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Severity of scorpion envenomation in Saudi Arabia: A systematic review

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ABSTRACT

Over the course of five years, 72,168 scorpion stings were recorded in Saudi Arabia. Though a number of articles have been published on scorpion stings in the country, no review studies have sought to determine the severity of scorpion envenomation using a standardized scale. The purpose of this systematic review is, thus, to explore the signs and symptoms of scorpion envenomation victims in Saudi Arabia and classify them using the Abroug's severity scale. This review identified 49 articles published between January 1953 and September 2024 on scorpion sting incidents in Saudi Arabia. Out of this total, 26 (53.1 %) articles met the systematic review criteria. The selected articles were reviewed by an emergency physician, a pediatrician, an assistant professor, and a consultant in toxicology, knowing that all examined articles were published in peer reviewed journals indexed in PubMed, EMBASE, Scopus, Web of science and CINAHL. Preset keywords and medical subject headings (MeSH terms) were used for the review. Three reviewed studies reported that 20–52 % of scorpion victims are asymptomatic. Other studies confirmed that Class I local manifestations, such as pain, erythema, swelling, and burning are present in the majority of scorpion sting victims (47.4–100 %). Class II systemic symptoms, such as hypertension, tachycardia, restlessness, cold extremities, gastrointestinal abnormalities and priapism, were reported in 15 studies, while bleeding was recorded in 2 patients in the same study. More complicated Class III cases manifested neurological deteriorations (seizures, neurotoxicity and unconsciousness), pulmonary edema, and pulmonary/cardiac arrest. Jointly, the studies revealed that a total of 16,745 scorpion sting victims were admitted and hospitalized for more than 24 h, and hospital stay duration varied, for all patients, between 3 h and 4 weeks. Around 1371 cases in six studies refused treatment and were discharged against medical advice. Fifteen victims across ten studies died from the scorpion stings. Children and patients with pre-existing clinical conditions generally reported more severe signs and symptoms. Study findings showed that practitioners should be aware of the early warning signs of pulmonary edema, cardiac toxicity and myocarditis, which are not uncommon post scorpion envenomation. Practitioners should also take into consideration that electrolyte imbalances might occur, but they do not usually pose serious clinical problems. Hemorrhages might happen, but they are mostly treatable. In conclusion, it is advised that practitioners utilize the standardized Abroug's classification for grading signs and symptoms of scorpion stings.

1. Introduction

Scorpions are eight-legged, predatory invertebrates, characterized by a segmented curved tail over their back, and a venomous stinger at the tail tip [1]. Their size ranges between 0.9 and 23 cm, and they live in all continents except Antarctica [1]. There are over 1500 species of scorpions worldwide, as scorpions have a distinguished ability to change taxonomy [2]. In the Middle East, there are at least 117 species of scorpions, of which 22 are dangerously venomous [3]. Some scorpions stings are even fatal to humans, especially in remote areas where access to emergency medical care is delayed [2]. However, there are few scorpions species, such as *Buthacus leptochelys* in North Africa, that have

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not had their venom investigated and characterized yet [4]. The global estimated number of scorpion sting victims is around 1.2 million per year, and the annual mortality rate is approximately 3250 (0.3 %). These rates vary across geographical regions and scorpion species [5]. Saudi Arabia, Iraq and Jordan report the highest numbers of stings in the region [3]. People usually get stung while performing outdoor activities (as scorpions hide in tree barks, under rocks and logs, or inside holes) or indoor spaces, where scorpions seek cooler temperatures in shoes, bags or bed linens [2].

