

BMJ Open Pesticide poisoning in Zhejiang, China: a retrospective analysis of adult cases registration by occupational disease surveillance and reporting systems from 2006 to 2010

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ABSTRACT

Objective: Despite the rapid industrialisation and urbanisation over the past 30 years, agriculture is one of the largest economic sectors in China and the unregulated use of pesticides result in extensive pesticide poisoning. The objective of this study was to analyse pesticide poisoning cases registration received by Zhejiang Provincial Center for Disease Control and Prevention, China.

Design: Register-based study.

Setting: Cases registered regarding pesticide poisoning. Data were obtained from the Occupational Disease Surveillance and Reporting Systems in Zhejiang province from 2006 to 2010, which contains anonymous records representing general population of Zhejiang province, China.

Participants: All cases registered as pesticide poisoning were identified.

Primary outcome: Monthly and age-group pesticide poisoning death rates were calculated.

Results: A total of 20 097 pesticide poisoning cases with 1413 deaths were recorded during the study period. There were 10 513 male pesticide poisoning cases with 782 deaths, and 9584 females with 631 deaths. Pesticide poisoning occurred mostly in non-occupational exposure (79.86%), in which the majority (85.77%) of the cases was of intentional pesticide poisoning. The occupational exposure was most common in men during the farming season. The death rate increased stepwise with age, and the pesticide suicide rate was higher in the older age group.

Conclusions: Pesticide poisoning remains a major health problem in China, and further recommendations to reduce the pesticide poisoning are required.

BACKGROUND

Pesticide poisoning is a significant global public health problem. According to WHO data, an estimated three million cases of pesticide poisoning occur every year, resulting in an excess of

Strengths and limitations of this study

- This study is representative of the general population.
- However, incidence cases obtained in this study are likely to be an underestimation of all incident cases present in the community.
- This study is limited by cases being from only one province of China.

250 000 deaths worldwide.¹ Combining data from six regions, the study by Gunnell *et al*,² estimates that the annual number of pesticide suicides worldwide is 258 234 with a plausible range of 233 997–325 907, and this accounts for 30% (range 27–37%) of all suicides globally every year. Intentional and unintentional pesticide poisoning has been acknowledged as a serious problem in many agricultural communities of low-income and middle-income countries, including China, India, Sri Lanka and Vietnam.³ Recently, a growing number of suicides due to pesticide ingestion have been reported in other low-income and middle-income countries.⁴

In China, agriculture is an important economic sector and a major source of income. However, the pesticides are extensively mis-handled when used to protect crops and improve production.⁵ The unregulated and unsafe use of pesticides in industries, agriculture and home storing causes toxicity due to intentional and unintentional exposure.⁶ To prevent intentional and unintentional deaths from pesticide poisoning, the Chinese government has implemented sustainable epidemiological surveillance and monitoring of pesticide poisoning in clinical settings and communities. Since 2006, the Occupational Disease Surveillance and Reporting Systems (ODSRS) have been launched in each province and

autonomous region of Mainland China. This computer-based and internet-based reporting systems collect all-category occupational hazards and poisoning. In this study, we present the overall epidemiological characteristics of pesticide poisoning using the data of pesticide poisoning case registrations from ODSRS in Zhejiang province, China.

METHODS

Ethics

Our research required secondary data analysis, and the identification of patients had already been encrypted in the official pesticide poisoning statistics and the ODSRS by Zhejiang Provincial Center for Disease Control and Prevention (CDC), China; therefore, our research complied with the Declaration of Helsinki and protected the privacy of patients. Thus, this study was determined to be exempt from institutional ethical review by Research Ethics Board of Zhejiang Provincial CDC.

Data source

The pesticide poisoning data were obtained from ODSRS in Zhejiang province. The reporting system database consists of data from the health institutions, including hospitals and community healthcare centres in cities, and clinical settings (clinics or dispensaries) in rural areas. Since its launch in 2006, the reporting systems have established 395 hospital-based surveillance sites, including 11 provincial hospitals, 36 municipal hospitals, 151 county hospitals, and 197 community healthcare centres and rural clinics. The pesticide poisoning and death certification were reported by the physicians from these health institutions. These health institutions were required by Zhejiang CDC to report the pesticide poisoning cases. The data on pesticide poisoning were obtained from the routine surveillance system (ie, ODSRS) by Zhejiang CDC, and the use of the database was approved by Zhejiang CDC. Hence, the database is an essential resource of representative and evidence-based data for studies in medical and health research, which may play a valuable role in health policy.

