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PAPER

TOXICOLOGY

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The Forensic Deaths Caused by Pesticide Poisoning Between the Years 2006 and 2009 in Izmir, Turkey*

ABSTRACT: Pesticide poisoning is still a significant health problem in Turkey. We conducted a retrospective study of autopsy cases at Izmir Branch of the Council of Forensic Medicine to describe the characteristics of deaths caused by pesticide poisoning between 2006 and 2009. The distributions of the cases according to gender and age were as follows: men 74.1% (n = 40, mean [±SD] age, 44.7 ± 14.1), women 25.9% (n = 14, mean [±SD] age, 39.2 ± 18.9). The majority of pesticide-poisoning deaths were suicides (n = 43, 80%) followed by accidents (n = 4, 8%) and homicide (n = 1, 2%). The manner of death could not be determined in six cases (11%). Suicides mostly occurred at home (n = 26, 63%) ($p < 0.05$). Methomyl was the most frequent pesticide (n = 9, 17%) among the all cases. This study reported that most of the pesticides found in poisoning cases were highly hazardous types. Combined efforts of medical professionals and law makers are needed for enacting strict laws against highly hazardous pesticides.

KEYWORDS: forensic science, forensic toxicology, pesticides, poisoning death, autopsy, surveillance

Pesticide is a substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (United States Environmental Protection Agency, http://www.epa.gov/opp00001/about/#what_pesticide.html [accessed February 15, 2010]). A number of studies report acute and chronic toxic effects of pesticides (1–15). Approximately, 3 million people in the world have been intoxicated by agricultural pesticides, which results in more than 220,000 deaths every year (4).

Pesticides can be classified according to their indications as insecticides, herbicides, fungicides, antimicrobials, and rodenticides (1,2) or according to their chemical properties as organophosphates, carbamates, organochlorine compounds, and pyrethroids (1). Several studies report that organophosphates and carbamates are mostly used pesticides and presents higher toxicity compared to the others (1–3). In the United States, 8.4% of all pesticide poisonings occur because of organophosphates and these are responsible for about 22% of deaths caused by pesticide poisoning (8). It is also known that pesticide poisoning is one of the most common methods of suicide in developing countries (9,10).

There are few studies reporting pesticide-poisoning-related deaths in Turkey (14,15). In 1950s, Cam et al. (12) first observed serious neurological symptoms and dermatological abnormalities in their patients and reported cutaneous porphyria disease caused by consumption of bread contaminated with hexachlorobenzene (13). In spite of understanding lethal effects since the 1950s, unfortunately the governments have not taken adequate measures for preventing indiscriminate use of pesticides till 2010. The aim of this study was to document the forensic deaths caused by pesticides reported from a center located in western region of Turkey between the years 2006 and 2009.

Materials and Methods

Izmir is the third biggest city in Turkey in terms of population, located in the Aegean region of the country. The Aegean region is located in the western part of the country with a population of *c.* 10 million (in year 2009) which makes it as big as many countries in Europe. Izmir Branch of the Council of Forensic Medicine is one of the seven major forensic institutes in Turkey, serving Izmir and also other cities located in Aegean region.

A retrospective descriptive 4-year review of data from the autopsy reports was carried out. Data were obtained from pesticide-poisoning autopsies performed by Morgue Department of Izmir Branch of Council of Forensic Medicine between January 1, 2006 and December 31, 2009. Pesticide poisoning was confirmed in these cases by analyzing the substance in biological samples (stomach, brain, liver, lung, and kidney) using thin layer chromatography and gas chromatography–mass spectrometry at the Toxicology Department of Izmir Branch of the Council of Forensic Medicine.

A computer-based recording form was designed to obtain the data from all cases. The variables such as age, sex, toxicological findings, seasonal variations, and manner of death were recorded in a database (FileMaker Pro 5.0 [FileMaker Inc., Santa Clara, CA] was used to design a data recording program) and analyzed by The Statistical Package for Social Sciences (SPSS) version 8.0 (SPSS Inc., Chicago, IL). Descriptive statistics and chi-square test were

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used to analyze the data. Fisher's probability test was carried out when necessary. Statistical significance was accepted at $p < 0.05$.

Results

The total number of pesticide-poisoning cases examined by the Morgue Department was 54 between January 2006 and December 2009. Forty of them (74%) were men and 14 (26%) were women.