Scorpion venom contains a mix of neurotoxins and enzyme inhibitors, stored in two glandular sacs that are self-regulated by the scorpion. Venom in scorpions originally aims at paralyzing and killing prey [6]. There is a wide array of signs and symptoms caused by scorpion stings that range from mild to severe or even lethal manifestations [7]. Emergency departments (ED) at hospitals use Abroug's classification to clinically asses the severity of scorpion envenomation. It is graded into three levels: Level I for localized symptoms, Level II for systemic symptoms, and Level III for life threatening symptoms [7]. The majority of scorpion sting patients who arrive to the ED are usually under Level I [7]. Localized symptoms include pain, edema, erythema, or sometimes a blister. Systemic manifestations occur in less than one third of the patients, and they include cholinergic syndrome, leukocytosis, hyperglycemia, lactic acidosis, elevated cardiac liver and pancreatic enzymes, as well as electrolyte imbalances. Under Level III, patients develop desaturation, blood pressure fluctuation, seizures, respiratory distress, cardiac impairments, and respiratory/cardiac arrest [8]. The severity and rapidity of symptoms within each level vary, and are exacerbated among high-risk patients, mainly pregnant women, children, geriatrics, and patients with pre-existing morbidities. They are also dependent on the scorpion species and the number of stings [8]. In Iran, the clinical outcomes of pregnant women stung by scorpions are miscarriage (1.5 %), stillbirth (4.5 %), and preterm birth (0.6 %) [9]. In Egypt, mortality due to organ failure is significantly higher in children who suffered from agitation, coma, convulsions, arrhythmia, heart failure, pulmonary edema, and priapism [10].

Each species of scorpion is distinguished by its level of venom toxicity/potency [11]. In the Persian Gulf area, EDs receive patients suffering from scorpion stings of various toxicity levels, which necessitates robust and rapid clinical management. This is only natural given the diversity, number, and wide geographical distribution of scorpions, in addition to their long-term seasonal activity in this area [12]. In general, supportive treatments have been recommended for Level I severity scorpion envenomation, *i.e.* pain control, ice packs, cleaning of the sting area and tetanus prophylaxis [8]. For levels II and III, treatment modalities depend on emerging symptoms [8]. In parallel, the administration of passive immunotherapy, *i.e.,* a dose adjusted scorpion antivenom is favored as early as possible, based on the scorpion species, duration between the sting and arrival to ED, and the clinical progress [8].

Although scorpion envenomation poses a serious public health hazard, literature in some countries remain scarce. Nonetheless, findings from studies on scorpion envenomation in different regions are particularly significant to the local knowledge body and clinical management. ED clinicians in these regions can benefit from well-organized, brief, and customized synopses of evidence-based research in all the clinical aspects of scorpion envenomation, mainly clinical severity and outcomes. In addition, studies regarding scorpion stings can raise public community awareness regarding treatment and practices.

Few review studies have been published on scorpion envenomation in the Middle East and the Arabian Peninsula region. It is possible that the diversity of therapeutic approaches (vasodilators and antivenoms) has decreased focus on the topic as a main research field, but such studies remain in demand particularly in countries with high sting rates, such as the Persian Gulf [10]. A previous study recommended more attention to scorpion envenomation in subtropical hyper desert regions, where it is necessary to address toxic scorpion stings and prevent possible casualties [13]. Saudi Arabia is a country situated in the Arabian Gulf, distinguished by a unique harsh climate, favorable for harmful species of scorpions. Over the course of the past 5 years, 72,168 scorpion sting cases were recorded in the 11 regions of the Kingdom [14]. This review paper summarizes findings from studies conducted about scorpion stings in Saudi Arabia then aligns them with international literature. The purpose of this systematic review study is, therefore, to explore the signs and symptoms of scorpion envenomation victims, as discussed in studies from Saudi Arabia, then rate their severity using Abroug's classification for grading signs and symptoms of scorpion stings.

2. Materials and methods

This review study is approved by the Institutional Review Board (IRB) at King Abdullah International Medical Research Center (RC18/254) and registered on the international database of prospectively registered systematic reviews PROSPERO (CRD42018110525).

Saudi Arabia has an area of 2,150,000 km^2 (5th largest in Asia), and is comprised of 13 provinces mostly dominated by hot climate desert landscapes. There are 28 species and subspecies of scorpions that have been officially recognized in the Kingdom. They are classified into three families - *Buthidae, Hemiscorpiidae* and *Scorpionidae* - found mostly in Jazan, Al-Medina, Al-Baha, Hail and Riyadh. *Buthidae* is the largest family of scorpions, known by its colloquial name as a fat tailed, yellow or bark scorpion. *Hemiscorpiidae* have very flat or broad black bodies, and *Scorpionidae* are referred to as the burrowing or pale-legged scorpions [15].

