

International Journal of Environmental Health Research

ISSN: 0960-3123 (Print) 1369-1619 (Online) Journal homepage: www.tandfonline.com/journals/cije20

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To cite this article: Gholamali Dorooshi, Amirreza Shirazi , Awat Feizi , Farzad Gheshlaghi , Rokhsareh Meamar & Nastaran Eizadi-Mood (12 Oct 2026): Association between leukocytosis and adverse clinical outcomes in thrombocytopenic patients with acute pesticide poisoning: a cross-sectional study from a referral poisoning center in Iran, International Journal of Environmental Health Research, DOI: 10.1080/09603123.2026.2745889

To link to this article: https://doi.org/10.1080/09603123.2026.2745889

Published online: 12 Oct 2026.

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INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH
https://doi.org/10.1080/09603123.2026.2745889

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RESEARCH ARTICLE

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Association between leukocytosis and adverse clinical outcomes in thrombocytopenic patients with acute pesticide poisoning: a cross-sectional study from a referral poisoning center in Iran

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ABSTRACT

This study evaluated the association between leukocytosis and adverse clinical outcomes in patients with pesticide poisoning who also had thrombocytopenia. This cross-sectional study used medical records of patients who presented between 2016 and 2021, including 241 adult patients with confirmed pesticide poisoning. We extracted demographic data, clinical signs, laboratory parameters, and outcomes. We categorized hospitalization duration as >72 hours, 24–72 hours, and <24 hours. Leukocytosis was present in 43.2% of patients (n = 104). The overall mortality rate was 25.3% (n = 61), with 49.8% requiring intensive care unit (ICU) admission (n = 120) and 44.4% requiring intubation (n = 107). Patients with elevated WBC had higher odds of prolonged hospitalization than those with normal counts: OR = 3.36, p = 0.004 for 24–72 h; and OR = 4.63, p < 0.001 for hospitalizations longer than 72 h. Leukocytosis was also strongly associated with intubation (OR = 3.50, p < 0.001) and ICU admission (OR = 3.58, p < 0.001). After adjustment, only ICU admission and leukocytosis remained significantly associated (OR = 2.20, p = 0.024). Leukocytosis may be a valuable parameter in predicting ICU admission and hospitalization duration in thrombocytopenic patients with acute pesticide poisoning. Further prospective multicenter studies are needed.

ARTICLE HISTORY
Received 18 February 2026
Accepted 2 October 2026

KEYWORDS
Pesticide poisoning; acute; Leukocytosis; thrombocytopenia; outcome

Introduction

Pesticides, a broad class of chemical agents used to eliminate agricultural pests, are widely used in both domestic and industrial settings. While their use has enhanced agricultural productivity, it has also introduced substantial health hazards, particularly in low- and middle-income countries (LMICs), where regulatory oversight and appropriate handling practices are often inadequate. Approximately 168,000 people die from pesticide self-poisoning every year. Approximately 168,000 people die from pesticide self-poisoning annually (Bonvoisin et al. 2020). Pesticide self-poisoning is particularly prevalent in Southeast Asia and China. In countries like Iran, where agriculture constitutes a significant portion of the economy, pesticides are widely used and are among the leading causes of poisoning-related hospitalizations and deaths. Ons and deaths (Soltaninejad et al. 2007; Alinejad et al. 2017; Eizadi-Mood et al. 2023, 2024).

Beyond the acute toxic effects of pesticide exposure, recent evidence has highlighted its impact on hematological parameters, including alterations in white blood cell counts and platelet levels (Nejatifar et al. 2022; Ruiz-Arias et al. 2025). Inconsistent and controversial findings have been reported regarding platelet levels, with reports of both thrombocytosis and thrombocytopenia in cases of pesticide exposure (Fareed et al. 2013; Freire et al. 2015; García-García et al. 2016). The ratio of leukocytes to platelets in organophosphorus poisoning has been associated with increased disease severity and adverse outcomes, though its prognostic significance remains inadequately characterized (Elsayed et al. 2024). Leukocytosis, often accompanied by neutrophilia and occurring alongside thrombocytopenia, has

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been frequently reported in pesticide poisoning (Faluomi et al. 2022). Leukocytosis reflects the systemic inflammatory response triggered by pesticide-induced oxidative stress and tissue damage. Previous studies have shown that elevated leukocyte levels correlate with the severity of organophosphate poisoning (Anormallikleri 2010; Sumathi et al. 2014). These cells travel from the blood to tissues during infections and stress-like conditions and are crucial for an immune response (Mathour et al. 2023). However, the prognostic value of leukocytosis may differ depending on concurrent hematological abnormalities, such as thrombocytopenia.

Recent studies (Nejatifar et al. 2022; Ruiz-Arias et al. 2025) demonstrated hematologic disturbances, such as increased WBCs and altered platelets in pesticide-exposed humans. Recognizing potent prognostic biomarkers is needed in the clinical management of acute pesticide-poisoned patients to predict outcomes (Elhosary and Abdelbar 2018).

