ALERT AND SENTINEL APPROACHES TO DETECT WORK-RELATED DISEASES

SENSOR-Pesticides Program, USA

This discussion paper is part of a series aiming at describing alert and sentinel approaches for the early detection of work-related diseases (WRDs) in order to provide more insight into the way these systems function and into the drivers of and obstacles to the implementation of such systems. This article describes the Sentinel Event Notification System for Occupational Risks (SENSOR)-Pesticides in the United States and is based on EU-OSHA's project 'Alert and sentinel approaches for the identification of work-related diseases in the EU' (EU-OSHA, 2018) consisting of a literature review and an in-depth qualitative study and commissioned to a research team made of experts from the Catholic University of Leuven, the Coronel Institute, the Finnish Institute of Occupational Health, the University of Manchester and the University of Bologna.

Introduction to the approach

The Sentinel Event Notification System for Occupational Risks (SENSOR)-Pesticides is a state-based surveillance programme in the United States that monitors pesticide-related illness and injury.

Summary of main characteristics

- SENSOR was the first OSH surveillance system to be designed according to the sentinel approach (Baker, 1989).
- The SENSOR-Pesticides Program is the only remaining system of the initial SENSOR that has retained its original name; schemes for other WRDs have developed into independent systems with different names.
- SENSOR has three main sources of data: the State Department of Agriculture, poison control centres and the workers' compensation system.
- The main strong points of the SENSOR-Pesticides Program are its clear case definitions; a detailed description of cases through numerous standardised variables; and a thorough assessment procedure of the reported cases, including classification of cases, determination of case severity, case investigation and follow-up.
- Usage of SENSOR data is closely related to the activities of the Environmental Protection Agency (EPA), which enables the necessary link with prevention and pesticide-related policy.

Initiating organisation

The initiating organisation is the National Institute for Occupational Safety and Health (NIOSH). This is the United States' federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) within the US Department of Health and Human Services.

History of the approach

The SENSOR system began in 1987 (Baker, 1989). The original idea was to set up sentinel providers that would be linked to NIOSH and provide information on any identified work-related health problems. The SENSOR-Pesticides Program is the only remaining system of the initial SENSOR that has retained its original name, whereas schemes for other WRDs have developed into independent systems with different names.

At the time of the system's initiation, the sentinel providers were physicians working in different clinics across the USA. However, because of this method of organisation, the system failed to sufficiently reach its objective. Physicians' reporting seemed inefficient as a source of data collection, as physicians did not consider reporting to public health authorities a priority in their clinical practice.

This led to changes in the organisation of the SENSOR network. Reporting physicians were replaced by three other sources of data collection: the State Department of Agriculture, poison control centres and the workers' compensation system. The state health departments also played a significant role in the data collection process, as they are public health authorities and were supported by state laws that require all healthcare providers to report pesticide poisoning to the state health department. The new organisational model proved to be more efficient and has been in place ever since, currently covering 13 of 50 states across the USA.

Programme's aim and objectives

The SENSOR-Pesticides programme aims to identify emerging acute pesticide-related health problems. SENSOR-Pesticides provides post-marketing surveillance, after pesticides are tested for possible risks and officially put on the market. This system is in charge of detecting any adverse health effects that could be linked to exposure to pesticides launched on the market. In this sense, SENSOR has a similar design to the corresponding system in the drug industry for post-marketing surveillance of adverse events in the use of approved drugs. The objective of this system is closely linked to the activities of the federal EPA, which creates laws that regulate pesticide use and delegates enforcement authority in each state.

Description of the programme's workflow and reporting

Reporting

Cases of pesticide poisoning, reported mainly by telephone, are transferred each day from the State Department of Agriculture and poison control centres to the state health departments. Workers' compensation data are transferred on a weekly basis. Experts from the state health departments also apply a data mining method by using established search algorithms in order to identify compensation cases related to pesticide poisoning.