Peer reviewed articles indexed in PubMed, Scopus, Web of Science and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) were screened by study investigators based on preset keywords and selection criteria. Keywords were "scorpion, sting, Saudi Arabia, incidence, severity, outcomes and management". Further mesh terms included "rate, envenomation, grade, level of triage, mortality, treatments and anti-venom". Selection was not restricted by the year of publication. Articles published in English and investigating the epidemiological / clinical aspects of scorpion stings in different regions of Saudi Arabia were chosen. Furthermore, selection criteria accounted for victims of all age groups. Studies involving laboratory experiments (animal research) and anti-venom production facilities, documentaries, editorials, and letters were excluded.

Articles that met the preset criteria were then meticulously revised, with relevant information extracted and tabulated. The authors' names, publication year, journal (local or international), region of incidence (province), target population and study design were noted as the articles' characteristics. As for victims' characteristics, they included age, sex and comorbidities. Setting characteristics included the type, location, and size of the health care facility that provided emergency care. Outcome characteristics were mainly scorpion type, incidence of stings, clinical severity, mortality rate, and length of hospital stay. Reported types of scorpions were categorized as per the recognized species in Saudi Arabia. Incidences of scorpion stings and mortality rates were presented as reported by each study, either as an incidence period (within a time interval) or population incidence (within a targeted group). Reported sting severity was rated using Abroug's three-level grading system (localized, systemic, life threatening), and reported outcomes were classified as either requiring supportive care/monitoring, symptomatic treatments, or anti-venom therapy.

2.1. Journal characteristics and eligible articles

This study identified a total of 49 articles published between January 1953 and September 2024 on scorpions in Saudi Arabia. Twenty-six (53.1 %) articles met the systematic review criteria. Certain articles were excluded for being lab experimental studies not targeting humans (n = 11), systematic reviews (n = 2), editorials (n = 6), non-English

papers and conference non-peer reviewed papers. Fig. 1 illustrates the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow chart. Eleven studies were published in local Saudi Arabian journals, while 15 studies were published in international journals.

2.2. Methodological characteristics

Of the 26 reviewed articles, 10 (38.5 %) presented data on scorpion stings that occurred in the central region of Saudi Arabia (Riyadh and Qassim), 6 dealt with stings in the Southern region (Abha, Asir, Baha), 5 in the Northern region (Hail and Tabuk), 3 in the Western region (Medina and Rabegh), and 2 in multiple regions (refer to Table 1). Study objectives and main conclusions were tabulated in Table 2. Seventeen studies documented cases in tertiary or general health care facilities, while 6 looked into cases in primary health care facilities (of which one was an offsite military medical unit) [7]. Thirteen of the health care facilities had obtained accreditation (local and/or international). Seventeen studies (65.4 %) adopted cross-sectional retrospective analysis of data, and 5 (20.8 %) used prospective observational analysis. Four studies were case reports

3. Results

3.1. Frequency of scorpion sting cases

Some studies reported the frequency of scorpion stings in exact numbers [5,16–20], while others reported them per 1000 emergency cases [21–24]. Others, still, reported an incidence period over a 1-year interval or a 5-year interval [7,22,25–27]. The highest number of cases was recorded in the Northern region (4287 cases), while the lowest was in Western region (319 cases) (refer to Table 3). A number of studies investigated scorpion stings in children [16–18,25,27–31] or in adults only [32], while others examined cases among all age groups. Studies conducted in the Central and Northern regions showed that adults there were more likely to be stung compared to children. Males, as well, proved to be more prone to scorpion stings in all regions when compared to females. It is important to note that four studies did not provide detailed demographic data on scorpion victims [19,20,23,33].

