provide impetus for organized education and control activities regarding the use of Pesticides
- Assess the impact of different intervention strategies for the problem of APP.
- Monitor soil, water, and work places, as well as pesticide residues in food.
- Characterize under-registration, using a standard model

## **6. Evaluation of the System**

To evaluate the fulfillment of APP surveillance activities, an assessment must be carried out at every participating level: local, regional, and national. Evaluation includes: 1) fulfillment of the directives established by the system, 2) ad-

ministrative and human resources, including appropriate materials for the development of the system and resources necessary to carry out activities of surveillance, 3) Aspects related to the system's capacity to detect cases and prevent and control future cases, 4) Reduction of morbidity and mortality rates.

Indicators of fulfillment of surveillance actions

- Proportion of reported cases with complete report file
- Proportion of cases reported by the community
- Proportion of alert situations that are investigated
- Proportion of alert situations with intervention follow-up in occupational and accidental cases
- Time elapsed between reported and investigated cases.

Attributes of the system:

It is considered a prerequisite that data available through the surveillance system are of good quality and consistent. The system must also be sustainable and stable.

*Simplicity:* Ease of collection and analysis of APP data.

*Flexibility:* Capacity to incorporate monitoring of the APP in existing surveillance systems.

*Acceptability:* Willingness of individuals and organizations to participate in the Surveillance System.

*Sensitivity:* Ability of the system to capture the cases of APP that really occur in the population. It can be affected by underreporting and low quality of the diagnosis.

*Positive predictive value:* Proportion of APP cases captured by the system that really are cases.

*Representativeness:* Capacity of the system to accurately reflect APP that occur at territorial levels. It can also be affected by underreporting.

*Opportunity:* Rapid availability of the APP data for its report and response.

## 7. Responsibilities of the Surveillance System at different levels.

Local level:

- Data collection
- Alert identification
- Epidemiological investigation of the alerts
- Epidemiological analysis
- Prevention and control actions
- Report to higher levels
- Dissemination of pertinent information

Regional level:

- Consolidation of information from local levels
- Epidemiological analysis of behavior of the problem in the region
- Report to the national level
- Advisory services at the local levels
- Dissemination of information at regional and local levels

– Evaluation of the System at the local level

National level:

- Consolidation of information from the regional levels
- Epidemiological analysis of the behavior of the problem at the national level
- Advisory services at regional levels
- Strengthening of sanitary regulation regarding pesticides
- Evaluation of the Surveillance System at the regional level
- Dissemination of information at the national, regional and local levels

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*Source:* Prepared by Dr. Samuel Henao from the PAHO/WHO Representation in Costa Rica and Dr. Maria Patricia Arbelaez from the Public Health Department of the University of Antioquia, Medellin, Colombia.