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Original Article

Can mortality from agricultural pesticide poisoning be predicted in the emergency department? Findings from a hospital-based study in eastern Taiwan

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A B S T R A C T

Objectives: Pesticides are the leading toxicants resulting in emergency department (ED) admission. Factors which help emergency physicians predict mortality from pesticide poisoning have rarely been elucidated. There is also a lack in epidemiologic data on pesticide exposure in eastern Taiwan. This study describes the characteristics of patients with pesticide poisoning in eastern Taiwan and identifies available ED predictors for mortality from pesticide poisoning.
Materials and Methods: Patients with pesticide exposure who presented to the ED in the only medical center in eastern Taiwan between July 2001 and July 2008 were reviewed retrospectively. Clinical information was collected for comparison between survivors and nonsurvivors. Logistic regression was conducted to identify the predictors for poisoning-related mortality.
Results: During the study period, a total of 573 patients with pesticide exposure presented to our ED. There were 145 poisoning-related fatalities (25.31%) with a mean survival of 3.63 days. Paraquat (37.5%) was the leading pesticide involved, followed by glyphosate (23.0%) and organophosphates (13.4%). The significant predictors for mortality from pesticide poisoning were paraquat intoxication [odds ratio (OR) = 83.39; $p < 0.001$], organophosphate intoxication (OR = 10.88; $p = 0.009$), suicide attempt (OR = 15.98; $p < 0.001$), and abnormal body temperature (OR = 2.76; $p = 0.043$). In paraquat poisoning cases, age over 60 years (OR = 4.64; $p = 0.003$), suicide attempt (OR = 9.27; $p < 0.001$) and abnormal body temperature (OR = 2.63; $p = 0.038$), especially hypothermia, were risk factors for death. In non-paraquat poisoning cases, suicide attempt (OR > 999; $p < 0.001$) and initial respiratory distress (OR = 23.25; $p = 0.001$) were predictors for mortality.
Conclusion: Paraquat and organophosphates are the pesticides most associated with mortality. In paraquat exposure, elderly patients, those with suicidal intent and those presenting with an abnormal body temperature are at high risk for death. With nonparaquat pesticides, patients with suicidal intent and respiratory distress are at high risk for mortality.

1. Introduction

Since the development of organophosphates in the 1930s and paraquat in 1961, agricultural chemicals have played an important role in the development of modern agriculture and have helped increase agricultural production. These chemicals are widely used, especially in developing countries.

Intoxication from agricultural chemicals, especially paraquat, has resulted in high mortality rates [1–5]. Because of the availability of these chemicals, intoxication, either incidental or intended, is frequently seen in the emergency setting. Several methods have been proposed to evaluate the severity and prognosis of specific types of agricultural pesticide intoxication, but some problems remain. [2,5–12]. First, these evaluation methods may require laboratory support, such as drug level monitoring and additional laboratory data, which is a burden in developing countries, and emergency departments (ED) in remote areas. An

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evaluation system using readily accessible clinical information and physical findings, such as body temperature, respiratory condition, and blood pressure, has not been proposed. Second, although prognostic factors have been proposed for individual pesticides and herbicides such as organophosphates and paraquat, many ED patients do not report the specific pesticide involved. Thus, prognostic factors for overall agricultural pesticide intoxication should be established. Third, local data on this problem are not available, especially in eastern Taiwan.

Here, we retrospectively analyzed the clinical data of patients with agricultural pesticide poisoning admitted to our ED, including initial vital signs, general patient and clinical data, and specific toxicant analysis. We identified the risk factors for high mortality through readily available information in the ED. The results can help emergency physicians perform early risk stratification and therapeutic interventions.

2. Materials and methods

2.1. Study design and patient population

The Buddhist Tzu Chi General Hospital is a tertiary care center with 1000 beds in eastern Taiwan. The ED receives more than 55,000 patient visits per year. The hospital is also the toxicant, drug information and antidote control center in eastern Taiwan. A retrospective study was conducted to analyze patients admitted to the ED with acute poisoning from agricultural pesticides between July 1, 2001 and July 31, 2008.

