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Review

Overview of Pesticide Poisoning in South Korea

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Abstract

The purpose of this article is to provide an overview of pesticide poisoning in South Korea and the relevant epidemiologic characteristics. During the period of 1996–2005, an approximate average of twenty-five hundred fatalities occurred per year due to pesticide poisoning, while age-standardized mortality rates by pesticide poisoning significantly increased from 4.42 to 6.42 per 100,000 population. Intentional self-poisoning was the primary cause of death due to pesticides (84.8% of total pesticide poisoning deaths). The prevalence of non-fatal pesticide poisoning among farmers varied from 5.7% to 86.7%. Paraquat was the leading causative agent for pesticide poisoning, followed by organophosphate insecticides. A variety of work-related factors such as pesticide usage, pesticide application days, hazardous practices and poor personal hygiene were significantly related with pesticide poisoning. The majority of the poisoned were male, elderly individuals possessing low levels of education and residing in rural areas. The number of pesticide poisoning cases was the highest during the growing season of May to August. Further evaluation of the incidence and risk factors of pesticide poisoning at the national level in South Korea is warranted to reduce the number of victims of pesticide poisoning.

Key words: epidemiology, pesticides, poisoning, South Korea

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Introduction

Pesticide poisoning is a major worldwide public health issue. According to World Health Organization estimates published in 1990, the over three million annual pesticide poisoning cases result in 220,000 deaths[1]. One recent study estimates that 258,234 annual deaths stem from pesticide self-poisoning worldwide[2].

Pesticide poisoning made up the largest proportion of all deaths by poisoning in South Korea[3]. Acute pesticide poisoning has also been reported as a prevalent health problem among South Korean farmers[4]. Traditionally, South Korea was an agricultural nation, and it still retains a farm population in excess of 3.1 million[5]. Pesticide production surpassed 23,000 tons in 2008, and 1,287 pesticide formulations had been registered as of the end of December 2008. The average pesticide application by area was 10.4 kg/ha in 1998, and this increased to 13.2 kg/ha in 2008[6].

In this paper, we provide an overview of the epidemiology for fatal and non-fatal pesticide poisoning in South Korea based on a literature review.

Deaths from Pesticide Poisoning

A small number of mortality studies on pesticide poisoning have been conducted using death registration data from South Korea. The most recent study[3] reported that the total number of pesticide poisoning deaths from 1996 through 2005 was 25,360 and that the age-standardized mortality rates by pesticide poisoning significantly increased from 4.42 to 6.42 per 100,000 population. The longitudinal trend of pesticide poisoning deaths exhibited an increasing tendency with escalating total suicide and poisoning deaths among both men and women, whereas total deaths steadily declined (Figure 1). The causes of pesticide-related deaths were classified by underlying cause of death according to the International Classification of Diseases and Related Health Problems, 10th Revision (ICD-10)[7], including intentional self-poisoning (ICD-10 X68), accidental poisoning (X48), assault (X87) and undetermined intent poisoning by and exposure to pesticides (Y18). Among these, intentional self-poisoning was the primary cause of death from pesticides (84.8% of total pesticide-related deaths). In South Korea, anyone is allowed to buy, handle and apply toxic agricultural chemicals without any necessary safety procedures. Pesticides, therefore, have become a common means for suicide in South Korea, whereas analgesics are the most common poisoning agent in the United States[8].