While leukocytosis has been recognized as a marker of severity in pesticide poisoning (Dundar et al. 2014; Elhosary and Abdelbar 2018; Kumar et al. 2018), its prognostic value specifically in patients with concurrent thrombocytopenia remains unexplored. This knowledge gap is clinically significant because patients with both leukocytosis and thrombocytopenia may represent a distinct subgroup with different pathophysiological mechanisms and clinical trajectories. Since the complete blood count is one of the most common tests obtained in Intensive Care Unit (ICU) patients, the level of leukocytes could serve as an easily obtainable and cost-effective prognostic marker for predicting clinical outcomes in patients with pesticide poisoning. On the other hand, the combination of leukocytosis and thrombocytopenia may indicate a distinct inflammatory and coagulopathic profile that warrants separate investigation. However, none have focused on the subgroup of thrombocytopenic patients with acute poisoning and evaluated leukocytosis as a prognostic marker. To address this gap, this cross-sectional study was conducted in a referral poisoning center (a single center) in Iran. The aim was to assess the association between leukocytosis and clinical outcomes, including ICU admission, intubation, and duration of hospitalization, in patients with pesticide poisoning who also exhibited thrombocytopenia.

Method

Study design and setting

This cross-sectional observational study was based on a retrospective chart review of patients registered at Khorshid Hospital, affiliated with Isfahan University of Medical Sciences, Isfahan, Iran, between 2016 and 2021. The study complied with the Declaration of Helsinki guidelines and was approved by the ethics committee of the Review Board of Isfahan University of Medical Sciences (IR.ARI.MUI.REC.1404.034). The data used in this study were derived from a larger study (IR.MUI.MED.REC.1400.381) (Gheshlaghi et al. 2025)(. On admission, written informed consent for treatment was obtained from all patients or their legally authorized representatives, including permission for future anonymized research use of their data. For the retrospective chart review, the ethics committee waived additional informed consent because the data were anonymized and already covered by the original consent. When patients could not consent (e.g., unconscious or intubated), surrogate consent was obtained from a legal guardian or next of kin. For deceased or unreachable patients, the committee approved a waiver for use of anonymized data. For minors, parents or legal guardians provided consent. To protect patients' identities, password-protected files were used to securely store their records.

Sample size and sampling method

As this study was a secondary analysis of an existing hospital registry and was designed as a cross-sectional study based on a retrospective chart review, no separate a priori sample size calculation was performed. A census-based sampling method was used, and all patients recorded in the registry between 2016 and 2021 who met the eligibility criteria were included. Therefore, the sample size was determined by the total number of eligible cases available in the registry, rather than by a formal power calculation. This census-based approach ensured that all eligible patients were included and thereby minimized the risk of selection bias.

All patients aged 18 years or older with pesticide poisoning (such as organophosphate, paraquat, zinc phosphide, and aluminum phosphide) without a history of platelet disorders or antiplatelet drug use, and who experienced thrombocytopenia upon admission or during hospitalization were included. Thrombocytopenia was defined as a platelet count below 150×10^3 per microliter at admission and during hospitalization (Gauer and Whitaker 2022). After screening all registry records, 241 patients with pesticide poisoning and thrombocytopenia met the eligibility criteria and were included in the final analysis.

Patients with incomplete medical records or those without a leukocyte count reported in their laboratory exam were excluded from the study. Patients with documents related to infectious diseases were also excluded. Leukocytosis was defined as an elevated white blood cell (WBC) count above the normal reference range. The normal reference range of WBC in our hospital was 4,000–10,000 cells/μL (WBC count based on the international standard: 5000–10,000/mm^3) (Pagana et al. 2014). WBC and platelet counts were determined using the cell counter Sysmex KX21N (Medical Electronics, Japan).

Data collection

The data collection was based on the ICD-10 code. T60.0 (organophosphate), T60.3 (paraquat), T60.4 (zinc phosphide), and T60.7 (aluminum phosphide) of ICD-10 were used for the classification of patient diagnosis. Upon patient admission, blood samples were collected for laboratory examinations. Arterial Sampling using Vacutainer tubes containing Ethylenediaminetetraacetic acid (EDTA) as an anticoagulant was used. All EDTA blood samples were analyzed within 24 hours of collection. In addition, this study used a standardized data collection checklist. Data were abstracted from the hospital's medical documents and laboratory records using a standardized data collection checklist. The method adopted to collect the data was manual extraction by trained researchers. The following data were collected: demographic data, toxicological details, past medical and drug histories, physical examination parameters at admission, and muscarinic (increased body secretions, salivation, lacrimation, bronchorrhea, urinary and fecal incontinence, vomiting, and miosis) and nicotinic manifestations (muscle weakness, cramps, fasciculations, and paralysis) were also retrieved from medical documents. Laboratory findings, including hematological, hepatic, and renal function tests, were also collected. Therapeutic interventions such as gastric lavage, activated charcoal, atropine, pralidoxime, corticosteroids, N-acetylcysteine (NAC), vitamin C/E, paraffin gavage, and dialysis were documented.