2.2. Data collection, processing and categorization

A poisoning report form, which was developed in the hospital to collect clinical information on patients with poisoning, was used. The information collected included patient data; exposure agent, time, type, route, amount, and reason; history of suicide attempts; initial vital signs and consciousness level in the ED; presenting symptoms and signs; management and antidote use in the ED; and final outcomes. A well-trained medical assistant was responsible for collecting and recording the data in a computerized database system within 3 days after patient admission. The final outcomes were documented from the discharge chart.

Data were analyzed from patients with poisoning from the computerized database. Only patients with agricultural pesticide (insecticides or herbicides) intoxication were included for the study. The Protection of Human Subjects Institutional Review Board of Buddhist Tzu Chi General Hospital approved this study. All enrolled patients were categorized into the survival group or poisoning-related fatality group for further comparison. The potential predictors of poisoning-related fatalities evaluated in this study included age, gender, initial vital signs on arrival in the ED (body temperature, heart rate, respiratory rate, blood pressure, and consciousness level), classification of the pesticide(s) (paraquat, organophosphates, glyphosate, carbamates, and pyrethroids, and others or unknown pesticides), suicide attempt, exposure route (oral or not), concomitant use of alcohol, and number of agents (multiple or single). Two physicians reviewed the charts from the enrolled patients and rechecked the accuracy of the data collection. The classification of pesticides was based on the chart describing the label on the pesticide container carried with patient or patient's confirmation. If the pesticide was not one of the five types of pesticides listed above or was not known, it was classified as others or unknown. Not all the patients' initial vital sign were obtained from the chart review. If a datum was not obtained, it was recorded as a missing value in the database.

2.3. Statistical analysis

To identify significant clinical data and types of pesticide associated with poisoning-related fatalities, Student's *t* test for continuous variables and the Chi-square test (corrected with Fisher's exact test as appropriate) for categorical variables were used to perform univariate analysis. A p value <0.05 was considered statistically significant, and all statistical tests were two-tailed. For multivariate analysis, the categorical variables with a $p < 0.05$ were selected in the initial univariate analysis into a logistic regression forward stepwise Wald test to calculate the odds ratios. SPSS statistical software was used to perform the statistical analyses (SPSS 12.0; SPSS Institute Inc, Chicago, IL, USA).

3. Results

3.1. Characteristics and clinical status of the poisoning cases

From July 1, 2001 to July 31 2008, a total of 573 patients with agricultural pesticide poisoning were admitted to the ED. Among them, 352 were male (61.4%). The mean age was 46.9 $\pm$ 17.4 years. Overall, 64.4% of the poisoning exposures (369 patients) involved suicidal intent. The poison was ingested orally by 503 patients (87.8%), and 179 patients (31.2%) used alcohol concomitantly. Twenty patients (3.5%) were exposed to more than one agent (Table 1). Paraquat (215 patients, 37.5%) was the most common agent, followed by glyphosate (133 patients, 23.2%; Fig. 1). Among these patients, 16.3% had an abnormal body temperature including hyperthermia (body temperature $\geq$ 37.5°C) or hypothermia (body temperature $\leq$ 35°C), 33.1% had an abnormal heart rate including tachycardia (heart rate > 100 beats/minute) or bradycardia (heart rate < 60 beats/minute), 9.6% exhibited respiratory distress (defined as a respiratory rate > 24 or < 10 breaths/minute or necessity for intubation), 3.1% were in shock (defined as a systolic pressure < 90 mmHg) and 27.2% had impaired consciousness [Glasgow Coma Scale (GCS) score < 15; Table 1].

3.2. Characteristics and predictors of fatalities

There were 145 poisoning-related fatalities (25.31%), including 11 who died on arrival and 134 who died during hospitalization. The mean survival was 3.63 $\pm$ 4.52 days. Among these 145 fatalities, 86.2% were suicide cases and all fatalities (100%) were intoxicated orally. Paraquat was the major agent involved in fatal exposures and accounted for 83.4% of the fatalities, followed by organophosphates (8.3% of the fatalities; Table 1).