3.2. Scorpion sting characteristics

Ten studies did not mention the season during which the scorpion cases were reported to health care facilities [5,16,17,23,28,30,31,33–35]. All others stated that 39–92.5 % of the cases occurred during the summer months between June and September [7,14,18,19,21,22,24–27,29,30,36,37]. Nine studies mentioned that the time of incidents was mainly during the night [14,18,19,21,22,25,26,29,31,36], except for one study in which 53 % of the cases were diurnal [7]. Studies specified that scorpion types were confirmed either by the victims, who physically described the scorpion's morphological features, or by bringing the insect dead/alive to the health care facility. The yellow scorpion was the most documented in all regions except the central region, where both the yellow and fat tail black scorpion recorded similar numbers of incidents. Unknown scorpion types were registered for 3–25 per 100 cases. Eleven studies, however, did not present any data on

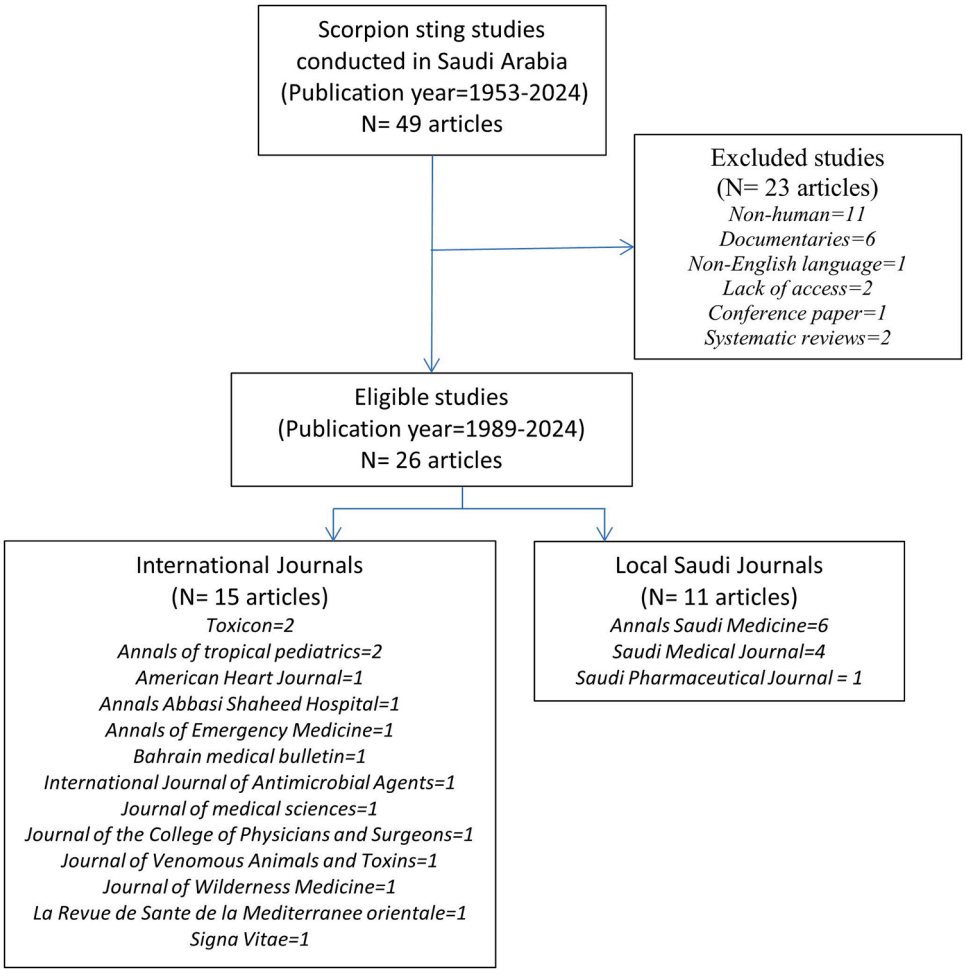

Fig. 1. PRISMA flow chart.

Table 1
Methodological characteristics of the reviewed studies.