Assessment of the severity of organophosphate poisoning was based on clinical symptoms, with latent, mild, moderate, and severe categories defined (Namba et al. 1971).

Outcomes evaluated included ICU admission, intubation, duration of hospitalization (<24 hours, 24–72 hours, and >72 hours), and outcome (death, recovery).

Statistical analysis

Data were analyzed using SPSS software version 21 (Armonk, NY: IBM Corp). Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as means ± standard deviations. Univariate associations between variables and study outcomes were assessed using Chi-square or Fisher's exact test for categorical variables and independent-samples t-tests or ANOVA for continuous variables. Binary and multinomial logistic regression models (univariable and multivariable) were applied to evaluate the association between leukocytosis and the study's clinical outcomes, including mortality, ICU admission, intubation, and the duration of hospitalization (categorized into three groups: <24 hours (reference category), 24–72 hours, and >72 hours) in crude and adjusted analyses, respectively. Each outcome variable in the logistic regression models was adjusted for its own set of confounding variables—specifically, those that were significantly associated with the response variable at the 5% level in prior univariate analyses. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported for all logistic models. A two-sided p-value < 0.05 was considered statistically significant.

Results

A total of 241 patients with pesticide poisoning and thrombocytopenia were included in the study, with 43.2% (n = 104) experiencing leukocytosis. The overall mortality rate was 25.3% (n = 61), and 49.8% (n = 120) of patients required ICU admission. Intubation was necessary for 44.4% (n = 107) of the patients.

Table 1 presents demographics and toxicological characteristics of patients with pesticide poisoning based on outcome, duration of hospitalization, ICU admission, and intubation. Male sex had a significantly higher proportion of mortality (91.8% vs. 8.2%) and rates of intubation (84.1% vs. 15.9%) compared to females.

Among the physical examination findings (Table 2), significant differences were observed in the duration of hospitalization in terms of pupil size, GI manifestations, muscarinic symptoms, and severity of poisoning ($p < 0.05$). Muscarinic manifestations had a higher proportion among patients with longer duration of hospitalization and those who were intubated ($p < 0.001$). Nicotinic symptoms were significantly higher in patients who were admitted to the ICU or intubated ($p < 0.01$). Severity of poisoning was also associated with all study-dependent variables, including outcomes, duration of hospitalization, ICU admission, and intubation (all $p < 0.001$).

As shown in Table 3, there were statistically significant differences in many treatment measures and clinical outcomes.

In univariate associations between treatments and outcomes, several therapeutic interventions showed significant associations with clinical outcomes, likely reflecting their use as markers of patient severity (confounding by indication). Gastric lavage and activated charcoal were not significantly associated with mortality, hospitalization duration, ICU admission, or intubation. In contrast, pralidoxime use was linked to lower mortality ($p = 0.049$) but markedly higher odds of prolonged hospitalization (>72 h, $p < 0.001$), ICU admission ($p = 0.002$), and intubation ($p < 0.001$). Atropine showed no significant relation to mortality but was strongly associated with longer hospitalization ($p < 0.001$), ICU admission ($p < 0.001$), and intubation ($p < 0.001$). N-acetyl cysteine (NAC), vitamin C, and vitamin E were each significantly related to higher mortality (all $p < 0.001$), longer hospitalization (all $p < 0.001$), and increased ICU admission (all $p < 0.001$); NAC and vitamin E were also associated with intubation ($p = 0.007$ and $p = 0.004$, respectively). Paraffin gavage was associated with higher mortality ($p = 0.03$) but not with other outcomes. The dithionate test showed significant crude associations with mortality ($p = 0.04$) but inconsistent relations with other outcomes. Finally, hemodialysis was strongly associated with higher mortality ($p < 0.001$), prolonged hospitalization ($p < 0.001$), ICU admission ($p < 0.001$), and intubation ($p < 0.001$). Full details of these analyses are presented in Table 3. Among patients with pesticide poisoning who developed thrombocytopenia, leukocytosis was more frequent in those with adverse outcomes. Specifically, leukocytosis was present in 55.7% of patients who died compared to 38.9% of those who recovered ($p = 0.022$). Regarding the duration of hospitalization, leukocytosis was observed in 20.0% of patients hospitalized for <24 hours, 45.6% of those hospitalized for 24–72 hours, and 53.7% of those hospitalized for >72 hours ($p < 0.001$). Additionally, leukocytosis was found in 59.8% of intubated patients versus 29.9% of non-intubated patients ($p < 0.001$), and in 58.3% of patients admitted to the ICU versus 28.1% of those not admitted ($p < 0.001$).