Comparison of the fatality and survival groups (Table 1) showed significant differences, in 11 variables, including body temperature, respiratory rate, consciousness level, suicide attempt, oral administration, and type of pesticide. Abnormal body temperature (27.4% vs. 12.9%, $p < 0.001$), abnormal respiratory rate (18.6% vs. 6.9%, $p < 0.001$), consciousness impairment (40.0% vs. 22.7%, $p = 0.003$), suicide attempt (86.2% vs. 57.0%, $p < 0.001$), oral administration (100.0% vs. 83.6%, $p < 0.001$) and paraquat intoxication (83.4% vs. 22.0%, $p < 0.001$) accounted for higher proportions in the fatality group compared with the survival group. Moreover, patients in the fatality group had a lower initial mean body temperature (35.9 $\pm$ 1.3°C vs. 36.3 $\pm$ 1.1°C, $p = 0.002$) and higher mean respiratory rate (22.5 $\pm$ 7.2 vs. 20.5 $\pm$ 3.2, $p < 0.001$) than those in the survival group. However, patients who were exposed to organophosphates (8.3% vs. 15.2%, $p = 0.035$), glyphosate (4.8% vs. 29.4%, $p < 0.001$), carbamates (2.1% vs. 6.3%, $p = 0.048$), pyrethroids (0.0% vs. 8.4%, $p < 0.001$) and others or unknown pesticides (5.5% vs. 21.0%, $p < 0.001$) accounted for lower proportions in the fatality group.

Table 1
Clinical characteristics and exposure agents of the fatalities ($n = 145$) and survivors ($n = 428$) groups of patients with pesticide poisoning.

	Fatalities ($n = 145$), n (%)	Survivors ($n = 428$), n (%)	Total ($n = 573$), n (%)	p
Age (y)	48.1 ± 17.3	46.5 ± 17.4	46.9 ± 17.4	NS
Body temperature (°C)	35.9 ± 1.3 ($n = 117$)	36.3 ± 1.1 ($n = 381$)	36.2 ± 1.1 ($n = 498$)	0.002
Heart rate (/min)	91.5 ± 24.6 ($n = 132$)	92.1 ± 19.6 ($n = 394$)	91.9 ± 21.0 ($n = 526$)	NS
Respiratory rate (/min)	22.5 ± 7.2 ($n = 118$)	20.5 ± 3.2 ($n = 390$)	20.9 ± 4.5 ($n = 508$)	<0.001
Systolic blood pressure (SBP; mmHg)	134.8 ± 29.5 ($n = 128$)	137.8 ± 28.0 ($n = 387$)	137.1 ± 28.4 ($n = 515$)	NS
Diastolic blood pressure (mmHg)	77.1 ± 19.0 ($n = 128$)	79.4 ± 17.0 ($n = 387$)	78.8 ± 17.5 ($n = 515$)	NS
Age groups				NS
≥60 yrs	38 (26.2)	106 (24.8)	144 (25.1)	
<60 yrs	107 (73.8)	322 (75.2)	429 (74.9)	
Gender				NS
Male	88 (60.7)	264 (61.7)	352 (61.4)	
Female	57 (39.3)	164 (38.3)	221 (38.6)	
Body temperature				<0.001
Hyperthermia (≥37.5°C) or hypothermia (≤35°C)	32 (27.4)	49 (12.9)	81 (16.3)	
Body temperature 35.1–37.4°C	85 (72.6)	332 (87.1)	417 (83.7)	
Heart rate				NS
Tachycardia (>100/min) or bradycardia (<60/min)	48 (36.4)	126 (32.0)	174 (33.1)	
Heart rate 60–100/min	84 (63.6)	268 (68.0)	352 (66.9)	
Respiratory rate				<0.001
Respiratory distress or necessity of intubation	22 (18.6)	27 (6.9)	49 (9.6)	
Respiratory rate 10–24/min	96 (81.4)	363 (93.1)	459 (90.4)	
SBP				NS
Hypotension (SBP < 90 mmHg)	6 (4.7)	10 (2.6)	16 (3.1)	
SBP ≥ 90 mmHg)	122 (95.3)	377 (97.4)	499 (96.9)	
Consciousness level				0.003
Glasgow coma scale < 15	32 (40.0)	53 (22.7)	85 (27.2)	
Glasgow coma scale = 15	48 (60.0)	180 (77.3)	228 (72.8)	
Suicide attempt				<0.001
Yes	125 (86.2)	244 (57.0)	369 (64.4)	
No	20 (13.8)	184 (43.0)	204 (35.6)	
Oral administration				<0.001
Yes	145 (100.0)	358 (83.6)	503 (87.8)	
No	0 (0.0)	70 (16.4)	70 (12.2)	
Concomitant use of alcohol				NS
Yes	41 (28.3)	138 (32.2)	179 (31.2)	
No	104 (71.7)	290 (67.8)	394 (68.8)	
Number of exposure agents				NS
Multiple agents	6 (4.1)	14 (3.3)	20 (3.5)	
Single agent	139 (95.9)	414 (96.7)	553 (96.5)	
Exposed pesticides				
Paraquat				<0.001
Yes	121 (83.4)	94 (22.0)	215 (37.5)	
No	24 (16.6)	334 (78.0)	358 (62.5)	
Organophosphate				0.035
Yes	12 (8.3)	65 (15.2)	77 (13.4)	
No	133 (91.7)	363 (84.8)	496 (86.6)	
Glyphosate				<0.001
Yes	7 (4.8)	126 (29.4)	133 (23.2)	
No	138 (95.2)	302 (70.6)	440 (76.8)	
Carbamate				0.048
Yes	3 (2.1)	27 (6.3)	30 (5.2)	
No	142 (97.9)	401 (93.7)	543 (94.8)	
Pyrethroid				<0.001
Yes	0 (0.0)	36 (8.4)	36 (6.3)	
No	145 (100.0)	392 (91.6)	537 (93.7)	
Others/unknown pesticides				<0.001
Yes	8 (5.5)	90 (21.0)	98 (17.1)	
No	137 (94.5)	338 (79.0)	475 (82.9)	