Data analysis

The age classification by the Office for the Population Census of Zhejiang province was adopted as follows: aged 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74 and over 75 years. The official death statistics and database of ODSRS employ the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) coding system in China, so we defined unintentional poisoning by using the ICD-9-CM external causes of injury codes (E codes) to classify poisoning types into accidental poisoning by insecticides of organophosphate (E863.1), carbamates (E863.2), mixture of insecticides (E863.3), other and unspecified insecticides (E863.4), accidental poisoning by herbicides (E863.5), fungicides (E863.6), rodenticides (E863.7), fumigants (E863.8), and other and unspecified (E863.9).

RESULTS

Intentional pesticide poisoning exposure accounts for most of the poisoning cases and deaths

The yearly pesticide poisoning cases and deaths remained steady from 2006 to 2010, so we combined all cases as study population, that is, totally, 20 097 incident pesticide poisoning cases with 1413 deaths in Zhejiang province (table 1). There were 4048 pesticide poisoning cases due to the occupational exposure with 27 deaths and 16 049 cases due to the non-occupational exposure with 1386 deaths. The death rate of non-occupational exposure (8.63%) was higher than that of occupational exposure (6.67%). Among the non-occupational pesticide exposure, there were 2448 unintentional poisoning cases with 56 deaths and 13 765 intentional poisoning cases with 1330 deaths, which consisted mostly of pesticide poisoning and pesticide suicide (intentional poisoning death; table 1). As to the poisoning pesticide types, poisoning by organophosphates took the majority of

Table 1 Poisoned patients by different types of pesticides

	Incident case	Death case	Deaths (%)
All	20 097	1413	7.03
Organophosphates	13 391	1134	8.47
Dichlorvos	5379	437	8.12
Methamidophos	3326	314	9.44
Parathion	219	16	7.31
Omethoate	1613	245	15.19
Trichlorfon	199	5	2.51
Isocarbophos	183	6	3.28
Other organophosphates	2472	111	4.49
Carbamates	450	20	4.44
Carbofuran	177	8	4.52
Methomyl	153	10	6.53
Other carbamates	120	2	1.67
Insecticides	2982	111	3.72
Organochlorine	103	6	5.83
Chlordimeform	92	1	1.09
Dimehypo	525	49	9.33
Deltamethrin	329	5	1.52
Pyrethroid	1022	18	1.76
Other insecticides	911	32	3.51
Herbicides	1326	69	5.20
Paraquat	461	50	10.8
Other herbicides	865	19	2.20
Fungicides	143	1	0.70
Rodenticides	812	19	2.34
Tetramine	158	10	6.33
Fluoroacetamide	42	2	4.76
Anticoagulant rodenticides	174	1	0.57
Other rodenticides	438	6	1.37
Others	993	59	5.94
Multipurpose formulation	342	7	2.05
Others unspecified	651	52	7.99

all pesticide poisoning (13 391 cases and 1134 deaths) with highest death rate (8.47%). Details of pesticide poisoning and death cases by each type of pesticide used are provided in [table 1](#).

Occupational pesticide poisoning is common for men during the farming season

According to the distribution of incident pesticide poisoning cases in different months, the pesticide poisoning was