In crude logistic regression models, leukocytosis was significantly associated with mortality (OR = 1.98, $p = 0.023$), prolonged hospitalization > 72 hours (OR = 4.63, $p < 0.001$), intubation (OR = 3.50, $p < 0.001$), and ICU admission (OR = 3.58, $p < 0.001$). After adjustment for potential confounders, the association with ICU admission remained statistically significant at the 5% level (OR = 2.20, $p = 0.024$). For mortality, the adjusted OR remained elevated (OR = 2.19, $p = 0.17$), and for prolonged hospitalization > 72 hours, the adjusted OR was 2.46 ($p = 0.065$); although these did not reach statistical significance, the point estimates continue to suggest leukocytosis as a potential risk factor for these outcomes. In contrast, the associations with intermediate hospitalization (24–72 hours) and intubation also attenuated after adjustment (OR = 2.59, $p = 0.055$ and OR = 1.95, $p = 0.078$, respectively), yet the direction and magnitude of the effects consistently indicate an increased risk. More details are presented in Table 4.

Discussion

Acute pesticide poisoning is still a major public health problem in many developing countries, due to the high mortality and lack of effective treatment. Each year, hundreds of patients in rural areas are hospitalized

Table 1. Demographic characteristics and toxicological factors of patients with pesticide poisoning based on outcome, duration of hospitalization, ICU admission and intubation.

		Outcome			Duration of hospitalization				ICU admission			Intubation		
Variable	Category	Recovery n = 180	Mortality n = 61	*p*-value	<24 h n = 60	24–72 h n = 57	>72 n = 123	*p*-value	No ICU n = 121	ICU admission n = 120	*p*-value	No intubation n = 134	Intubation n = 107	*p*-value**
Age		35.59 (16.18)	38.28 (18.35)	0.28	35.2 (14.22)	36.77 (17.79)	36.72 (17.55)	0.79	35.71 (15.48)	36.84 (17.998)	0.60	34.92 (15.20)	37.97 (18.45)	0.16
Sex	Male	130 (72.2%)	56 (91.8%)	0.002*	42 (70.0%)	46 (80.7%)	98 (79.7%)	0.27	94 (77.7%)	92 (76.7%)	0.85	96 (71.6%)	90 (84.1%)	0.022*
	Female	50 (27.8%)	5 (8.2%)		18 (30.0%)	11 (19.3%)	25 (20.3%)		27 (22.3%)	28 (23.3%)		38 (28.4%)	17 (15.9%)	
Employment status	Unemployed or student	15 (8.3%)	5 (8.2%)	0.020*	5 (8.3%)	4 (7.0%)	11 (8.9%)	0.95	10 (8.3%)	10 (8.3%)	0.90	11 (8.2%)	9 (8.4%)	0.16
	Housewife	45 (25.0%)	4 (6.6%)		15 (25.0%)	10 (17.5%)	24 (19.5%)		23 (19.0%)	26 (21.7%)		34 (25.4%)	15 (14.0%)	
	Employed	113 (62.8%)	49 (80.3%)		38 (63.3%)	41 (71.9%)	82 (66.7%)		82 (67.8%)	80 (66.7%)		83 (61.9%)	79 (73.8%)	
	Farmer	7 (3.9%)	3 (4.9%)		2 (3.3%)	2 (3.5%)	6 (4.9%)		6 (5.0%)	4 (3.3%)		6 (4.5%)	4 (3.7%)	
Level of education	Under Diploma	40 (50.0%)	18 (72.0%)	0.12	10 (50.0%)	9 (32.1%)	39 (69.6%)	0.017*	18 (43.9%)	40 (62.5%)	0.17	29 (48.3%)	29 (64.4%)	0.15
	Diploma	28 (35.0%)	6 (24.0%)		8 (40.0%)	15 (53.6%)	11 (19.6%)		17 (41.5%)	17 (26.6%)		24 (40.0%)	10 (22.2%)	
	University	12 (15.0%)	1 (4.0%)		2 (10.0%)	4 (14.3%)	6 (10.7%)		6 (14.6%)	7 (10.9%)		7 (11.7%)	6 (13.3%)	
Type of exposure	Intentional	149 (82.8%)	48 (78.7%)	0.61	46 (76.7%)	48 (84.2%)	102 (82.9%)	0.29	97 (80.2%)	100 (83.3%)	0.84	110 (82.1%)	87 (81.3%)	0.45
	Accidental	16 (8.9%)	6 (9.8%)		7 (11.7%)	7 (12.3%)	8 (6.5%)		11 (9.1%)	11 (9.2%)		13 (9.7%)	9 (8.4%)	
	Unknown	13 (7.2%)	7 (11.5%)		7 (11.7%)	1 (1.8%)	12 (9.8%)		12 (9.9%)	8 (6.7%)		9 (6.7%)	11 (10.3%)	
	By others	2 (1.1%)	0 (0.0%)		0 (0.0%)	1 (1.8%)	1 (0.8%)		1 (0.8%)	1 (0.8%)		2 (1.5%)	0 (0.0%)	
Past medical history	Yes	39 (21.7%)	13 (21.3%)	0.95	13 (21.7%)	16 (28.1%)	23 (18.7%)	0.37	27 (22.3%)	25 (20.8%)	0.78	28 (20.9%)	24 (22.4%)	0.77
Past drug history	Yes	45 (25.0%)	16 (26.2%)	0.85	12 (20.0%)	15 (26.3%)	33 (26.8%)	0.59	26 (21.5%)	35 (29.2%)	0.17	33 (24.6%)	28 (26.2%)	0.79
Addiction history	Yes	62 (34.4%)	21 (34.4%)	0.99	20 (33.3%)	22 (38.6%)	40 (32.5%)	0.72	42 (34.7%)	41 (34.2%)	0.93	48 (35.8%)	35 (32.7%)	0.61
History of psychiatric disease	Yes	40 (22.2%)	14 (23.0%)	0.91	11 (18.3%)	15 (26.3%)	27 (22.0%)	0.58	26 (21.5%)	28 (23.3%)	0.73	28 (20.9%)	26 (24.3%)	0.53
Suicide history	Yes	32 (17.8%)	8 (13.1%)	0.40	9 (15.0%)	14 (24.6%)	16 (13.0%)	0.14	21 (17.4%)	19 (15.8%)	0.75	23 (17.2%)	17 (15.9%)	0.79