Values shown are n (%) or mean ± SD, as appropriate; p was obtained between fatalities and survivors groups.
NS = no significance.

To find predictors of poisoning-related fatalities, binary logistic regression analysis (forward stepwise Wald test) was conducted for the 11 significant variables derived from univariate analysis. Oral administration and suicide attempt were correlated (Pearson's correlation coefficient: 0.502, $p < 0.001$), but only the latter was included in logistic regression analysis. Paraquat [odds ratio (OR) = 83.39; 95% confidence interval (CI) 19.08–364.53] and organophosphate intoxication (OR = 10.88; 95% CI 1.83–64.72), suicide attempt (OR = 15.98; 95% CI 4.32–59.09), and abnormal body temperature (OR = 2.76, 95% CI 1.03–7.36) were the most significant predictors associated with poisoning-related fatalities (Table 2).

3.3. Characteristics and predictors of fatalities in patients with paraquat poisoning

Because paraquat intoxication was the most significant predictor of fatality and accounted for 83.4% of the poisoning-related fatalities, the clinical characteristics that were associated with fatality in paraquat intoxication were further examined. The

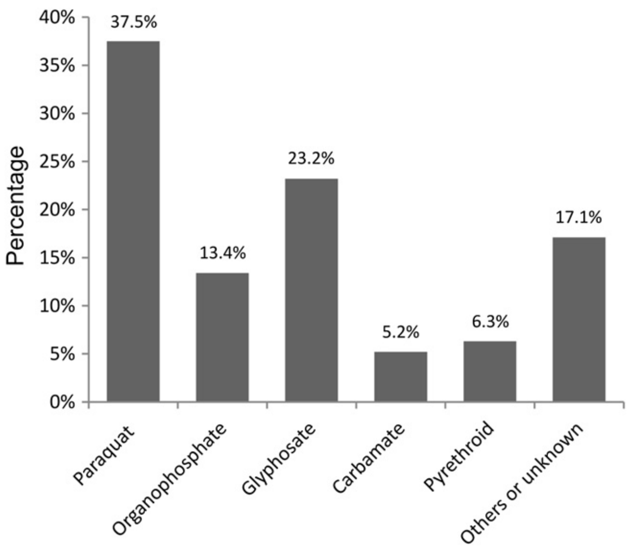

Fig. 1. Types of pesticides implicated in 573 poisoning cases. The total percentage is >100%, because 20 cases involved more than one kind of pesticide.