Work-relatedness evaluation

Experts in the state health departments perform the first assessment of cases to select those that fit the definition determined by NIOSH in its "Case Definition for Acute Pesticide-Related Illness and Injury Cases Reportable to the National Public Health Surveillance System" (NIOSH, 2012). For the case definition, a case is characterised by an acute onset of symptoms that depend on the formulation of the pesticide product and involve one or more of the following:

- systemic signs or symptoms (including respiratory, gastrointestinal, allergic and neurological signs/symptoms);
- dermatological lesions;
- ocular lesions.

NIOSH has also determined criteria for classifying a case as "occupational if exposure occurs defining a case as work-related: a case is classified as occupational if exposure occurs while at work (this includes working for compensation; working in a family business, including a family farm; working for pay at home; and working as a volunteer emergency medical technician, firefighter or law enforcement officer). All other cases are classified as non-occupational. All cases involving suicide or attempted suicide should be classified as non-occupational". (NIOSH, 2012)

In addition, a case can be reported to the SENSOR surveillance system when it has (NIOSH, 2012):

- documentation of new adverse health effects that are temporally related to a documented pesticide exposure; AND
- consistent evidence of a causal relationship between the pesticide and the health effects based on the known toxicology of the pesticide from commonly available toxicology texts, government publications, information supplied by the manufacturer, or two or more case series or positive epidemiologic investigations; OR
- insufficient toxicological information available to determine whether or not a causal relationship exists between the pesticide exposure and the health effects.

If available, laboratory data can be used to confirm exposure to a pesticide.

Reporting mechanism

After the initial screening of the reported case, the expert from the state health department assigns an investigator to follow it up. As the information provided by the initial case report is usually scarce, the experts from the state health department who assess the case need to obtain additional data in order to determine whether or not the abovementioned criteria are fulfilled. This process differs among states. In some states, further information is gathered through medical records exclusively, whereas in others data are collected through phone interviews with the worker or even through worksite inspections. The latter usually take place in larger agricultural pesticide drift events, when the investigators often go on site, sometimes accompanied by an investigator from the state departments of agriculture and labour.

Cases are then scored on the basis of the classification criteria provided by NIOSH and described in its documentation. Specific criteria are defined to classify each of the aspects ‘exposure’, ‘health effects’ and ‘causal relation’ from 1 (strong evidence) to 4 (evidence lacking). The classification matrix is provided with the case classification categories and the criteria scores needed to place the case in a specific category. The categories are definite cases, probable cases, possible cases, suspicious cases, unlikely cases, cases with insufficient information and not a case (Table 1).

Table 1: Case classification matrix

Classification criteria	Classification categories[a]									
	Definite case	Probable case		Possible case	Suspicious case	Unlikely case	Insufficient information		Not a case: Asymptomatic[b]	Not a case: Not related[c]
A. Exposure	1	1	2	2	1 or 2	1 or 2	4	-		3
B. Health effects	1	2	1	2	1 or 2	1 or 2	-	4	3	
C. Causal relation	1	1	1	1	4	2	-	-		3

a Only reports meeting case classifications of definite, probable, possible and suspicious are reportable to the national public health surveillance system. Additional classification categories are provided for states that choose to track the reports that do not fit the national reporting criteria.

b The matrix does not indicate whether or not asymptomatic individuals were exposed to pesticides, although some states may choose to track the level of evidence of exposure for asymptomatic individuals.

c Unrelated = illness determined to be caused by a condition other than pesticide exposure, as indicated by > 3 in the evidence of exposure or causal relationship.

Source: NIOSH, 2012

Definite, probable, possible and suspicious cases are reportable to the national surveillance system. Additional classification categories are provided for states that choose to track reports that do not fit the criteria for national reporting.