The death rate from accidental pesticide poisoning, in

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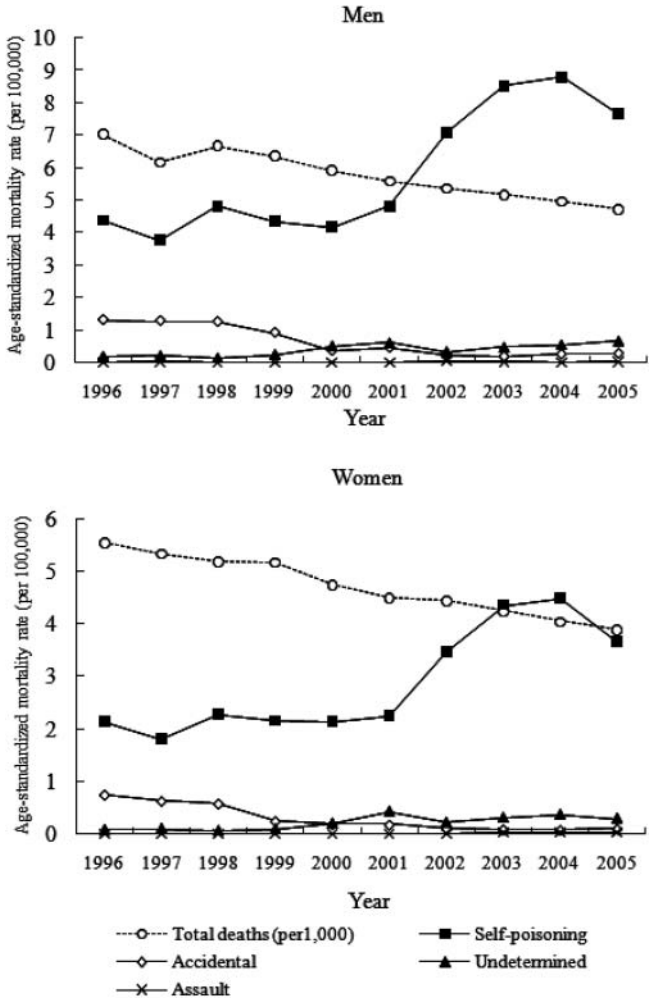

Figure 1 Age-standardized mortality rates for pesticide poisoning deaths by gender and year in South Korea, 1996–2005.

contrast, markedly decreased from 1.03 to 0.19 per 100,000 population from 1996 to 2005, which suggests improved workplace safety in agriculture. However, accidental poisoning deaths continue to occur due to dangerous work practices, poor personal hygienic practices, inappropriate mixing of pesticides and insufficient education on pesticide usage. Other causes of death from pesticides, assault and undetermined intent poisoning by and exposure to pesticides, occurred at low rates (0.02, 0.50 per 100,000 population in 2005, respectively).

By making use of hospital admissions data, several additional pesticide poisoning studies have been conducted in South Korea. The bulk of the studies, however, have been limited by specific areas, small sample sizes or clinical manifestations. Recently, a nationwide survey of 38 hospitals was conducted by the Rural Development Administration at the Ministry for Food, Agriculture, Forestry and Fisheries[9]. In this study, a total of 1,657 pesticide poisoning patients were enrolled between August 2005 and July 2006. It reported that the most common type of poisoning was intentional ingestion (87%). The overall mortality rate was 22%, but varied by causative agent between 6% to 78%. A similar large-scale study of 30 hospitals reported that pesticides (33.3%) made up the second most frequent substances involved in total poisonings, following medication (41.9%), and that the fatality rate of pesticides was 85.2%, whereas the total fatality rate was 5.1% in 2004 and 2005[10].

However, the hospital and death registration data were principally able to identify clinically evident systemic poisonings treated at health centers, whereas low-level poisoning, poisoning unrecognized by the victims themselves or underdetected or misdiagnosed poisonings were not reported. Therefore, studies based on hospital records or mortality data may underestimate the full impact of pesticide poisoning.

Prevalence of Non-fatal Pesticide Poisoning

The prevalence of non-fatal pesticide poisoning has been reported to vary from 5.7% to 86.7% among South Korean farmers, depending on the study subjects, years studied and definition of pesticide poisoning (Table 1). Since the first study of pesticide poisoning was published in 1975, a number of cross-sectional surveys have been conducted among farmers. These surveys have focused primarily on male farmers, although women are often equally exposed to pesticides. Pesticides may also trigger a variety of chronic health effects, such as cancers, neurologic effects and reproductive effects, and the prevalence of those diseases have not been considered.