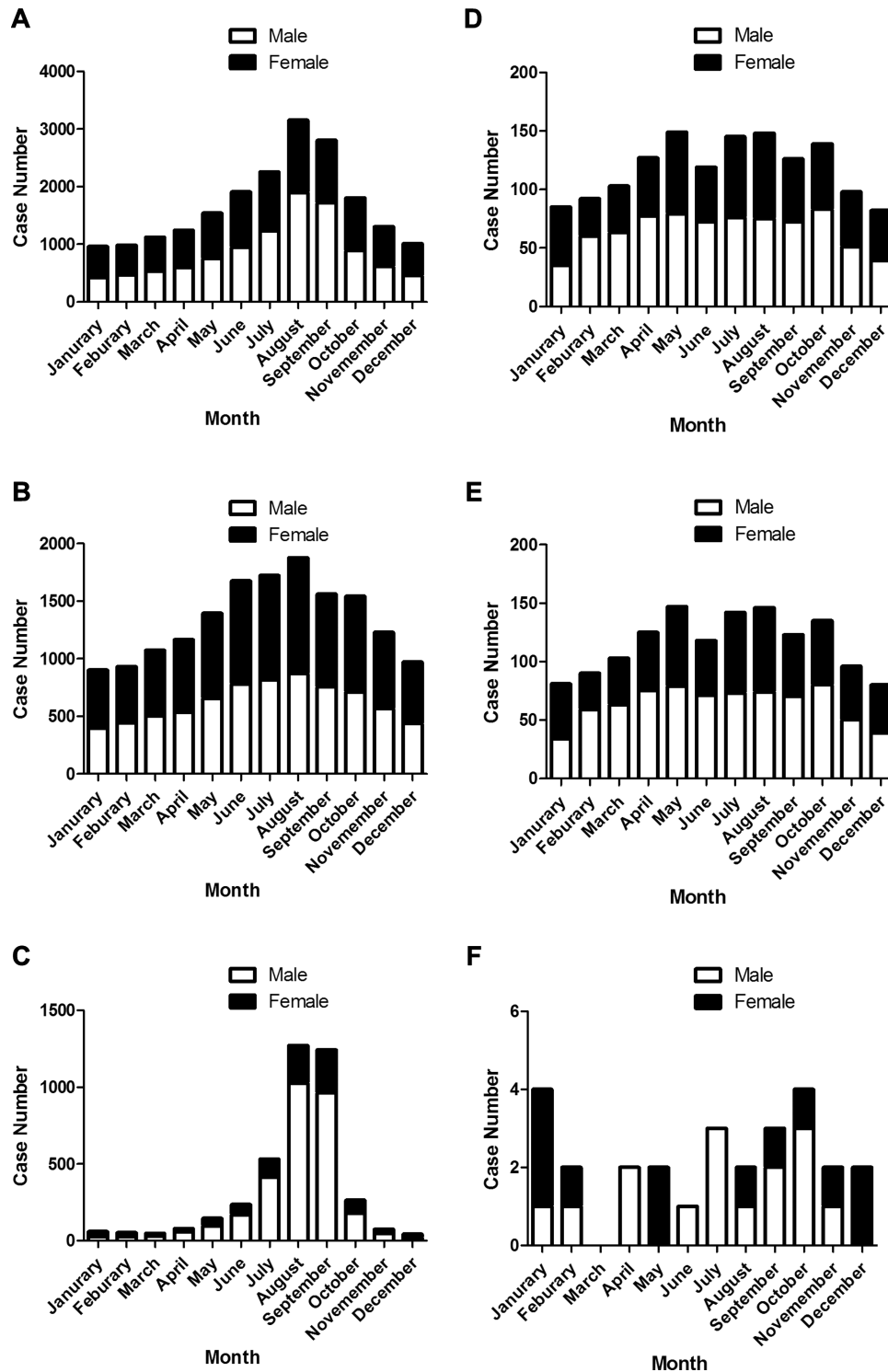


Figure 1 Monthly pesticide poisoning cases and deaths in Zhejiang province, China from 2006 to 2010. (A) Overall monthly pesticide poisoning cases. Monthly pesticide poisoning cases by non-occupational (B) and occupational (C) exposure. (D) Overall monthly pesticide poisoning death cases. Monthly pesticide poisoning death cases by non-occupational (E) and occupational (F) exposure.

common in August with 3150 cases and September with 2805 cases and less in January with 962 cases and February with 985 cases (figure 1A). Similar distribution pattern of monthly pesticide poisoning cases was found in the non-occupational pesticide exposure cases (figure 1B). For the occupational exposure, however, there were 1272 and 1243 pesticide poisoning cases in August and September, which accounted for 31.42% and 30.71% of all occupational exposed pesticide poisoning cases, respectively (4048 cases; figure 1C). Furthermore, in August and September, 1027 (80.74%) and 962 (77.39%) male poisoning cases were occupational pesticide poisoned, while only 245 (19.26%) and 281 (22.61%) female poisoning cases were found (figure 1C).