Furthermore, a severity index is assigned to all the cases classified as definite, probable, possible or suspicious. This severity index is based on existing systems for ranking the severity of poisonings, including pesticide illness. It takes into account the following: signs and symptoms, whether or not medical care was sought, whether or not the individual was hospitalised, and whether or not working time or time on usual activities was lost. In this way, this severity index is used in conjunction with the case definition determined by NIOSH. The severity categories are death, high-severity illness or injury, moderate-severity illness or injury, and low-severity illness or injury.

Communication

Workers receive no active feedback within the SENSOR reporting system. However, if a worker wants to know more about his or her case, the state will provide the information, but this kind of feedback needs to be initiated by the worker.

On the other hand, feedback to the reporting centres is a common step in the assessment procedure. This is critical for maintaining reporting to the surveillance programme and ensuring that this very educational aspect is used to deliver prevention information.

Data storage

The collected data on each poisoning case are organised using variables. For all variables that are collected, states are encouraged to use standardised formats. The standardised variables are the following:

- Administrative and demographic variables: information on the source(s) of the report, relevant dates, event identifiers, county and state of exposure and residence, sex, age, ethnicity and race.
- Occupation and industry data: occupation is coded using either US Bureau of Census codes (National Centre for Health Statistics - NCHS 2003) or the 2000 Standard Occupational Classification codes (OMB 2000). Codes for industry can be based on either Bureau of Census codes (NCHS 2003) or North American Industry Classification System.
- Exposure descriptions: type of exposure (drift, direct spray, indoor air, contact, etc.), route(s) of exposure, whether or not exposure was intentional, the person's activity at the time of exposure and protective equipment worn by the exposed person. This item also captures information on the equipment used to apply the pesticide, the intended target of the application, where the pesticide was being applied and where the person was located when exposed (farm, nursery, home, school, manufacturing facility, etc.).
- Chemical information: information on the pesticide product(s) associated with the exposed person's illness or injury.
- Health effects description: information on biological monitoring, medical diagnosis, pre-existing conditions, signs and symptoms, type of care received, and whether or not the person lost working time or time on regular activities.
- Investigation findings.
- Case classification.

The stored data are submitted to NIOSH annually and NIOSH uses the data to assemble an aggregated database.

Dissemination

Results of the site inspections are disseminated through written reports of findings provided to the affected person(s), and the employer or third party responsible for the pesticide application. In the case of worksite inspections, a summary report may be provided to all interviewed workers. This report should clearly communicate any recommendations arising from the case assessment. Follow-up to determine if these recommendations are adopted should be conducted after an appropriate time interval. Follow-up may be conducted by mail, telephone or a site visit, especially if the recommendations included engineering controls.

Financial aspects

The estimated costs of maintaining the SENSOR-Pesticides system are approximately USD 1 million to USD 2 million per year. The system's financial resources differ among the participating states and are mostly provided by either NIOSH or EPA, although some states are currently self-supported. Of the 13 states participating in the SENSOR-Pesticides programme, the following 5 receive federal funding and NIOSH technical support to bolster pesticide-related illness and injury surveillance: California, Illinois, Michigan, Texas and Washington. The other eight states receive technical support from NIOSH, but are federally unfunded SENSOR-Pesticides partners: Florida, Iowa, Louisiana, Nebraska, New Mexico, New York, North Carolina and Oregon.

Usage of data

Examples of data usage for informing policy and prevention

The usage of the data collected by the SENSOR-Pesticides programme for prevention and policy is closely related to the activities of EPA. As mentioned before, one of the tasks of EPA is the legal regulation of pesticide use. More specifically, the EPA Office of Pesticide Programs (OPP) is dedicated to reviewing pesticide products and potential risks to human health, the environment and the users, be they home owner users or professional appliers. The OPP registers pesticides before they are released onto the market. The pesticide industry and the registrant who develops the chemical and the product have to submit to a variety of different OPP studies to provide evidence that the product is safe. OPP experts assess and evaluate these findings. The role of SENSOR-Pesticides is to provide EPA with additional data on adverse health effects caused by pesticides, which will then be integrated into the ongoing re-evaluation process of new chemicals. Some of the incidence data are also gathered through the EPA Incidence Data System, but this system focuses on home pesticide users and owners, and thus excludes a large group of users, for instance commercial operators, pest control operators and farm appliers. Therefore, data provided by SENSOR are of great importance in the overall pesticide registration and evaluation procedure.