*p-value < 0.05, **Resulted from chi-square or Fisher exact test and ANOVA test. ICU: intensive care unit.

Table 2. Physical examination of patients with pesticide poisoning who experienced thrombocytopenia, categorized by outcome, duration of hospitalization, ICU admission, and intubation.

		Outcome			Duration of hospitalization				ICU admission			Intubation		
Variable	Category	Recovery	Mortality	*p*-value	<24 h	24–72 h	>72	*p*-value	No ICU	ICU admission	*p*-value	No intubation	Intubation	*p*-value**
Skin	Normal	144 (80.0%)	49 (80.3%)	0.62	53 (88.3%)	48 (84.2%)	91 (74.0%)	0.17	101 (83.5%)	92 (76.7%)	0.44	111 (82.8%)	82 (76.6%)	0.48
	Dry and warm	6 (3.3%)	4 (6.6%)		2 (3.3%)	1 (1.8%)	7 (5.7%)		3 (2.5%)	7 (5.8%)		6 (4.5%)	4 (3.7%)	
	Icteric	1 (0.6%)	1 (1.6%)		0 (0.0%)	1 (1.8%)	1 (0.8%)		1 (0.8%)	1 (0.8%)		1 (0.7%)	1 (0.9%)	
	Wet and cold	28 (15.6%)	7 (11.5%)		4 (6.7%)	7 (12.3%)	24 (19.5%)		15 (12.4%)	20 (16.7%)		15 (11.2%)	20 (18.7%)	
	Unknown	1 (0.6%)	0 (0.0%)		1 (1.7%)	0 (0.0%)	0 (0.0%)		1 (0.8%)	0 (0.0%)		1 (0.7%)	0 (0.0%)	
Pupil	Normal	121 (67.2%)	42 (68.9%)	0.96	44 (73.3%)	46 (80.7%)	73 (59.3%)	0.011*	91 (75.2%)	72 (60.0%)	0.040*	105 (78.4%)	58 (54.2%)	<0.001*
	Mydriasis	30 (16.7%)	10 (16.4%)		10 (16.7%)	8 (14.0%)	21 (17.1%)		16 (13.2%)	24 (20.0%)		16 (11.9%)	24 (22.4%)	
	Miosis	29 (16.1%)	9 (14.8%)		6 (10.0%)	3 (5.3%)	29 (23.6%)		14 (11.6%)	24 (20.0%)		13 (9.7%)	25 (23.4%)	
Pharynx examination	Erosion	6 (3.3%)	3 (4.9%)	0.38	1 (1.7%)	2 (3.5%)	6 (4.9%)	0.16	2 (1.7%)	7 (5.8%)	0.12	6 (4.5%)	3 (2.8%)	0.13
	Ulcer	1 (0.6%)	1 (1.6%)		0 (0.0%)	0 (0.0%)	2 (1.6%)		0 (0.0%)	2 (1.7%)		2 (1.5%)	0 (0.0%)	
	Hyperemia	3 (1.7%)	3 (4.9%)		0 (0.0%)	0 (0.0%)	6 (4.9%)		2 (1.7%)	4 (3.3%)		1 (0.7%)	5 (4.7%)	
GI manifestation	Yes	125 (69.4%)	41 (67.2%)	0.75	34 (56.7%)	43 (75.4%)	89 (72.4%)	0.049*	85 (70.2%)	81 (67.5%)	0.65	104 (77.6%)	62 (57.9%)	0.001*
Nausea/ Vomiting	Yes	113 (62.8%)	38 (62.3%)	0.95	31 (51.7%)	39 (68.4%)	80 (65.0%)	0.12	77 (63.6%)	74 (61.7%)	0.75	91 (67.9%)	60 (56.1%)	0.059
Diarrhea	Yes	10 (5.6%)	2 (3.3%)	0.74	2 (3.3%)	1 (1.8%)	9 (7.3%)	0.22	4 (3.3%)	8 (6.7%)	0.23	7 (5.2%)	5 (4.7%)	0.85
Abdominal pain	Yes	15 (8.3%)	5 (8.2%)	0.97	4 (6.7%)	4 (7.0%)	12 (9.8%)	0.71	11 (9.1%)	9 (7.5%)	0.65	14 (10.4%)	6 (5.6%)	0.18
Abdominal examination	Abnormal	9 (5.0%)	1 (1.6%)	0.46	3 (5.0%)	4 (7.0%)	3 (2.4%)	0.34	6 (5.0%)	4 (3.3%)	0.53	8 (6.0%)	2 (1.9%)	0.19
Muscarinic symptoms	Yes	59 (32.8%)	20 (32.8%)	>0.99	13 (21.7%)	11 (19.3%)	54 (43.9%)	0.001*	33 (27.3%)	46 (38.3%)	0.067	31 (23.1%)	48 (44.9%)	<0.001*
Nicotinic symptoms	Yes	57 (31.7%)	21 (34.4%)	0.69	15 (25.0%)	15 (26.3%)	47 (38.2%)	0.11	29 (24.0%)	49 (40.8%)	0.005*	32 (23.9%)	46 (43.0%)	0.002*
Severity of poisoning	latent	16 (8.9%)	4 (6.6%)	0.19	12 (20.0%)	5 (8.8%)	3 (2.4%)	<0.001*	16 (13.2%)	4 (3.3%)	<0.001*	16 (11.9%)	4 (3.7%)	<0.001*
	Mild	118 (65.6%)	33 (54.1%)		36 (60.0%)	43 (75.4%)	71 (57.7%)		84 (69.4%)	67 (55.8%)		106 (79.1%)	45 (42.1%)	
	Moderate	21 (11.7%)	9 (14.8%)		7 (11.7%)	2 (3.5%)	21 (17.1%)		12 (9.9%)	18 (15.0%)		12 (9.0%)	18 (16.8%)	
	Severe	25 (13.9%)	15 (24.6%)		5 (8.3%)	7 (12.3%)	28 (22.8%)		9 (7.4%)	31 (25.8%)		0 (0.0%)	40 (37.4%)	