The monthly pesticide poisoning deaths ranged from 82 to 149 cases, in which the number of deaths was the highest in May and the least in December (figure 1D). Similar distribution pattern of monthly pesticide poisoning deaths was found in the non-occupational pesticide exposure (figure 1E). Monthly pesticide poisoning deaths from the occupation exposure were limited (figure 1F). On the other hand, the overall deaths were the highest from January to May, the lowest from June to September and moderate from October to December (figure 2A). Except July, August and September, the overall deaths were higher in men when compared to that of women in other months. For the non-occupational pesticide poisoning, however, deaths were higher in men than women in every month (figure 2B). We did not analyse deaths of occupational pesticide poisoning individuals due to the limited number of deaths.

Death of pesticide poisoning individuals increased stepwise with age

Next, we analysed the pesticide poisoning cases in different age groups. As shown in figure 3A, more incident pesticide poisoning cases were found in the age groups 35–39 and 40–44 years. Similar distribution pattern of pesticide poisoning cases was found in the non-occupational pesticide exposure cases in different age groups (figure 3B). For the occupational exposure,

however, the number of pesticide poisoning cases increased stepwise from age group 20–24 to 55–59 years, and then decreased to age group over 75 years, and more occupational pesticide poisoning cases were found in men (figure 3C).

For all pesticide poisoning deaths, fewer cases were found in age groups under 34 years and more were found in the age group over 75 years (figure 3D). Similar distribution of pesticide poisoning deaths was found in the non-occupational pesticide exposure cases in different age groups (figure 3E), while the pesticide poisoning deaths were very limited due to occupational pesticide exposure (figure 3F).

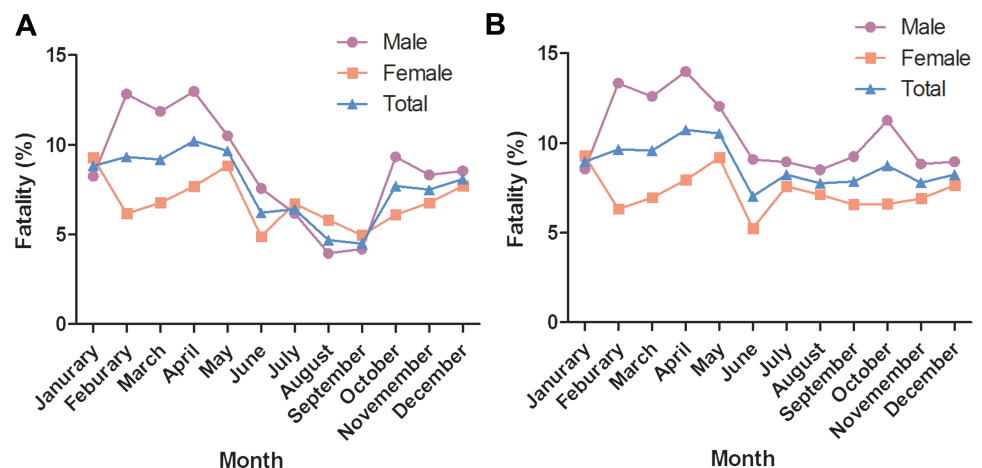
Deaths also increased stepwise with age in all pesticide-exposed and non-occupational pesticide-exposed population, and similar deaths were found between men and women (figure 4A,B). We did not analyse deaths in the occupational pesticide-exposed population due to the limited number of deaths.

Pesticide suicide is a serious public health problem in Chinese aged population

Since the intentional pesticide poisoning was more common than the unintentional pesticide poisoning in China (table 1), we next analysed the intentional pesticide poisoning in different months and age groups. More cases were found from May to October in intentional pesticide poisoning (figure 5A). The intentional pesticide poisoning death (suicide) cases were higher from May to October than those in other months (figure 5B). Generally, the deaths due to intentional pesticide poisoning was higher in men than that in women except some special months (eg, January; figure 5C).

In different age groups, the intentional pesticide poisoning cases increased from age 20–24 to 35–39 years, decreased from age 40–44 to 65–69 years and increased from age 70–74 to over 75 years (figure 5D). Compared to young age groups (<34 years), the intentional pesticide poisoning death (suicide) cases increased in age groups from 35–39 to 65–69 years, and further increased in age groups of 70–74 years and over 75 years (figure 5E).