The mean (±SD) age of cases was 43.3 ± 15.5 years. The highest frequencies of the poisoning cases were in the 25–44 year (40.7%) and 45–64 year (40.7%) age groups.

Suicide ($n = 43$, 80%) was the most common manner of death in pesticide poisonings, followed by accidents ($n = 4$, 8%) and homicide ($n = 1$, 2%). Owing to the lack of adequate information in coroner's investigation forms, the manner of death could not be determined in six cases (11%).

The cross-tabulation of manner (suicide, homicide, accident, and undetermined) of pesticide-poisoning deaths by sex and age group (0–24, 25–44, 45–64, 65 and over) showed that suicide in men in the 25–44 year and 45–64 year age groups is the leading manner of death and accounted for 59.3% ($N = 32$) of all cases.

The places where poisoning occurred were as follows: 31 cases (57.4%) at home, four cases in agricultural area, four cases in unmanned area, the other places were school ($n = 1$), beach ($n = 1$), riverside ($n = 1$), under bridge ($n = 1$), cool mine company area ($n = 1$), and store ($n = 1$). We could not determine the places in nine cases because of lack of adequate information.

The frequencies of pesticide-poisoning deaths according to the seasons of the year were as follows: summer 35.2%, spring 33.3%, autumn 16.7%, and winter 14.8%. Pesticide-poisoning deaths reached a peak in June (Table 1).

When we compared suicidal and accidental poisoning deaths according to the place of the exposure, suicides mostly occurred (63.4%, $n = 26$) at home and all off the accidental poisoning deaths occurred (100%, $n = 4$) in agricultural area ($p < 0.05$). Using pesticides by an untrained person without taking adequate precautionary measures might be a reason for accidental deaths that occurred during the agricultural activities. Considering the time of the exposure, the distribution of the accidental poisoning cases was not specific, on the other hand, that of suicide cases tended to increase between May and August ($p > 0.05$).

In 48 of the 54 autopsies, toxicological analyses were positive for pesticides. Methomyl was the most common pesticide ($n = 9$, 17%) found in toxicological analyses; the other common pesticides were dichlorvos (DDVP) ($n = 7$, 13%), endosulfan ($n = 6$, 11%), chlorpyrifos ($n = 5$, 9%), methamidophos ($n = 5$, 9%), and others ($n = 16$, 30%). Six of the 54 pesticide-poisoning deaths were treated in the hospital and stayed there for a long time. For that reason their toxicological analysis at the morgue department resulted negative pesticide levels because of the elimination process of pesticides while they stayed in hospital.

TABLE 1—*Total number of fatal pesticide poisoning deaths by month and year.*

	Year				
Month	2006 *n* (%)	2007 *n* (%)	2008 *n* (%)	2009 *n* (%)	Total *n* (%)
January	1 (1.9)				1 (1.9)
February	1 (1.9)			2 (3.7)	3 (5.6)
March	2 (3.7)	1 (1.9)		1 (1.9)	4 (7.4)
April		1 (1.9)			1 (1.9)
May	5 (9.3)			2 (3.7)	7 (13)
June	4 (7.4)	3 (5.6)	2 (3.7)	1 (1.9)	10 (18.5)
July	3 (5.6)	1 (1.9)	1 (1.9)	2 (3.7)	7 (13)
August	4 (7.4)	1 (1.9)	3 (5.6)		8 (14.8)
September	1 (1.9)	2 (3.7)	1 (1.9)		4 (7.4)
October	2 (3.7)	1 (1.9)			3 (5.6)
November	1 (1.9)	1 (1.9)	1 (1.9)		3 (5.6)
December	3 (5.6)				3 (5.6)
Total	27 (50)	11 (20.4)	8 (14.8)	8 (14.8)	54 (100)

Discussion

Pesticide poisoning is still a significant public health problem in Turkey (14,15). Yaycı et al. (14) reported that the ratio of pesticide-related deaths to all poisonings was 49.5% in the Mediterranean region, 41.2% in the Aegean region, and 5.3% in the Marmara region of Turkey between 1997 and 2001. A previous study from Izmir revealed that 8.8% of the all poisoning cases were caused by pesticides, and 47.6% of the pesticides were organophosphates (11).

