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## Assessment of Health Care and Economic Costs Due to Episodes of Acute Pesticide Intoxication in Workers of Rural Areas of the Coquimbo Region, Chile

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### ABSTRACT

**Background:** The increase in agricultural activity that Chile experienced in the past 20 years resulted in a boost in the use of pesticides. Despite pesticides' productivity benefits, they caused health problems such as the increased frequency of episodes of acute poisoning, which constitutes a relevant problem in terms of occupational health. The Chilean authorities require several preventive measures at workplaces, which are not always implemented, increasing the risk of intoxications in farmers. So far in Chile, there are no studies concerning the public health care expenses associated with acute work-related pesticide intoxications. From the societal perspective, there are costs involved if the worker needs to take sick leave and families incur costs to take care of their sick members. **Objectives:** This study aimed to determine the costs associated with health care services used by people who suffered from work-related acute pesticide poisoning, as well as the economic costs for the families of the workers involved, and finally the costs of these episodes for the employer/industrial sector. **Methods:** This study considered a 3-year period (January 2009 to December 2011). Three sources of data were reviewed: reported cases at the Regional Health Authority, for the profile of the intoxications; registers of patients attended in public hospitals, for data on costs of health care services; and public

information of living conditions nationwide. **Results:** The overall costs of a single case depend on the severity of intoxication, days of sick leave, and type of health care needed. Most cases (77%) would be ambulatory and would be assisted at an emergency room, with an average cost of US \$330 per case. Those cases that might need hospitalization (23%) and, therefore, more days off work have an average cost of US \$1158 per case. Taking into account the number of patients reported each year in the country, the cost per annum would be about US \$185,000, but considering the underreporting of intoxications and underestimation of costs at the public insurance system fees, this amount could be six to eight times higher (US \$1.1 million to US \$1.4 million a year). **Conclusions:** This study is the first attempt to estimate costs related to this occupational and public health problem. There is an opportunity to further improve the cost-benefit balance of preventive measures that relate not only to acute poisonings but also to health problems originating from chronic and low-dose exposure to pesticides (e.g., neuropsychological impairment). **Keywords:** cost analysis, occupational health, pesticide poisoning.

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### Introduction

According to the ODEPA Employment Bulletin, the workforce in Chile for the period March to May 2012 amounted to 7,613,709 persons, 694,047 of whom were linked to agriculture [1]. Data from the International Labour Organization indicate that Chile exported agricultural products worth US \$5.411 million in 2007, primarily fruits (US \$3.351 million), wines (US \$1.241 million), and seeds (US \$230 million) [2–4]. Over the past 20 years, the import of pesticides increased by 469%. The imports of insecticides for agricultural use increased by approximately 20% between 2001 and 2005 [5]. The use of pesticides contribute to the enhancement of agricultural

productivity, but the harmful effects that such applications have on the health of human populations are also well known and have been demonstrated. The Coquimbo region is located in the central/north of Chile, with a total of 720,000 inhabitants. Agriculture is the primary economic activity in this region, with about 45,000 workers [6].

The Regulation on Basic Sanitary and Environmental Conditions in the Workplace in Chile [7] requires safety and preventive measures that should be adopted by the employers at workplaces. These measures focus on providing personal protection equipment, safe storage, restrictions when using hazardous products (pesticides among others), as well as specific reentry times after the use of pesticides. This regulation also establishes

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the permissible limits for biological tolerance values in the case of exposed workers and limits for the environmental exposure to physical and chemical agents.

Supreme Decree N° 594 establishes the limit of biological tolerance at 70% of the baseline levels of cholinesterase activity in an individual. This implies that measurements of enzymatic activity must be repeated, a baseline one before exposure and a second one after exposure, thus duplicating the cost of diagnosis. The cost of a single cholinesterase evaluation at the National Institute of Public Health is US \$72.98 [8]. The compliance assessment is the task of the Regional Ministerial Secretariats of Health (Sanitary Authorities—Ministry of Health).

There is also a national network on acute poisoning surveillance (red de vigilancia epidemiologica de intoxicaciones por Pesticidas [Pesticides Intoxications Network]), created by Supreme Decree N° 88, dated October 2004 [9]. In the period 2009 to 2011, the total number of poisoning cases notified to the red de vigilancia epidemiologica de intoxicaciones por Pesticidas was 1514. Of these, 932 were work-related (61.6%) and 39% of the intoxications were caused by organophosphate pesticides [10-13]. The real number of poisonings is estimated to be much higher because, in general, the affected workers do not report the incidents (they fear consequences in terms of their employment status) or there are no health care records due to lack of information about the effects of the pesticides and due to underdiagnosis. The total number of poisonings is estimated to be three to four times higher than the official registrations, thus corresponding to around 3000 annual poisoning cases.