Figure 2 Monthly fatalities due to pesticide poisoning in Zhejiang from 2006 to 2010. Monthly fatalities due to pesticide poisoning (A), and due to pesticide poisoning by non-occupational exposure (B).



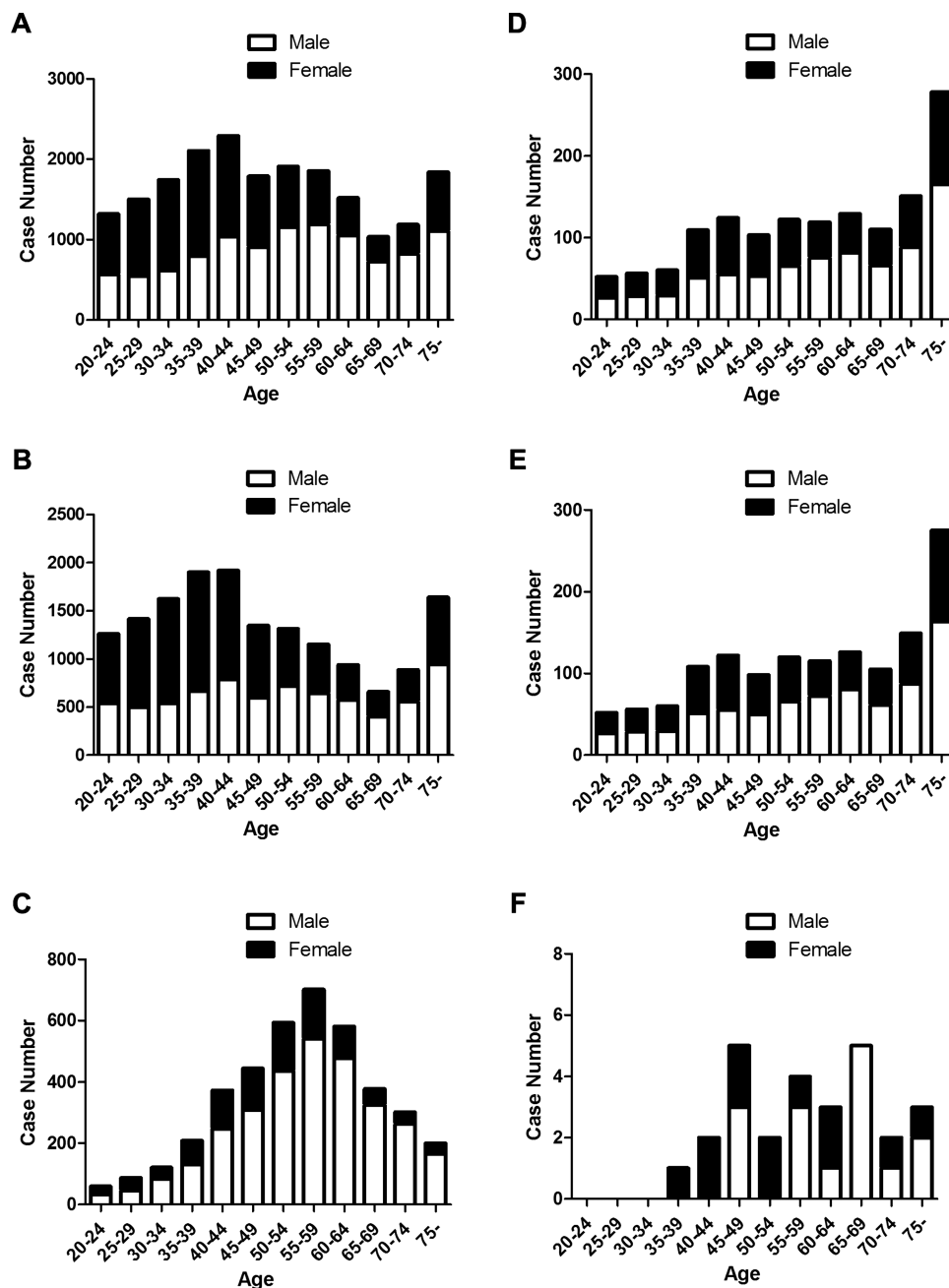


Figure 3 Pesticide poisoning cases and deaths in Zhejiang from 2006 to 2010 in different age groups. (A) Overall pesticide poisoning cases in different age groups. Pesticide poisoning cases by non-occupational (B) and occupational (C) exposure in different age groups. (D) Overall pesticide poisoning death cases in different age groups. Pesticide poisoning death cases by non-occupational (E) and occupational (F) exposure in different age groups.