patients with paraquat poisoning were divided into fatality and survival groups. There were 215 patients exposed to paraquat during the study period, of whom 121 (56.28%) died during hospitalization with a mean survival of 3.79 ± 4.7 days. Comparison between the fatality and survivor groups showed that five variables—age ≥ 60years (26.4% vs. 11.7%, $p = 0.007$), abnormal body temperature (25.5% vs. 12.9%, $p < 0.033$), abnormal respiratory rate (15.4% vs. 4.5%, $p = 0.013$), suicide attempt (86.8% vs. 51.1%, $p < 0.001$) and oral administration (100.0% vs. 87.2%, $p < 0.001$)—were significantly associated with poisoning-related fatality. Concomitant use of alcohol (29.8% vs. 43.6%, $p = 0.035$) accounted for a lower proportion in the fatality group (Table 3). Moreover, older age (46.8 ± 17.2 vs. 40.3 ± 15.3, $p = 0.005$), lower initial body temperature (35.9 ± 1.2 vs. 36.4 ± 0.7, $p = 0.002$) and higher respiratory rate (22.0 ± 6.2 vs. 20.3 ± 2.3, $p = 0.018$), were also found in the paraquat poisoning fatalities.

In logistic regression analysis of the above significant variables, age ≥ 60 years (OR = 4.64; 95% CI 1.68-12.82), suicide attempt (OR = 9.27; 95% CI 4.05–21.21), and abnormal body temperature (OR = 2.63; 95% CI 1.06–6.56) were the three most significant predictors for paraquat fatalities (Table 4).

3.4. Characteristics and predictors of fatalities in patients with nonparaquat poisoning

Because of the highly recognizable blue or green color of paraquat, the emergency physician is likely to be able to identify paraquat intoxication when performing gastric lavage. However, pesticides other than paraquat are not recognized easily, especially when patients present to the ED without a pesticide container.

Table 2
Predictors associated with poisoning fatality in all patients with pesticide poisoning.

Parameters	Odds ratio (95% confidence interval)	p
Paraquat poisoning	83.39 (19.08–364.53)	<0.001
Organophosphate poisoning	10.88 (1.83–64.72)	0.009
Suicide attempt	15.98 (4.32–59.09)	<0.001
Abnormal body temperature	2.76 (1.03–7.36)	0.043

Oral administration and suicide attempt were correlated; only suicide attempt was included in logistic regression analysis.

Therefore, the differences between fatalities and survivors were analyzed among patients with nonparaquat poisoning to find early prognostic factors. The results are shown in Table 5. Twenty-four (6.7%) of the 358 patients with nonparaquat pesticide poisoning died. The mean survival was 2.83 ± 3.2 days.

In univariate analysis, eight variables were found to be significantly different between the fatality and survival groups in nonparaquat poisoning. These included abnormal body temperature (36.8% vs. 12.8%, $p = 0.004$), abnormal heart rate (57.1% vs. 29.4%, $p = 0.008$), abnormal respiratory rate (42.9% vs. 7.6%, $p = 0.001$), hypotension (15.0% vs. 2.6%, $p = 0.025$), consciousness impairment (86.7% vs. 24.2%, $p < 0.001$), suicide attempt (83.3% vs. 58.7%, $p = 0.017$), oral administration (100.0% vs. 82.6%, $p = 0.02$) and organophosphate poisoning (45.8% vs. 19.5%, $p = 0.002$) (Table 5) with the fatality group showing higher percentages. A higher initial respiratory rate (26.82 ± 13.47 vs. 20.53 ± 3.43, $p < 0.001$) was also found in nonparaquat fatalities. The results of binary logistic regression analysis (forward stepwise test) of the above significant variables showed that suicide attempt (OR > 999, $p < 0.001$) and respiratory distress (OR = 23.25, 95% CI 3.52-153.5, $p = 0.001$) were the most significant predictors for fatalities among patients with nonparaquat poisoning (Table 6).

3.5. Comparison of patients with paraquat and nonparaquat poisoning

All variables were further compared between paraquat and nonparaquat poisoning cases. There was a significantly higher mortality rate in the paraquat group (56.3% vs. 7.0%, $p < 0.001$), and suicide attempt (71.2% vs. 60.3%, $p = 0.009$) and oral administration (94.4% vs. 83.8%, $p < 0.001$) were also seen at higher frequencies in this group (results not shown). Among fatalities, there was no significant difference in the mean survival between the paraquat and nonparaquat groups (3.79 ± 4.74 vs. 2.83 ± 3.20, respectively, $p = 0.348$).