Acute poisonings among agricultural workers generate a cost to the country (considering the demand for health care services), loss of workforce (and a need for its replacement), and sick leave due to the poisoning, with an average of 6 days for each sick leave [14,15]. Up to date, there is no previously published study regarding the overall costs associated with poisonings due to exposure to pesticides at work.

This study aimed to determine the costs associated with health care services used by people who suffered from work-

related acute pesticide poisoning, as well as the economic costs for the families of the workers involved, and finally the costs of these episodes for the employer/industrial sector.

### Methods

This cost analysis was conducted from the societal perspective, and it includes health care costs, costs of productivity losses from poisoning episodes, and the costs of seeking and/or undergoing care as they fall on patients. During the investigation, it became clear that not all cases admitted in hospitals were reported to the Epidemiology Unit (Regional Health Authority, Ministry of Health) and vice versa; not all reported cases were attended at the public hospitals; probably many had gone to a primary health care facility in rural areas and/or to the private system when near to a city.

Therefore, three sources of data were assessed for the study period January 2009 to December 2011: (1) Information regarding pesticide intoxications reported at the Epidemiology Unit (Ministry of Health), which corresponds to 57 work-related poisonings. From this source, the profile of the poisonings, average days off work, and days of sick leave were known. (2) Information about health care services from the three main public hospitals in the region was reviewed, taking into account people who suffered acute intoxication due to pesticides and who required hospitalization, corresponding to 26 patients. (3) Finally, information from public Web sites and publications related to national living costs and conditions was searched. For more detail, refer to Figure 1.

From the hospitals, data to assess the health care costs were taken from the 26 patients' files, discharges registers, and hospital administration registers. Access to medical files was approved by the directors of the health facilities. For the analysis of health care costs, the study considered only people of working age (women aged 18-60 years and men aged 18-65

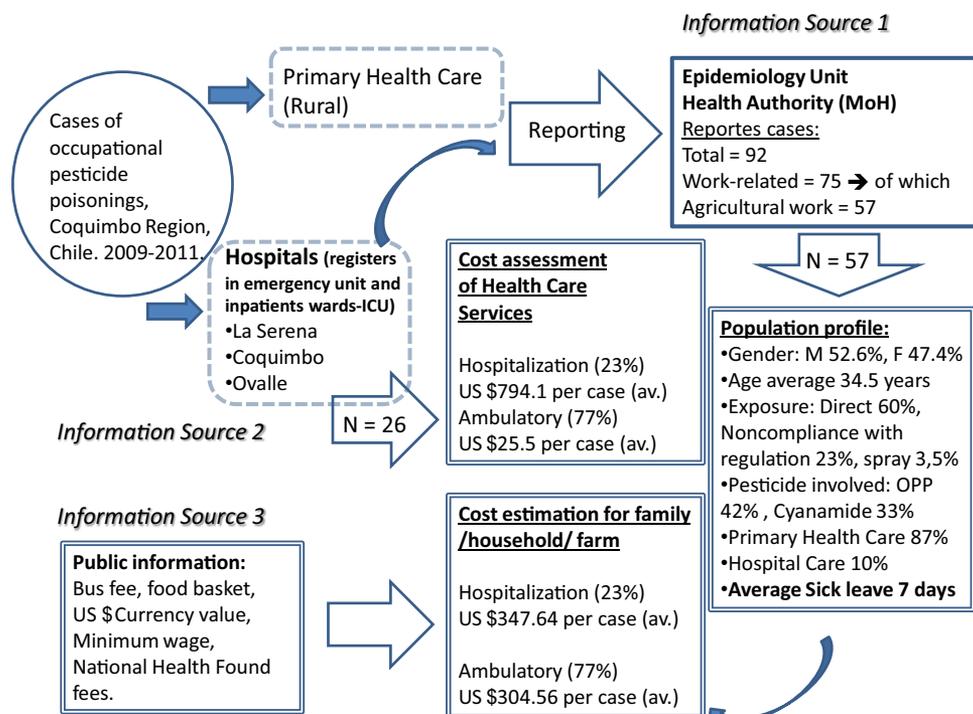


Fig. 1 – Chart of methods, sources of information, sampling strategies, and main results. av., average; F, female; ICU, intensive care unit; M, male; MoH, Ministry of Health; OPP, organophosphate pesticide.