Most studies have identified pesticide poisoning cases by examining the subjects' history of pesticide poisoning experiences or symptoms through a questionnaire-based survey. As a result, the major challenge to interpreting the prevalence findings of the studies is the absence of a uniform definition of poisoning. Since symptoms related to pesticide poisoning could have been attributed to other risk factors, their prevalence may be overestimated. However, certain studies have applied relatively objective methods for defining pesticide poisoning. One population-based study reported a 25.4 per 100,000 population annual incidence of pesticide poisoning by studying 1,618 cases of documented pesticide poisoning obtained from medical records in Gyeongsangbuk Province in 1982–1983[28]. Several studies have examined blood cholinesterase activity as a diagnostic tool and reported a 14.7–33.3% prevalence of pesticide poisoning among farmers, lower than claimed by studies based on

Table 1 Non-fatal pesticide poisoning prevalence in South Korea

Author, year	No. of subjects	Prevalence	Case definition
Kwon YJ *et al.*, 2004[11]	541	39.9%	Pesticide poisoning history
Song JS *et al.*, 2003[12]	257	52.9%	Pesticide poisoning symptom
Lim KS and Kim CN, 2003[13]	166	22.9%	Pesticide poisoning history
Lee KM *et al.*, 2002[14]	144	26.4%	Pesticide poisoning history
Lee KM *et al.*, 2000[15]	390	86.7%	Pesticide poisoning symptom
Lee SK *et al.*, 2000[16]	45	28.9%	Pesticide poisoning symptom
Lee WJ *et al.*, 1999[17]	43	79.1%	Pesticide poisoning symptom
Park SK *et al.*, 1999[18]	143	33.0%	Pesticide poisoning history
Koo HM *et al.*, 1999[19]	252	35.3%	Pesticide poisoning history
Shin JS and Kim CJ, 1999[20]	233	29.1%	Pesticide poisoning symptom
Kim DH and Jung C, 1998[21]	426	24.9%	Pesticide poisoning history
Lim KS, 1997[22]	100	68.0%	Pesticide poisoning history
Lee JY *et al.*, 1994[23]	142	25.4%	Pesticide poisoning symptom
Chang WS and Rhee JA, 1994[24]	652	5.7%	Pesticide poisoning history
Shin DC *et al.*, 1994[25]	88	14.7%	Acetylcholinesterase activity
Jung MS and Jung MH, 1986[26]	465	56.8%	Pesticide poisoning symptom
Cha MY *et al.*, 1984[27]	307	28.3%	Pesticide poisoning symptom
Jung JH and Cho JY, 1983[28]	Population-based	25.4 per 100,000	Doctor diagnosis
Lim HS, 1982[29]	413	23.0%	Pesticide poisoning history
Yi TK, 1981[30]	478	44.1%	Pesticide poisoning history
Jung SK *et al.*, 1981[31]	403	19.6%	Pesticide poisoning symptom
Jung JH, 1975[32]	821	33.4%	Pesticide poisoning symptom

symptoms or history of pesticide poisoning performed in the 1990s[16, 25]. The most recent nationwide study, initiated in 2006 by Rural Development Administration, was conducted on 1,233 farmers from 18 widespread rural counties[33]. It reported that 7.2% of farmers had received medical treatment for the symptoms in question and that 3.3% had been admitted to a hospital.

Although these studies do not provide sufficiently accurate data on pesticide poisoning, they do offer information on gross figures of non-fatal pesticide poisoning among South Korean farmers.