SENSOR-Pesticides enables the identification of the root causes of pesticide-related illnesses among farm workers, which has led to the most dramatic revision to the worker protection standards in the last 20 years. A great deal of work was done to make these standards more modern, more protective and closer to OSHA labour standards. These changes were also intended to provide much more hazard and safety information to farm workers and to make agriculture employers more accountable for complying.

Another example is the changes in the law related to pesticide use in schools after identification of pesticide poisoning associated with pesticide use at schools. Most of the data regarding this issue were derived from SENSOR-Pesticides. After an article on this topic was published in 2005, several states adopted laws requiring schools to use integrated pest management practices for pest control (Alcaron et al., 2017). The article also served as evidence for the advocates of integrated pest management in schools to highlight the issue of using pesticides in schools and to insist on the application of alternative (non-chemical) measures whenever possible.

SENSOR data also highlighted adolescent workers as a vulnerable group regarding pesticide exposure. After publishing the results (Calvert et al., 2003), EPA changed the worker protection standard and the certification and training standard. A minimum age of 18 years has been determined for workers applying pesticides in agricultural areas.

Another vulnerable group of workers identified through SENSOR is pregnant farm workers. Three farmworkers who gave birth to infants with severe birth defects were identified and a case report on this issue was published in 2007 (Calvert et. al., 2007). The cases were grouped according to time and space: three infants were born within eight weeks of one another to mothers who worked for the same tomato grower in Florida. It was documented that they had all been exposed to pesticides by going into fields prematurely. In addition, the women had not used the appropriate personal protective equipment. This article was cited in the revision of the worker protection standard, and some specific protective measures aimed at pregnant farm workers as a particularly vulnerable group were raised.

Examples of data usage for detecting new/emerging WRDs

SENSOR data from 2001 to 2005 were analysed to investigate possible health risks related to exposure to pyrethrins and pyrethroids. Pyrethrins and their synthetic derivatives, pyrethroids, have become the predominant class of insecticide for public health and residential uses thanks to their low environmental persistence and the slow development of resistance to them in pests. They were also introduced as a less hazardous substitute for organophosphate insecticides in the 1990’s. SENSOR data revealed several pyrethrin or pyrethroid pesticide poisonings, of which approximately one-quarter were work-related cases. A list of clinical signs and symptoms reported by people with pyrethrin or pyrethroid poisoning has been compiled, revealing respiratory symptoms to be the most common category, followed by neurological and gastrointestinal symptoms. Whereas some of the listed symptoms had already been linked with pyrethrin and pyrethroid exposure, several additional health effects were revealed that had not been previously recognised in this context (mainly respiratory symptoms). Moreover, data analysis showed that pre-existing conditions such as allergies and asthma were significantly associated with chemical sensitivity and illness severity.

These data were published in an article in 2009 and served as the basis for a list of recommendations for the EPA, emergency response workers, state agencies or health departments, and health-care providers (Walters, 2009).