4. Discussion

In the present study, we retrospectively reviewed and identified the available prognostic factors for agricultural pesticide poisoning-related fatalities in the ED in our hospital from July 1, 2001 to July 31, 2008, a 7-year period. Paraquat and organophosphates were most associated with overall mortality. Suicidal intent and initial abnormal body temperature were also predictors for mortality. In paraquat poisoning, age over 60 years, suicide attempt and abnormal body temperature, especially hypothermia, were risk factors for death. In nonparaquat poisoning, suicide attempt and initial respiratory distress were predictors of mortality.

The most common agricultural chemical exposure in our study involved paraquat, followed by glyphosate and organophosphates. Epidemiologic data from other regions of Taiwan indicated that organophosphate was most common poisoning agent, followed by paraquat [4,13]. Similar results were also demonstrated in foreign countries [12,14]. Eastern Taiwan is still an agricultural area and rice is the main product. Frequent use of this herbicide and easy access may explain why paraquat is the leading pesticide resulting in poisoning in this area. This finding also suggests that farmers may not receive sufficient education regarding the potential lethal effects of paraquat. More detailed caution labels on containers and restrictions on the sale and distribution of paraquat may be needed to prevent the high mortality caused by paraquat intoxication. As seen in the present study, a large number of patients ingest paraquat when attempting suicide.

Serial studies have been done to identify the prognostic factors in poisoning from individual herbicides and insecticides such as

Table 3
Clinical characteristics and concomitant exposed agents of the fatalities ($n = 121$) and survivors ($n = 94$) groups of patients with paraquat poisoning.

	Fatalities ($n = 121$), n (%)	Survivors ($n = 94$), n (%)	p
Age (y)	46.8 ± 17.2	40.3 ± 15.3	0.005
Body temperature (°C)	35.9 ± 1.2 ($n = 98$)	36.4 ± 0.7 ($n = 85$)	0.002
Heart rate (/min)	91.4 ± 23.6 ($n = 111$)	92.9 ± 20.5 ($n = 88$)	NS
Respiratory rate (/min)	22.0 ± 6.2 ($n = 104$)	20.3 ± 2.3 ($n = 89$)	0.018
Systolic blood pressure (SBP; mmHg)	134.5 ± 27.7 ($n = 108$)	134.1 ± 24.7 ($n = 85$)	NS
Diastolic blood pressure (mmHg)	77.1 ± 18.4 ($n = 108$)	79.3 ± 13.9 ($n = 85$)	NS
Age groups			0.007
≥60 y	32 (26.4)	11 (11.7)	
<60 y	89 (73.6)	83 (88.3)	
Gender			NS
Male	74 (61.2)	54 (57.4)	
Female	47 (38.8)	40 (42.6)	
Body temperature			0.033
Hyperthermia (≥37.5°C) or hypothermia (≤35°C)	25 (25.5)	11 (12.9)	
Body temperature 35.1–37.4°C	73 (74.5)	74 (87.1)	
Heart rate			NS
Tachycardia (>100/min) or bradycardia (<60/min)	36 (32.4)	36 (40.9)	
Heart rate 60–100/min	75 (67.6)	52 (59.1)	
Respiratory rate			0.013
Respiratory distress or necessity of intubation	16 (15.4)	4 (4.5)	
Respiratory rate 10–24/min	88 (84.6)	85 (95.5)	
SBP			NS
Hypotension (SBP < 90 mmHg)	3 (2.8)	2 (2.4)	
SBP ≥ 90 mmHg)	105 (97.2)	83 (97.6)	
Consciousness level			NS
Glasgow coma scale < 15	19 (29.2)	9 (17.6)	
Glasgow coma scale = 15	46 (70.8)	42 (82.4)	
Suicide attempt			<0.001
Yes	105 (86.8)	48 (51.1)	
No	16 (13.2)	46 (48.9)	
Oral administration			<0.001
Yes	121 (100.0)	82 (87.2)	
No	0 (0.0)	12 (12.8)	
Concomitant use of alcohol			0.035
Yes	36 (29.8)	41 (43.6)	
No	85 (70.2)	53 (56.4)	
Number of exposure agents			NS
Multiple agents	4 (3.3)	4 (4.3)	
Single agent	117 (96.7)	90 (95.7)	
Concomitant exposed pesticides			
Organophosphate			NS
Yes	1 (0.8)	0 (0.0)	
No	120 (99.2)	94 (100.0)	
Glyphosate			NS
Yes	1 (0.8)	4 (4.3)	
No	120 (99.2)	90 (95.7)	
Others/unknown pesticides			NS
Yes	2 (1.7)	0 (0.0)	
No	119 (98.3)	94 (100.0)	