*p-value < 0.05, **Resulted from chi-square or Fisher exact test. ICU: intensive care unit, GI: gastrointestinal.

Table 3. Treatment measures of patients with pesticide poisoning who experienced thrombocytopenia, categorized by outcome, duration of hospitalization, ICU admission, and intubation.

		Outcome			Duration of hospitalization				ICU admission			Intubation		
Variable	Category	Recovery	Mortality	*p*-value	<24 h	24–72 h	>72 h	*p*-value	No ICU	ICU admission	*p*-value	No intubation	Intubation	*p*-value*
Gastric lavage	Yes	109 (60.6%)	34 (55.7%)	0.51	39 (65.0%)	30 (52.6%)	74 (60.2%)	0.39	75 (62.0%)	68 (56.7%)	0.40	80 (59.7%)	63 (58.9%)	0.90
Activated charcoal	Yes	115 (63.9%)	35 (57.4%)	0.37	40 (66.7%)	30 (52.6%)	80 (65.0%)	0.21	79 (65.3%)	71 (59.2%)	0.33	83 (61.9%)	67 (62.6%)	0.91
Pralidoxime	Yes	56 (31.1%)	11 (18.0%)	0.049*	3 (5.0%)	16 (28.1%)	48 (39.0%)	<0.001*	23 (19.0%)	44 (36.7%)	0.002*	24 (17.9%)	43 (40.2%)	<0.001*
Atropine	Yes	54 (30.0%)	22 (36.1%)	0.38	9 (15.0%)	14 (24.6%)	53 (43.1%)	<0.001*	25 (20.7%)	51 (42.5%)	<0.001*	22 (16.4%)	54 (50.5%)	. < 0.001*
N-Acetyl Cysteine	Yes	73 (40.6%)	50 (82.0%)	<0.001*	15 (25.0%)	31 (54.4%)	76 (61.8%)	<0.001*	42 (34.7%)	81 (67.5%)	<0.001*	58 (43.3%)	65 (60.7%)	0.007*
Vitamin C	Yes	56 (31.1%)	45 (73.8%)	<0.001*	9 (15.0%)	28 (49.1%)	63 (51.2%)	<0.001*	34 (28.1%)	67 (55.8%)	<0.001*	49 (36.6%)	52 (48.6%)	0.060
Vitamin E	Yes	52 (28.9%)	45 (73.8%)	<0.001*	8 (13.3%)	25 (43.9%)	63 (51.2%)	<0.001*	28 (23.1%)	69 (57.5%)	<0.001*	43 (32.1%)	54 (50.5%)	0.004*
Corticosteroids	Yes	68 (37.8%)	50 (82.0%)	<0.001*	14 (23.3%)	20 (35.1%)	83 (67.5%)	<0.001*	34 (28.1%)	84 (70.0%)	<0.001*	45 (33.6%)	73 (68.2%)	<0.001*
Paraffin gavage	Yes	10 (5.6%)	9 (14.8%)	0.03*	7 (11.7%)	6 (10.5%)	6 (4.9%)	0.20	11 (9.1%)	8 (6.7%)	0.49	8 (6.0%)	11 (10.3%)	0.22
Dithionate test	3+	5 (20.8%)	17 (53.1%)	0.04*	0 (0.0%)	2 (20.0%)	20 (45.5%)	0.07	3 (25.0%)	19 (43.2%)	0.13	6 (28.6%)	16 (45.7%)	0.33
	2+	3 (12.5%)	5 (15.6%)		0 (0.0%)	1 (10.0%)	7 (15.9%)		0 (0.0%)	8 (18.2%)		2 (9.5%)	6 (17.1%)	
	1+	8 (33.3%)	7 (21.9%)		0 (0.0%)	3 (30.0%)	12 (27.3%)		5 (41.7%)	10 (22.7%)		8 (38.1%)	7 (20.0%)	
	Negative	8 (33.3%)	3 (9.4%)		2 (100%)	4 (40.0%)	5 (11.4%)		4 (33.3%)	7 (15.9%)		5 (23.8%)	6 (17.1%)	
Hemodialysis	Yes	20 (11.1%)	33 (54.1%)	<0.001*	1 (1.7%)	9 (15.8%)	43 (35.0%)	<0.001*	12 (9.9%)	41 (34.2%)	<0.001*	18 (13.4%)	35 (32.7%)	<0.001*