Present study revealed that the mean age of fatal pesticide-poisoning deaths was 43.3 years. In the study of Yaycı et al. (14), approximately half of the pesticide-related poisoning deaths occurred under the age of 30 years. Kahraman et al. (15) evaluated pesticide poisonings in a University Hospital from June 1, 1993 to June 31, 2007 and they reported that the mean age was 34.1 years.

A male predominance was observed in our study compared with that reported by Yaycı et al. (14) (74.1% vs. 45%). Kahraman et al. (15) reported a similar rate of male subjects (61.1%) in Turkey. A previous study from Tehran on acute pesticide-poisoning-related deaths revealed that 63.3% of cases were men (16) and similar findings have also been reported in other studies in the literature (17,18).

In the present study, suicide ($n = 43$, 80%) was the most common manner of death. In the previous studies by Yaycı et al. and Kahraman et al. (14,15), suicide rates were 75% (153 subjects of 205) and 53.7%, respectively. Accidental cases were about 45% in the report by Kahraman et al. (15). The time of the poisoning was also similar in these three reports. Most of the patients died at home both in this report and in Yaycı et al. (14) (57.4% and 73%, respectively).

Methomyl and DDVP were the most common pesticides detected in poisoning deaths. According to WHO Pesticide Report, both methomyl and DDVP are classified as highly hazardous (Class Ib) pesticides (World Health Organization, http://www.who.int/ipcs/publications/pesticides_hazard/en/index.html [accessed February 15, 2010]). Similar to our report, DDVP was the most common pesticide found in organophosphate poisonings in the study by Kahraman et al. (15).

Endosulfan, a moderately hazardous (Class II) pesticide according to WHO (World Health Organization, http://www.who.int/ipcs/publications/pesticides_hazard/en/index.html [accessed February 15, 2010]), was the third most common type in this study. Methamidophos, a highly hazardous (Class Ib) pesticide (World Health Organization, http://www.who.int/ipcs/publications/pesticides_hazard/en/index.html [accessed February 15, 2010].), was the fifth most common pesticide. Methamidophos and endosulfan had been reported to be common pesticides in severe poisonings in Sri Lanka during the 1980s and early 1990s, before they were banned in 1995 and 1998 (19). After being banned in Sri Lanka, the number of deaths caused by the poisoning with methamidophos and endosulfan were significantly decreased (19,20).

Chlorpyrifos was the fourth most common pesticide found in poisoning deaths, which was classified as moderately hazardous (Class II) type (World Health Organization, http://www.who.int/

ipcs/publications/pesticides_hazard/en/index.html [accessed February 15, 2010]). A previous study reports that higher blood chlorpyrifos concentrations during pregnancy are found to be associated with poorer mental and motor development of children (21). Chlorpyrifos was one of the most widely used pesticides in the United States until being banned in 2005 (United States Enviromental Protection Agency, http://www.epa.gov/pesticides/reregistration/REDs/chlorpyrifos_red.pdf [accessed February 15, 2010]). In Turkey, there is no restriction for this hazardous substance. A pesticide, including chlorpyrifos, is still sold in the market without any restriction in 2011.

Depressive effects of pesticides on humans were shown in literature (22–24). The number of suicidal deaths was found to be increased between May and August in the recent study. Evaporation of the pesticides in hot summer days might have increased the toxicity and neurological depressive effects; but this speculation should be confirmed experimentally.

The National Vital Statistics Report of Turkey is released yearly and is not capable of showing all the underlying factors causing death (such as psychological, geographic, economic, and social factors associated with death). Although we do not present a new surveillance system in this article, we suggest that all important parameters must be momentarily recorded to a computer-based system for screening the underlying factors of poisoning deaths. Such a system may help to see the magnitude of the problems momentarily and allow taking sudden prevention measures. This kind of system can also provide evidence-based data for monitoring the effectiveness of prevention strategies.

In a conclusion, the lethal effects of pesticides are well presented in Turkey and in the world (25–30). Based on official surveillance systems, seven Central American 12 highly hazardous types of pesticides (26). According to the results of the present study, major policy adjustments are needed to protect public health. As a first step, very hazardous pesticide types should be banned or restricted. Also using pesticides by trained applicators is important to decrease the number of accidental pesticide-poisoning deaths.

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