Common Agents of Pesticide Poisoning

From 1996 to 2005, herbicides and fungicides were the major causative agents for pesticide poisoning death among all pesticide-related deaths, followed by unspecified pesticides and organophosphates and carbamate insecticides[3]. In the nationwide 38-hospital study[9], the most frequent causative pesticide was paraquat, 1,1'-dimethyl-4,4'-bipyridinium (35.5%), followed by organophosphate insecticides (20.5%), organophosphate herbicides (15.5%) and pyrethroid insecticides (8.5%; Table 2). Among organophosphate insecticides, dichlorvos was the most common agent followed by chlorpyrifos, diazinon, EPN and phosphamidon. Organophosphate herbicides include glyphosate and glufosinate. According to a review article on toxicants, carbon monoxide, paraquat and organophosphate pesticides were the three most commonly reported toxicants in research articles on poisoning published between 1980 and 2003[34]. A 2004 study of 150 hospitals using discharge injury surveillance data[35] similarly reported that pesticides were the most common poisons involved (45%), followed by medications (23%). A comparative analysis of acute drug intoxication between the 1980s and 1990s also showed that pesticides were the main agent in both decades[36].

Table 2 Common agents of pesticide poisoning from a nationwide hospital study in South Korea

Agents	Cases	%
Paraquat (quaternary ammonium herbicides)	538	35.5
Organophosphate insecticides	310	20.5
Organophosphate herbicides	234	15.5
Pyrethroid insecticides	128	8.5
Carbamate insecticides	70	4.6
Organochloride insecticides	38	2.5
Phenoxy herbicides	30	2.0
Others	166	11.0
Total	1,514	100

(Source: Rural Development Administration, 2008)

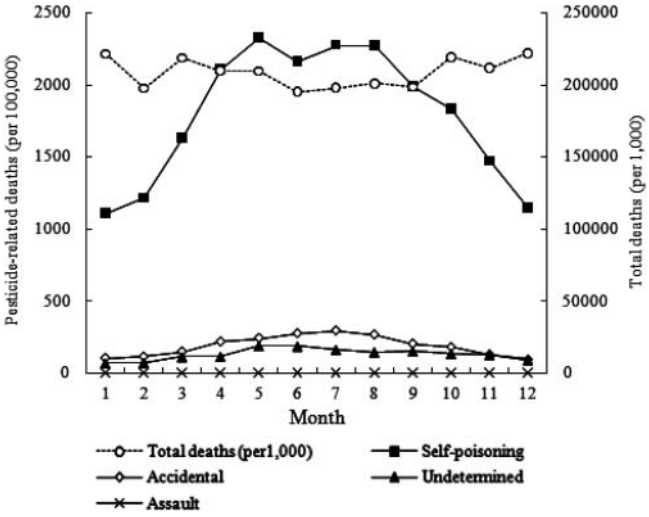

Figure 2 Seasonal variations in pesticide poisoning deaths in South Korea, 1996–2005.

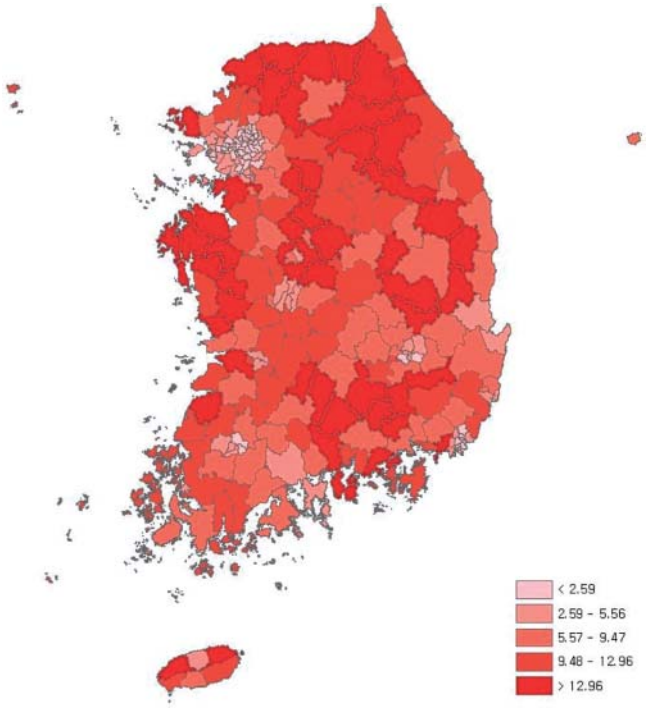

Figure 3 Geographical distribution of mortality for pesticide poisoning (per 100,000) in South Korea, 1996–2005.