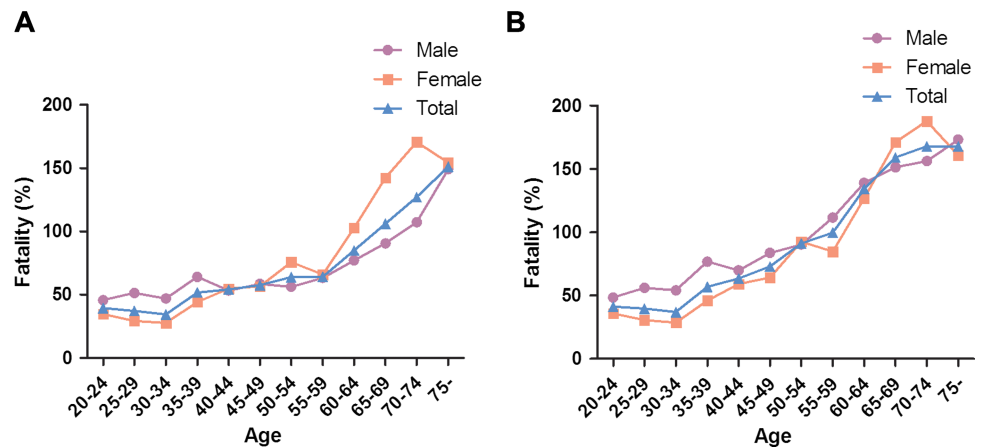
Deaths from pesticide poisoning suicide also increased stepwise with age, and similar deaths were found between men and women (figure 5F).

DISCUSSION

Our results indicated that pesticide poisoning was common in August and September, the farming season in Zhejiang, and the pesticide poisoning cases accounted for more than 60% of all occupational exposed pesticide poisoning cases. Previous studies have

shown that the incidence of pesticide poisoning varies quarterly in a year due to the season-specific agricultural activities, and the high incidence of pesticide poisoning correlates with pesticide availability during the farming season.^{7 8} Similarly, we found more pesticide poisoning and death cases in the farming season. Further investigations are required to examine the relationship between seasonal sales or use of pesticide and pesticide poisoning. Our data have also shown more occupational pesticide poisoned men in farming season. Since most of the agricultural activities are taken up by men in China,

Figure 4 Fatalities due to pesticide poisoning in Zhejiang from 2006 to 2010 in different age groups. Fatalities due to pesticide poisoning (A) and due to pesticide poisoning by non-occupational exposure (B) in different age groups.



more pesticide poisoning in men may be due to high occupational pesticide exposure in the farming season. This is consistent with the previous report on the gender difference of acute pesticide poisoning among agricultural workers.⁹

Although pharmaceuticals are the most common means of fatal poisoning in the developed countries, pesticides are the most common agents responsible for poisoning deaths in many developing countries.¹⁰ In China, recent global estimates of deaths from poisoning suggest that more than 150 000 deaths occur each year from pesticides poisoning alone.¹¹ Our data showed the intentional poisoning accounted for 68.49% (13 765/20 097) of all pesticide poisoning cases and the intentional poisoning death accounted for 94.13% (1330/1413) of all pesticide poisoning deaths. Thus, the suicide by pesticide poisoning is a serious public health problem in Zhejiang, and public awareness campaigns were conducted to reduce exposure to pesticide poisoning in suicide attempts. In addition, we found that deaths from pesticide poisoning suicide increased stepwise with age. China has much higher suicide rates in elderly people than those in young and middle-aged adults, but this pattern is not seen in other countries (eg, India).¹² Poor health, an increased number of comorbidities, high susceptibility to pesticide poisoning and postpoisoning complications might attribute to the older population's poor prognosis in China.