years) whose diagnosis was associated with a work-related poisoning. All cases were seen and treated at public hospitals under coverage by the National Health Fund (Fondo Nacional de Salud [FONASA]), which covers 76.5% of the regional population [16]. Cases from the private insurance system were not considered because private providers refused to give information. Health care costs were estimated using the microcosting methodology, looking into the different kinds of care/services provided to every person treated [17–19]. The cost was measured on the basis of invoiced care services registered at each of the hospitals. Data to determine the package of health care services were completed by the review of medical files. The items that were considered for valuation, when hospitalization was required, were medical consultation at emergency room, day-bed at intensive care unit, day-bed in general medical ward, kinesiology sessions, ambulance transport, diagnosis support (laboratory, electrocardiogram, x-ray), and medication. For those who were not hospitalized, medical records showed that no diagnostic support was provided (x-ray, laboratory work, or others); medical consultation at emergency room, medicines, and other pharmaceutical items were included for valuation in the investigation. The costs of the medical items were estimated from the prices defined each year by FONASA, published in the Official Gazette on January 28, 2013. As for the medicines, values were obtained from average prices that every hospital considered when purchasing medicines in the first quarter of the year 2013. For all costs, the considered currency rate was 472.62 Chilean pesos per US \$1, as of January 15, 2013 [20].

For the productivity loss at the workplace, the minimum wage was assumed to be US \$409/mo [21]. This considers 20 working days a month, assuming a cost per day of US \$20.46. Production losses associated with acute pesticide poisoning were assumed to correspond to the days of absence from work on the basis of notified cases at the Epidemiology Unit. Data on the days of sick leave were taken from the medical files of the notified cases. Because all cases were from rural areas, it was assumed that at least one family member would have to travel into the city on a daily basis (no cost for overnight stay was considered). The minimum transport fee was US \$3.18 one-way trip (two trips per day were assumed, either for ambulatory cases or for hospitalized cases). Regarding food, the costs were estimated from the value of minimum food basket, that is, about US \$80.6/mo (US \$2.7/d), according to the Ministry of Social Development (as of January 2013) [22].

## Results

### Profile of Work-Related Intoxications

The description of poisonings is based on reported cases of acute pesticide intoxication due to work-related activities in the study period at the Epidemiology Unit in the Coquimbo region (N = 57). For more details on characteristic of the population, route of exposure, and type of pesticides involved, refer to Figure 1. Health care was provided mainly at the primary level; 86% of the patients were sent back home and only 10.5% were referred to a hospital. For two cases (3.5%), the type of medical support was not registered. Finally, 34 cases registered days off work because of sick leave, with an average duration of 7 days.

### Cost Assessment on Health Care

Data on a total of 26 cases diagnosed with work-related acute poisoning were obtained from the three main public hospitals of the region over the study period. Of the 26 described cases, 20 (77%) sought assistance through ambulatory consultations (emergency room) and 6 (23%) required hospitalization. The length of hospital admission was on average 1 day at the intensive care unit and 4 days at the medical ward, based on medical files registers. For ambulatory cases, the cost was US \$25.5 per case. As for the hospitalized cases, the cost per case was US \$794. No fatalities were registered during the period of the study. See detailed figures in Table 1.

### Cost Assessment for Families, Households, or Farmers

An average of 7 workdays of medical leave was calculated from reported cases. The costs to the families correspond to a minimum of US \$29.52/d. The calculation of family costs per case depended on the severity of the poisoning, the type of health care required, and the period for recovery. For 77% of the cases referred to emergency room (ambulatory cases), the estimated overall cost was calculated to be US \$330.05 per case. As for the ones who needed to be hospitalized, one family member was assumed to travel and to have one daily meal in the city during the stay of the patient at the hospital (5 days on average). The same 7 days off for medical reasons were counted as a loss of productivity (in the farm) and loss of family income. The health care cost calculated per case was US \$810; adding the productivity

**Table 1 – Overall cost in US \$, per day and per case, of occupational poisonings due to pesticides: Coquimbo region, Chile (2009–2011).**

Cost of items regarding family care and health care	Ambulatory		Hospitalized	
	Per day	Per case	Per day	Per case
Family care/household/farm				
Productivity loss	20.46	143.22	20.46	143.22
Family cost	18.12	18.12	12.24	61.2
Family lost income	20.46	143.22	20.46	143.22
Subtotal	59.05	304.56	53.16	347.64
Health care services				
Medical consultation at emergency room	22.6		22.6	
Hospitalization (1-d ICU + 4-d medical ward)	–		550.35	
Ambulance transportation			25	
Pharmacy items (medicines and medical supplies)	2.98		127.79	
Diagnosis support (laboratory, x-ray, ECG)	–		85.25	
Subtotal	25.49		810.99	
Total cost per case	330.05		1158.63	

ECG, electrocardiogram; ICU, intensive care unit.

loss and family costs, each severe case costs US \$1158. For details, see Table 1.