SENSOR data from 2001 to 2007 were used to evaluate the health effects of Fipronil, a relatively new pesticide, after its introduction onto the market. Fipronil is a broad-spectrum phenylpyrazole insecticide, widely used to control residential pests, and is also used in the flea and tick treatment of pets. A paper by Lee et al. (2010) described the magnitude and characteristics of acute illnesses associated with Fipronil exposure. A total of 103 cases were identified in 11 states. Annual case counts increased from 5 in 2001 to 30 in 2007. Of the patients, 55 % were female, the median age was 37 years and 11 % were under 15 years old. The majority (76 %) had been exposed in a private residence, 37 % of the cases involved the use of pet care products and 26 % had work-related exposure. Most cases (89 %) had mild, temporary health effects. Neurological symptoms (50 %) such as headaches, dizziness and paraesthesia were the most common, followed by ocular (44 %), gastrointestinal (28 %), respiratory (27 %) and dermal (21 %) symptoms/signs. Exposures usually occurred from inadvertent spraying/splashing/spills of products or inadequate ventilation of the treated area before re-entry. The authors concluded that exposure to Fipronil may pose a risk of mild, temporary health effects in various body systems, and that precautionary actions should be reinforced to prevent Fipronil exposure among product users (Lee et al., 2010).

Stakeholders' views

This article is partly based on qualitative, in-depth face-to-face or telephone interviews with three stakeholders of the system. The interviews reflect the views of different actors in the system (e.g. owner of the system, workplace actor reporting it, and researcher or other stakeholder using the resulting data from the system) on the drivers and obstacles (Table 2), the quality of data and the transferability to other countries of the system or approach.

Drivers and obstacles

Table 2: Drivers and obstacles

Drivers	Obstacles
The ***motivation*** of healthcare providers to report is essential. Even though reporting is mandatory, stakeholders emphasised an additional need to encourage reporting. With regard to this, being able to contact the poison control centres makes the reporting procedure easier, especially if the reporting party is uncertain about the case. Stakeholder 2 (reporting party): *'We've tried to get the word out that all you have to do is call the poison centre … But over the years it has helped if they know that, if they're not sure if they should report it or not, they just call the poison centre and that helps.'*	The ***motivation*** of health care providers to report is also an obstacle as much as a driver. One of the stakeholders hinted that automation of the reporting procedure may be one possible way to deal with this issue. Stakeholder 2 (reporting party): *'What's true in the United States I can say is that unless there's a real reason why a physician would want to report it they're not going to report it: nobody's going to fine them or penalise them for not reporting. So, we need automated systems. So, the first visits, when folks first come to a clinic or an emergency room, there should be some way to just check a box if this is a reportable condition. And then it could be automatically transferred.'*

Drivers	Obstacles
Other states need motivation to participate. This is not necessarily linked to financial support; it is more closely related to the confirmation of the value of the system that the participating states have experienced. Therefore, it is essential to demonstrate the value of the system by analysing and publishing gathered data as well as providing recognition to all the participating states and stakeholders of the overall work of SENSOR. Stakeholder 1 (owner): *'Well, I think it's kind of interesting that out of the 13 states that currently participate, only 5 of them are currently receiving federal support. And so, the other eight states, even when they previously received federal support but no longer do, they typically don't drop out of the system. They still collaborate, they see the value of the system, they see that we're productive, that we use this data, we write these reports and that our programme has impacts. We share our findings with the EPA. And the EPA adopts regulations to address the issues that we identify.'*	***Financial support*** Even though finances are not always the determining factor for motivating individuals and states, they often limit human resources and thus indirectly affect the quality of the gathered data. As mentioned before, unequal distribution of money between the participating states often leads to varying quality of reported data. In addition, the lack of human resources makes data cleaning and analysis more difficult and creates a time lag between data collection and dissemination. Stakeholder 3 (researcher): *'Priorities have shifted. We literally have no capacity, funding or resources to support the states anymore. So that's a huge problem that we have to think about addressing, because if there are unfunded states there are absolutely less cases, less coding and sometimes they fall out.'*
In terms of drivers of prevention, interviewees pointed out the ***collaboration with EPA***, which is crucial for using SENSOR data for policy and prevention. However, this collaboration is often driven by politics, which determines the level of recognition and financial support that is given to environmental protection and safety.	
Stakeholder 2 (reporter): '*One of the key users is the environmental protection agency. And they have used our data and you can see it in the revision of the workers' protection standards. They're such a key organisation in serving our data.'*	