Values shown are n (%) or mean ± SD, as appropriate. NS = no significance.

paraquat [2,3,7,10], organophosphates [6,11,15], and glyphosate [16]. The serum concentration of paraquat and an Acute Physiology and Chronic Health Evaluation (APACHE) II score >20 have been demonstrated to have good accuracy in predicting mortality from paraquat poisoning [2,7,17]. However, monitoring of paraquat concentrations is not available in small and medium sized hospitals, especially in remote areas, and the APACHE II score is complicated and not timely enough for first line emergency physicians. To this end, we identified easily accessible clinical information, including age over 60 years, abnormal body temperature and suicide attempt, as factors predicting high mortality in paraquat poisoning patients. Similarly, several scoring systems have been proposed in specific nonparaquat intoxication. Bilgin et al showed that the GCS, APACHE II, and Simplified Acute Physiology Score II scores had similar predicting impact in evaluating mortality in patients with organophosphate poisoning in the intensive care unit. The GCS score has been considered a superior scoring system because it is easy to perform and does not require complex physiological and laboratory parameters [6]. However, Lee et al proposed that respiratory distress, requirement for hemodialysis, and pulmonary edema were prognostic factors of a poor outcome in glyphosate intoxication [16]. However, the risk factors for overall nonparaquat pesticide poisoning-related fatalities have not been described before. Identification of a suitable system is important for emergency physicians. In the present study, we demonstrated that patients with nonparaquat pesticide poisoning who presented initially with abnormal vital signs, shock, impaired consciousness, and suicide intent were at high risk for poisoning-related fatality. Moreover, organophosphate poisoning accounted for most fatalities among patients with nonparaquat poisoning. Further multivariate analysis demonstrated that initial respiratory distress is a strong predictor for nonparaquat fatality. Similar findings have also been demonstrated in poisoning from individual nonparaquat pesticides, such as organophosphates and glyphosate [9,18–20].

Evidence is accumulating that pesticide self-poisoning is a major but under-recognized public health problem, with

Table 4
Predictors associated with poisoning fatality in patients with paraquat poisoning.

Parameters	Odds ratio (95% confidence interval)	*p*
Age ≥ 60 y	4.64 (1.68–12.82)	0.003
Suicide attempt	9.27 (4.05–21.21)	<0.001
Abnormal body temperature	2.63 (1.06–6.56)	0.038

Oral administration and suicide attempt were correlated; only suicide attempt was included in logistic regression analysis.

250,000–370,000 deaths annually worldwide [21,22]. These deaths represent about a third of suicides globally [22]. Indeed, in our study, suicide attempts were highly associated with mortality in both the paraquat and nonparaquat groups. Possible approaches to reducing deaths from intentional pesticide ingestion have been addressed, including the following strategies: (1) reduce the availability of highly toxic pesticides, (2) reduce the use of pesticides in acts of self harm, (3) reduce the toxicity of pesticides taken in overdose, and (4) improve the management of pesticide poisoning [21]. These strategies must be undertaken more aggressively in eastern Taiwan.

An interesting finding from our results was that abnormal initial body temperature was a risk factor for mortality both in the overall pesticide and paraquat groups, but not in the nonparaquat group. The majority of the overall pesticide poisoning fatalities were paraquat intoxication; the abnormal body temperature found in the

Table 5
Clinical characteristics and exposure agents of the fatalities ($n = 24$) and survivors ($n = 334$) groups of patients with nonparaquat pesticide poisoning.