Before the establishment of ODSRS, pesticide poisoning was under-reported in China.⁵ The new pesticide poisoning reporting system under the ODSRS improves the reporting rate technically. However, under-reporting still exists in the new system. First, the pesticide poisoning cases and deaths were obviously under-reported as the ODSRS is hospital based. Though all the provincial and municipal general hospitals, most of the county hospitals and community healthcare centres, and a small percentage of rural clinics were included as surveillance sites, the overwhelming portion of the rural clinics were not included. However, pesticide poisoning was much more common in rural areas. Second, some subjective factors may contribute to under-reporting, including

affected people (eg, mild pesticide poisoning) not seeking professional medical care, or consulting care providers outside the systems and misdiagnosis. Third, occupational pesticide exposure is often under-reported as it does not present to hospital in the developing countries.¹³ Fourth, there may have out-of-hospital deaths by pesticide poisoning, which were not reported by the health institutions and resulted in under-reporting. Fifth, people with severe pesticide poisoning (eg, paraquat poisoning), will be transferred to provincial and municipal hospitals for further therapy from the community healthcare centres and rural clinics. They are often treated as 'survival' instead of being further followed up, which might result in the under-reporting of death cases and corresponding low death rates. In addition, although there are policies in China requiring physicians to report pesticide poisonings, many physicians in rural areas may fail to report cases because they lack the time or administrative resources.¹⁴ To estimate the pesticide poisoning more accurately in China, future studies on the reporting rate of pesticide poisoning by the ODSRS are warranted.

Another major limitation of this study is that we only included pesticide poisoning and death in Chinese adults with age over 20 years (≥ 20 years). Actually, the adolescents are an important group for self-harm including pesticides in some Asian countries, including China.² There may be a bimodal peak with high rates of self-harm producing an absolute high number of deaths in this age group. We found the incident pesticide poisoning cases and deaths were mostly common in Chinese adolescents (age group 14–19 years) compared to other age groups over 20 years, and the intentional pesticide poisoning accounts for the majority of poisoning cases and deaths for this age group population (see online supplementary data table S1).

China's rapid industrialisation and urbanisation over the past 30 years drives more people to move to industrial areas from agriculture, however, pesticide poisoning still remains the major public health problem in China.¹⁵ Thus, future recommendations to reduce pesticide poisoning are urgently required in China, for