Paraquat is a widely used herbicide, and highly concentrated (24.5%) paraquat dichloride remains available in South Korea. The most frequent use of herbicides as means for self poisoning death in rural areas may be due to the residents' perception that paraquat is the most lethal of the chemicals[37]. However, organophosphate pesticides were most frequently reported to be related with non-fatal pesticide poisoning in field surveys. The individual pesticides involved varied in each study. Organochlorine poisoning cases are uncommon today because the majority of these substances were banned or severely restricted in South Korea in the early 1970s.

Related Factors in Pesticide Poisoning

The reported work-related factors in pesticide poisoning from field surveys include pesticide application days or years, residence in an agricultural area, receipt of safety education and following safety guidelines, such as spraying with your back to the wind, following dose limits, reading manuals and not spraying when fatigued[18, 22]. Although one study from Gangwon Province[14] reported no association between experience of pesticide poisoning symptoms and protective equipment and safety education attendance, the bulk of the factors above were consistently reported to be related with pesticide poisoning.

Types of farming were also reported to be related with an increased risk of pesticide poisoning. Orchardists were frequently noted to possess the highest rate of poisoning among all types of farmers[11, 33]. Greenhouse farmers had longer working hours and increased frequency of pesticide application per year than non-greenhouse farmers, and the rate of pesticide intoxication of greenhouse workers was frequently reported to be higher than that of non-greenhouse farmers[23, 24]. In addition, farmers working in alpine areas used more pesticides and showed higher pesticide poisoning symptoms (67.9%) than lowland farmers (51.1%)[12].

The frequency of pesticide poisoning deaths showed a pronounced peak in late spring and summer (May to August), whereas total deaths decreased during the same period when compared to fall and winter (Figure 2)[3]. In one hospital survey[9], the monthly incidence of non-fatal pesticide poisoning was also the highest in August and lowest from December to February. These variations in pesticide poisoning may be explained by the seasonal accessibility of pesticides during the farming cycle. Rural areas demonstrated the highest rates of pesticide poisoning deaths, whereas metropolitan areas possessed the lowest (Figure 3), which supports the supposition that ease of accessibility is a key factor for the development of pesticide poisoning. Individuals who died from accidental exposure to pesticides were more likely to live in rural areas compared with people who died of other types of pesticide poisoning.

Particular socio-demographic factors, such as male sex, elderly age, possessing a low education and socioeconomic status and farming, are related to increased risk of pesticide

poisoning death in South Korea. Pesticide poisoning mortality rates were higher among men than in women across all age groups. This discrepancy between genders increased with age. The majority of pesticide poisoning deaths occurred among married people, which suggests that family affairs or issues may be a major trigger of pesticide ingestion as a means of suicide in South Korea. Non-fatal pesticide poisoning cases also showed similar results.

Conclusion

Deaths from pesticide poisoning increased substantially during the last decade, whereas the total death rate in South Korea decreased markedly. Non-fatal poisoning cases were also reported to be a prevalent health issue among South Korean farmers. Paraquat was the principle causative agent in pesticide poisoning cases, and a variety of factors, including work-related, socio-demographic and seasonal factors were significantly related with pesticide poisoning. Despite the scale of the problem, pesticide poisoning has been the focus of little research and policy attention in South Korea. Therefore, more detailed studies investigating the risks of pesticide poisoning, accompanied by intensive intervention efforts aimed at reducing pesticide mortality and morbidity, are critically needed in South Korea.

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