	Fatalities ($n = 24$), n (%)	Survivors ($n = 334$), n (%)	*p*
Age (y)	55.1 ± 16.6	48.2 ± 17.6	NS
Body temperature (°C)	35.9 ± 1.8 ($n = 19$)	36.3 ± 1.1 ($n = 296$)	NS
Heart rate (/min)	92.5 ± 29.7 ($n = 21$)	91.8 ± 19.4 ($n = 306$)	NS
Respiratory rate (/min)	26.8 ± 13.5 ($n = 14$)	20.5 ± 3.4 ($n = 301$)	<0.001
Systolic blood pressure (SBP; mmHg)	136.9 ± 39.4 ($n = 20$)	138.8 ± 28.8 ($n = 302$)	NS
Diastolic blood pressure (mmHg)	77.0 ± 22.5 ($n = 20$)	79.4 ± 17.8 ($n = 302$)	NS
Age groups			NS
≥60 y	6 (25.0)	95 (28.4)	
<60 y	18 (75.0)	239 (71.6)	
Gender			NS
Male	14 (58.3)	210 (62.9)	
Female	10 (41.7)	124 (37.1)	
Body temperature			0.004
Hyperthermia (≥37.5°C) or hypothermia (≤35°C)	7 (36.8)	38 (12.8)	
Body temperature 35.1–37.4°C	12 (63.2)	258 (87.2)	
Heart rate			0.008
Tachycardia (>100/min) or bradycardia (<60/min)	12 (57.1)	90 (29.4)	
Heart rate 60–100/min	9 (42.9)	216 (70.6)	
Respiratory rate			0.001
Respiratory distress or necessity of intubation	6 (42.9)	23 (7.6)	
Respiratory rate 10–24/min	8 (57.1)	278 (92.4)	
SBP			0.025
Hypotension (SBP < 90 mmHg)	3 (15.0)	8 (2.6)	
SBP ≥ 90 mmHg)	17 (85.0)	294 (97.4)	
Consciousness level			<0.001
Glasgow coma scale < 15	13 (86.7)	44 (24.2)	
Glasgow coma scale = 15	2 (13.3)	138 (75.8)	
Suicide attempt			0.017
Yes	20 (83.3)	196 (58.7)	
No	4 (16.7)	138 (41.3)	
Oral administration			0.02
Yes	24 (100.0)	276 (82.6)	
No	0 (0.0)	58 (17.4)	
Concomitant use of alcohol			NS
Yes	5 (20.8)	97 (29.0)	
No	19 (79.2)	237 (91.0)	
Number of exposure agents			NS
Multiple agents	2 (8.3)	10 (3.0)	
Single agent	22 (91.7)	324 (97.0)	
Concomitant exposed pesticides			
Organophosphate			0.002
Yes	11 (45.8)	65 (19.5)	
No	13 (54.2)	269 (80.5)	
Glyphosate			NS
Yes	6 (25.0)	122 (36.5)	
No	18 (75.0)	212 (63.5)	
Carbamate			NS
Yes	3 (12.5)	27 (8.1)	
No	21 (87.5)	307 (91.9)	
Pyrethroid			NS
Yes	0 (0.0)	36 (10.8)	
No	24 (100.0)	298 (89.2)	
Others/unknown pesticides			NS
Yes	6 (25.0)	90 (26.9)	
No	18 (75.0)	244 (73.1)	

Values shown are n (%) or mean ± SD, as appropriate.
NS = no significance.

Table 6
Predictors associated with poisoning fatality in patients with nonparaquat pesticide intoxication.

Parameters	Odds ratio (95% confidence interval)	*p*
Suicide attempt	>999 (N/A)	<0.001
Respiratory distress	23.25 (3.521–153.52)	0.001

Oral administration and suicide attempt were correlated; only suicide attempt was included in logistic regression analysis.

fatalities of in the overall pesticide population could be attributed to the paraquat poisoning fatalities. In the paraquat group, the mean body temperature of the patients who died was significantly lower than that of the survivors. Chang et al suggested that initial hypothermia is associated with 30-day mortality in patients with acute paraquat poisoning [23]. In 1997, the United States Environmental Protection Agency observed hypothermia in experimental animals with oral administration of an 50% lethal dose of paraquat [24]. Therefore, hypothermia may be an early poor prognostic sign in patients with paraquat poisoning.

Several limitations exist in the present study. First, although we attempted to incorporate complete data, some data were missing from the charts. Second, ED laboratory data were not available for this study. If laboratory data could be added into the analysis, better objective results could be obtained. Third, newer types of pesticides have been developed recently, but a more detailed classification of these pesticides could not be provided for the present study. A larger prospective study should be performed to verify the risk factors we identified, which may provide more accurate and more rapidly available data for emergency physicians for early risk stratification and treatment.

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