*p-value < 0.05, **Resulted from chi-square or Fisher exact test. ICU: intensive care unit.

Table 4. The association of leukocytosis with outcome, duration of hospitalization, intubation and ICU admission in patients with pesticide poisoning who experienced thrombocytopenia.

Leukocytosis		Outcome			Duration of hospitalization					Intubation			ICU admission		
		Death	Recovery	*p*-value	<24 h[$]	24-72 h	*p*-value	>72 h	*p*-value	Yes	No	*p*-value	Yes	No	*p*-value**
	N(%)	34 (55.7%)	70 (38.9%)	0.022*	12 (20.0%)	26 (45.6%)		66 (53.7%)	<0.001*	64 (59.8%)	40 (29.9%)	<0.001*	70 (58.3%)	34 (28.1%)	<0.001*
	Crude model	1.98 (1.10–3.56)	1	0.023*	1	3.36 (1.48–7.61)	0.004*	4.63 (2.24–9.56)	<0.001*	3.50 (2.05–5.97)	1	<0.001*	3.58 (2.09–6.13)	1	<0.001*
	Model 1	2.19 (0.71–6.72)	1	0.17	1	2.59 (0.98–6.88)	0.055	2.46 (0.95–6.41)	0.065	1.95 (0.93–4.09)	1	0.078	2.20 (1.11–4.37)	1	0.024*

*p-value < 0.05, **Results are presented as OR (95%CI) from binary and multinomial logistic regression, 1. Each outcome variable in the logistic regression models was adjusted for its specific set of confounding variables, which had been identified through prior univariate analyses (as depicted in Tables 1–3). [$]Reference category in multinomial logistic regression. ICU: intensive care unit.

due to pesticide poisoning, with a case fatality rate ranging from 15% to 30% (Eddleston et al. 2008). It is important to determine, upon admission to the emergency department, which patients may need to be transferred to the intensive care unit. Moreover, predicting the prognosis could be beneficial in guiding treatment decisions (Kamath and Gautam 2021). Thus, we aimed to identify potentially valuable and simple parameters, such as leukocytosis, for estimating the prognosis of thrombocytopenic patients with acute pesticide poisoning.

In our study conducted at a referral toxicology center in Iran, the overall mortality among pesticide-poisoned patients with thrombocytopenia reached 25.3%. One of the primary findings of this study was the significant association between leukocytosis and poor clinical outcomes, including increased mortality, prolonged hospitalization, ICU admission, and intubation in univariate analysis. Regardless of the different mechanisms of action of pesticides, pesticide poisoning triggers an inflammatory response in the body due to oxidative stress (Moezzi et al. 2025). Laboratory abnormalities, such as leukocytosis, may be observed in cases of pesticide poisoning as a result of the inflammatory response. Leukocytes are normally produced in the bone marrow and make up about 60% of blood cells (Kumar et al. 2018). In stress-like injuries such as poisoning, leukocytosis stems from neutrophil margination rather than increased bone marrow production (Kumar et al. 2018).

Previous studies have demonstrated alterations in leukocyte profiles during acute pesticide toxicity; however, their findings have not been entirely consistent. Chen et al. (2026) analyzed 134 cases of diquat poisoning, identifying that a high white blood cell (WBC) count ($\geq 17.11 \times 10^9$/L) is significantly linked to increased mortality (Zhang et al. 2026). Similarly, Xu et al. demonstrated that elevated neutrophil counts (Hazard Ratio = 1.12) serve as independent risk factors for mortality (Dong et al. 2025). While this partially aligns with our unadjusted results, our multivariable analysis showed that leukocytosis did not independently predict mortality after adjusting for confounders. This suggests that the leukocytosis observed in severe cases may reflect an acute stress response rather than a direct predictor of fatality.