To have a broader view on costs, this study considered estimating the cost on the basis of the reported cases, that is, 75 cases of work-related poisoning notified at a regional level and 933 cases in the country in 3 years [8]. For an overall estimation of cost per year, the number of cases was divided by 3. The overall estimated cost per year would amount to US \$14,915 for the Coquimbo region and US \$184,947 on a national level.

## Discussion

García [15] reported that for intoxications in the United States, costs depended on the severity of the case because this determines the type of health care needed and the number of days required for recovery. The same situation was found in the present study. Although the costs of health care for ambulatory cases were only US \$25, the health care costs of severe cases were 30 times higher. However, the cost for families and productivity loss were similar in any of the situations. Nevertheless, the expenses of these cases on families correspond to a substantial part of the minimum income (~50%). The costs calculated for hospitalization (average of US \$810/d) are similar to the costs published by García [15] regarding hospital health care for pesticide intoxication in the United States during the 1990s (US \$1000/d). The expenses for ambulatory cases are much lower compared with costs calculated for the United States (US \$25 and 630 per case, respectively). A possible explanation is the low cost rate for medical consultations in primary health care in Chile, where diagnostic support was not provided in any of the studied cases. When looking at the medicines prescribed for ambulatory cases, no atropine was used and the administration of antidote (oxime) was reported only in two cases. If those medicines were prescribed more frequently, the cost of consultations would probably be twofold higher. As was explained, the costing analysis of health care services used unit costs that correspond to reference fees supplied by FONASA, which are known to be underestimated and therefore do not reflect the cost of the services in economic terms [23]. Also, the costing analysis includes productivity losses in terms of people being absent from work for being ill and/or seeking and undergoing health care. At a societal level, these costs may be an overestimation of the real costs because, considering unemployment, these productivity losses can be mitigated by recruiting other workers.

If precautionary measures were observed, most of the poisonings would be prevented. Although preventive measures are enforced by law as an employer obligation, this is only for workers who have signed a contract. Unfortunately, in agricultural settings, temporary work occurs with no contracts as well as involves family farming (self-employed). It is well known that public resources to implement preventive programs and education in agricultural areas where workers are not part of any insurance system are scarce. Besides using protective equipment and clothing, one of the recommended preventive measures for acute intoxication is health surveillance by biomonitoring the workers. Plasma detection of cholinesterase activity should be conducted two times (as was explained before). Simple test evaluations of cholinesterase levels would be expected to be more cost-effective than the cost generated by the poisonings. The cost of assessing a single patient is two times the cost of cholinesterase, which corresponds to US \$146 [12], which is about 20% of the cost of one of the less severe cases (ambulatory care). Considering that the estimated incidence would be one case per 500 workers, US \$70,000 would be needed to diagnose a single case. The question arises: is cholinesterase detection an effective diagnostic test for poisoning? Scientific evaluations of this test show that the applicability is not as good as expected [24], with

wide variation in the test results among people tested. More clinical diagnosis based on signs and symptoms, plus exposure information, could represent a cost-effective alternative solution to an expensive laboratory test, but physicians must have the knowledge to properly identify cases and treat them.

The study has limitations: First, the Coquimbo region contributes with only about 3% of the cases that are reported on a national scale. Therefore, the studied population could not be considered to be representative of the entire nation. Second, the cost analysis is based on fees that poorly represent the real costs as is described in the study by Camilo et al. [23] about FONASA costs, in which costs appear to be on average 84% higher than established rates, showing differences ranging from 77% to 634%. Therefore, it is likely that estimated costs per case of the present study are underestimated. Regarding the approximate overall yearly costs for the Coquimbo region and Chile, they were calculated on the basis of reported cases. The estimated nationwide total cost was about US \$185,000, which would be three to four times higher, considering that underreporting is suspected. Given all these considerations, estimations of cost would be probably six to eight times higher, reaching US \$ 1.1 million to US \$1.4 million a year.

Finally, besides costs and consequences of acute poisoning, there are well known neuropsychological effects of chronic exposure to pesticides [25–27]. The social and economic impact of such long-term health effects is difficult to study but could contribute significantly to the overall public health problem. This study is the first step for further investigations that could assess cost-benefits of preventive measures, considering both acute and chronic health outcomes in workers exposed to pesticides.

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