Data quality

Some interviewees expressed their concerns about the quality of the coded data in the reporting form. NIOSH experts often spend a lot of time cleaning the data before they can be used for dissemination and publication in scientific papers. However, NIOSH is applying measures to address this issue. Twice a year, a quality control exercise is performed in the states, which consists of sending out a series of questions or scenarios to be coded. Afterwards, all the answers are collected and compared with the coding done by the NIOSH experts. The findings are presented, and each question is thoroughly discussed, which reveals the states that gave right or wrong answers. This takes place in the form of webinar or a workshop that brings everybody together in person. Overall, data collected by SENSOR are considered detailed and valuable, as long as the cases are coded adequately.

Stakeholder 3 (researcher): '*I think it's the very best quality there is for pesticide incidence because of the depth of detail that is provided when the state person has the time and ability to really thoroughly code the case.*'

As described by one of the stakeholders, poor quality of aggregated data is often linked to financial limitations:

Stakeholder 3 (researcher): 'It's limited in some states that don't have any federal funding and have way less time to devote to coding the cases. We pretty much only do the very basics, so there are many blanks.'

It is worth mentioning that the data collected differ even between the states that take part in the SENSOR-Pesticides programme. For instance, some states that have poorer funding do not follow up all the cases of pesticide poisoning but rather focus on occupational pesticide poisoning, which is in line with NIOSH's mission to protect workers above all else. However, even some states that focus only on workers are not able to follow up all workers' cases. Consequently, some information is comparable in all the states (mainly the information on conventional pesticides), whereas other information is not comparable (for instance surveillance for antimicrobials, which is poor in many states).

Moreover, data derived from the workers' compensation system are unequally distributed across different states. For instance, in Washington, California and Illinois the link with the workers' compensation system is good, thus providing a significant source of information. However, the other 10 states have very little access to workers' compensation data.

Another point regarding data quality raised during the interviews is the issue of time lag due to data cleaning. By the time the data are refined and available to the users in EPA, there is already a lag of about two years. However, any kind of alert event has priority in analyses and is called 'a high priority exposure event'. In such a case, information from the states is instantly sent to NIOSH and EPA with all the details.

Transferability to other countries

When discussing the transferability of SENSOR-Pesticides to other countries, the interviewees mentioned the well-defined case definition, standardised variables and severity index as items that are transferable and could be used to build a similar surveillance system, regardless of potential differences in data collection or the public health context. Moreover, the Centers for Disease Control and Prevention (CDC) and NIOSH have jointly published a standardised protocol called *Pesticide-Related Illness and Injury Surveillance: A How-to Guide for State-Based Programs* (CDC & NIOSH, 2005), which could be a helpful tool for setting up a pesticide surveillance programme.

Another prerequisite for implementing a system such as SENSOR is funding. Financial support is crucial to provide the necessary training for the people involved in the system, as well as to enable the recruitment of competent and motivated professionals. These professionals also need to play the role of mediators and do a lot of outreach and networking, which is necessary to keep all the stakeholders working together. Finally, federal backup is also a significant supporting factor for establishing and maintaining a pesticide surveillance system.

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- **Links for further reading**

Presentation on SENSOR Pesticides at the EU-OSHA project workshop in Brussels on 18 May 2017 (BE) available at: https://osha.europa.eu/sites/default/files/seminars/documents/SENSOR-Pesticides%20system%20USA%20Presentation%20Alarcon.pdf

The literature review report, the final report and summary report of the EU-OSHA's project 'Alert and sentinel approaches for the identification of work-related diseases in the EU', as well as two summaries of two seminars (18 May 2017 in Brussels (BE); and 31 January 2018 in Leuven (BE)) and the presentations given at the seminars are available from : https://osha.europa.eu/en/themes/work-related-diseases/alert-and-sentinel-systems-osh

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