While some research suggests leukocyte counts have moderate capacity to differentiate between mild and severe poisoning (Mathour et al. 2023). Differences in reported findings are likely driven by the heterogeneity of study designs and clinical factors such as pesticide type, timing of measurement, and different outcome definitions (Kumar et al. 2018; Mathour et al. 2023). Our findings expand on their work by demonstrating that these hematologic alterations retain predictive value even when focusing solely on patients with thrombocytopenia, a subgroup at inherently higher risk. The much stronger association of leukocytosis with prolonged hospitalization in our adjusted models (ORs > 30) may reflect delayed clinical recovery or prolonged need for monitoring in this subgroup, a relationship that prior studies did not explore.

In addition to the role of platelet count in thrombocytopenic patients, in a study of 96 subjects with acute organophosphate poisoning, researchers observed a significantly lower platelet count among non-survivors compared to survivors (Lionte et al. 2021). Similarly, a 2025 study examining the etiology of thrombocytopenia in acute pesticide poisoning patients noted a specific association between thrombocytopenia and intensive care unit (ICU) mortality (Gheshlaghi et al. 2025). Our study identified significant associations between leukocytosis in Thrombocytopenic patients and adverse outcomes such as prolonged hospitalization and ICU admission. This is particularly true for subgroups with lower event rates, where the likelihood of extreme OR estimates increases. Therefore, interpret these results with caution, as they are exploratory and require validation in larger, multicenter, prospective studies to confirm the stability and clinical relevance of these associations.

Furthermore, the observed univariate associations between certain treatments (such as hemodialysis, NAC, and pralidoxime) and adverse outcomes should be interpreted with caution. These findings do not imply that these interventions caused harm; rather, they serve as surrogates for initial clinical severity. In this observational cohort, patients with more severe physiological derangements were more likely to receive aggressive supportive care and adjunctive therapies. This phenomenon, known as ‘confounding by indication, suggests that the association is driven by the underlying severity of the poisoning rather than the therapeutic effect of the medications themselves.

Our study had several limitations. First, its retrospective observational design limits the ability to establish causal relationships between leukocytosis and clinical outcomes in pesticide-poisoned patients with thrombocytopenia. Second, the study was conducted in a single referral poisoning center, which may restrict the

generalizability of the findings to other settings, particularly non-specialized hospitals where diagnostic and therapeutic resources are limited. Third, due to the retrospective nature of data collection, some variables could not be reliably assessed. In addition, variability in physician decisions and delays in patient presentation may have influenced both laboratory parameters and clinical outcomes. Finally, as an observational study, our analysis of treatment associations is subject to significant confounding by indication. Because treatment decisions were made by clinicians based on the patient's acute status, intensive interventions were naturally clustered among the most severely ill patients, biasing unadjusted associations toward poorer outcomes. Furthermore, although patients with known hematologic disorders were excluded, the possibility of undocumented preexisting conditions affecting white blood cell or platelet counts cannot be entirely ruled out. Finally, the small number of events in some categories and the inability to infer causality should be mentioned. Future prospective multicenter studies are needed to confirm these findings.

Studying leukocytosis specifically within a cohort of 241 thrombocytopenic patients provides a unique clinical opportunity to refine prognostic accuracy. In patients presenting with both thrombocytopenia and leukocytosis, the inflammatory signal is often confounded by the platelet count, which can be suppressed by bone marrow toxicity or increased consumption in coagulopathy (El-Farouny et al. 2026)

By focusing on this subgroup, clinicians can better differentiate between a reactive, systemic inflammatory response (indicated by rising WBC/neutrophils) and hematologic complications specific to the toxic agent (e.g. zinc phosphide or severe organophosphate exposure). This approach is novel because it moves beyond general prognostic markers to investigate the interaction between inflammatory blood-cell indices and platelet depletion, potentially offering a more nuanced understanding of the patient's physiological stress and risk for multi-organ failure.

Conclusion

Our findings suggest that leukocytosis may serve as a potential prognostic marker for ICU admission and prolonged hospitalization in patients with acute pesticide poisoning and thrombocytopenia. Future prospective multicenter studies are warranted to confirm these findings.

Acknowledgements

We would like to thank the colleagues and personnel of the Clinical Toxicology Department and the archive staff of Khorshid Hospital for their valuable technical help and general support.

Study concept and design: GD, RM, NI-M. Data gathering: AS. Data analysis: AF. Drafting of the manuscript: RM, AS, NI-M, FG. Critical revision of the manuscript for important intellectual content: GD, NI-M, FG, AF. All authors approved the final version of the manuscript.

Author contributions

CRediT: **Amirreza Shirazi:** Writing – original draft; **Awat Feizi:** Formal analysis; **Farzad Gheshlaghi:** Writing – original draft; **Rokhsareh Meamar:** Conceptualization, Writing – original draft; **Nastaran Eizadi-Mood:** Conceptualization, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This project was supported by the Isfahan University of Medical Sciences under Grant [IR.ARI.MUI.REC.1404.034].

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Data availability statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

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