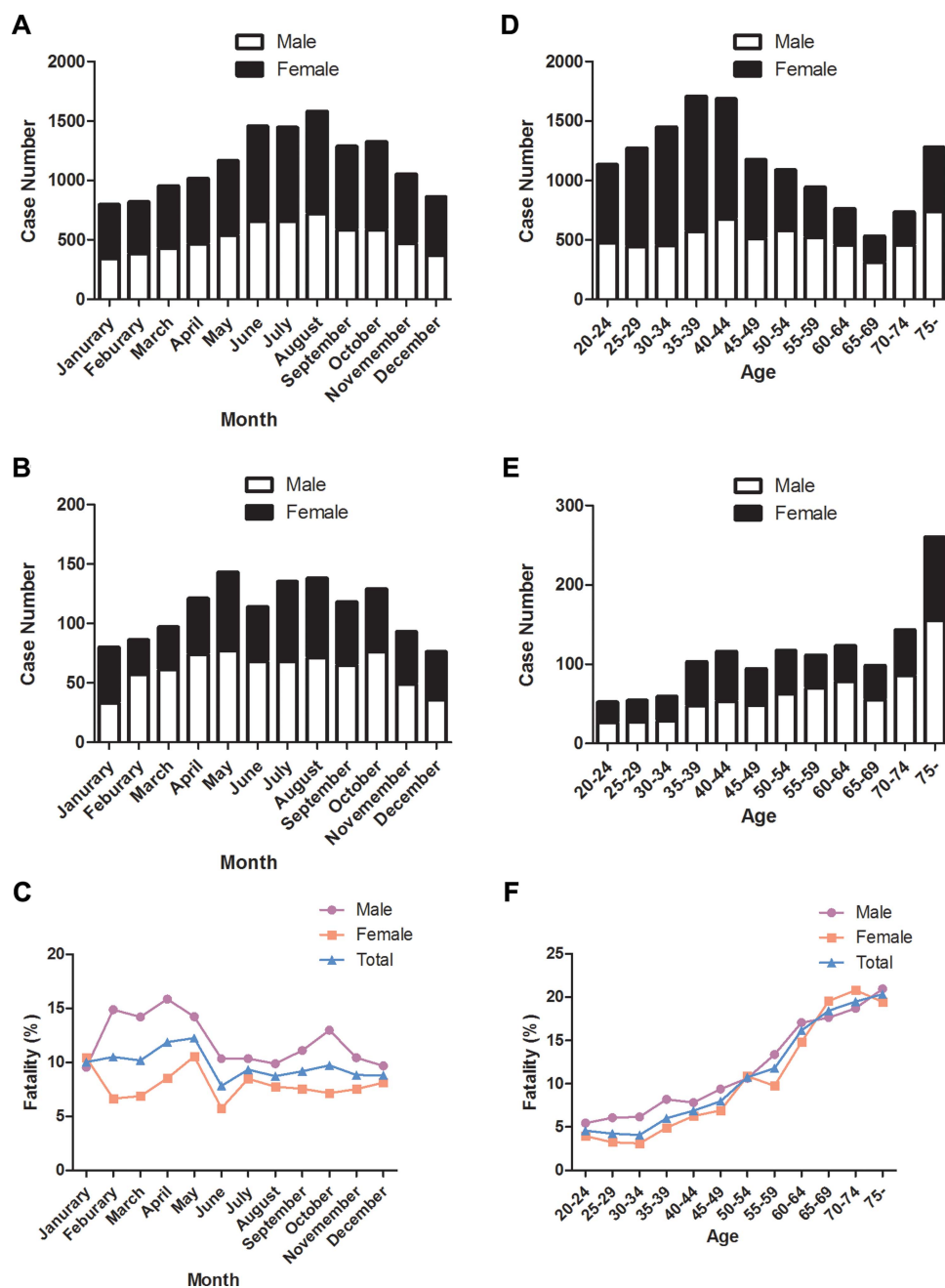


Figure 5 Intentional pesticide poisoning cases and deaths, and fatalities in Zhejiang from 2006 to 2010. Monthly intentional pesticide poisoning cases (A), deaths (B) and fatalities (C). Intentional pesticide poisoning cases (D), deaths (E) and fatalities (F) in different age groups.

example, education of pesticide safety, prevention and intervention of pesticide poisoning. The effective education programmes regarding pesticide safety could be useful in preventing pesticide poisoning.¹⁴ Previous studies have suggested that pesticide safety education among farmers could raise awareness of pesticide exposure risk¹⁶ and the adverse health consequences associated with acute pesticide poisoning.¹⁷ Improvements in pesticide safety knowledge using different delivery modes may lead to some improvement in protective practices¹⁸ and increase the use of personal protective equipment.¹⁹ On the other hand, the WHO

acknowledges that pesticide ingestion is among the most frequently used methods of suicide worldwide.²⁰ The systematic review by Gunnell *et al*² has estimated that pesticide self-poisoning accounted for about one-third of the world's suicides and suggested that we might prevent many of these deaths by restricting the access to pesticides. Recently, Chang *et al*²¹ have reported that easy access to pesticides was associated with a high incidence of pesticide suicide. Pesticides are readily available in rural areas of China and commonly used in impulsive acts of self-poisoning following acute life crisis. One strategy to reduce these deaths is to restrict the availability/

accessibility of toxic pesticides.^{22–24} In addition, other strategies for preventing pesticide poisoning and the pesticide poisoned deaths include safe storage in lockable boxes,^{25 26} centralised communal storage,²⁷ adopting non-pesticide management policy²⁸ and improved medical treatment of pesticide poisoning.²⁹ As to highly fatal pesticides, for example, omethoate with >15% deaths in our study, future banning may decrease deaths by pesticide poisoning in China.

CONCLUSIONS

The present study analysed pesticide poisoning in Zhejiang province, China, from 2006 to 2010 and our data show that the intentional pesticide poisoning exposure accounts for most of the poisoning cases and deaths, and deaths are higher in aged population due to pesticide poisoning. Further recommendations to reduce pesticide poisoning are required in China.

Contributors MZ, HZ and GC contributed to study design and wrote the paper. XF and LZ collected the data. LS, JZ and MJ performed the data analysis. All authors contributed to the interpretation of results. All authors have read and approved the final manuscript.

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Competing interests GC was supported by Technology Foundation for Excellent Overseas Chinese Scholar, Zhejiang Province Human Resources and Social Security Bureau, China.

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