	(Family name year)	Article title	Study region	Study design	Study period
1	(Neale 1990)	Scorpion sting in Eastern Riyadh	Riyadh (Central)	Retrospective analysis	5 years
2	(El amin et al. 1990)	Hematological and Biochemical Findings in Scorpion Stung Children	Medina (Western)	Prospective analysis	4 months
3	(El-Amin et al. 1991)	Scorpion sting: a management problem	Medina (Western)	Retrospective analysis	3 years
4	(Annobil et al. 1991)	Intracranial hemorrhages after Nebo *hierochonticus* scorpion sting.	Abha (Southern)	Case report	-
5	(Kumar et al. 1992)	Scorpion venom cardiomyopathy	Baha (Southern)	Retrospective analysis	4 months
6	(Annobil 1993)	Scorpion stings in children in the Asir Province of Saudi Arabia	Asir (Southern)	Prospective analysis	5 years
7	(Groshong 1993)	Scorpion envenomation in eastern Saudi Arabia	Open desert (Northern)	Prospective analysis	4 months
8	(Ismail 1994)	The treatment of the scorpion envenoming syndrome:the saudi experience with serotherapy	12 multiple regions	Retrospective analysis	8 months
9	(Dittrich et al. 1994)	Scorpion sting syndrome: A ten year experience	Riyadh (Central)	Retrospective analysis	10 years
10	(Mahaba et al. 1996)	Scorpion sting, is it a health problem in Saudi Arabia? Evaluation of management of 820 cases	Hail (Northern)	Prospective analysis	6 months
11	(Mahaba 1997)	Scorpion sting syndrome: epidemiology, clinical presentation and management of 2240 cases	Hail (Northern)	Retrospective analysis	15 months
12	(Al-Rashed et al. 1999)	Scorpion sting in children from northwestern area of Riyadh, Saudi Arabia	Riyadh (Central)	Retrospective analysis	15 years
13	(Gajre et al. 1999)	Scorpion Envenomation in Children: Should All Stings be Given Antivenom?	Baha (Southern)	Retrospective analysis	5 years
14	(Soormo et al. 2001)	A clinical evaluation of the effectiveness of antivenom in scorpion envenomation	Baha (Southern)	Retrospective analysis	12 years
15	(Dittrich et al. 2002)	Cardiac arrest following scorpion envenomation	Riyadh (Central)	Case report	-
16	(Al-Sadoon et al. 2003)	Epidemiological study of scorpion stings in Saudi Arabia between 1993 and 1997	11 multiple regions	Retrospective analysis	5 years
17	(Ismail 2003)	Treatment of the scorpion envenoming syndrome: 12-years experience with serotherapy	Riyadh (Central)	Retrospective analysis	6 years
18	(Al-Asmari et al. 2004)	Scorpion sting syndrome in a general hospital in Saudi Arabia	Riyadh (Central)	Retrospective analysis	5 years
19	(Jahan et al. 2007)	Scorpion stings in Qassim, Saudi Arabia—A 5-year surveillance report	Qassim (Central)	Retrospective analysis	5 years
20	(Jarrar et al. 2008)	Epidemiological aspects of scorpion stings in	6 Northern regions	Retrospective analysis	2 years
21	(Al-Asmari et al. 2008)	Role of prazosin on cardiovascular manifestations and pulmonary edema following severe scorpion sting	Asir (Southern)	Case report	-
22	(Al-Asmari et al. 2012)	Clinical aspects and frequency of scorpion stings in the Riyadh Region of Saudi Arabia	Riyadh (Central)	Retrospective analysis	2 years
23	(Al-Hemairi et al. 2013)	Scorpion envenomation: an experience with children at Rabigh General Hospital, ksa	Rabegh (Western)	Prospective analysis	4.5 years
24	(Mallick et al. 2018)	Priapism in Scorpion Stings within the Kingdom of Saudi Arabia: A Case Report	Tabuk (Northern)	Case report	-
25	(Khan et al. 2020)	The burden of bites and stings management: Experience of an academic hospital in the Kingdom of Saudi Arabia	Riyadh (Central)	Retrospective analysis	4 years
26	(Alyahya et al. 2023)	The epidemiology of poisoning and overdose in Saudi Arabia: exposures, risks, management and outcomes	Riyadh (Central)	Retrospective analysis	1 year

scorpion types [16,17,19,27–32,35,37]. Stinging sites, as reported by 11 studies, were mainly in the lower extremities [5,7,14,18,21,22,25–27,36,38], followed by the upper extremities then the upper torso. Only one study stated that the number of patients stung in their upper extremists exceeded those stung in their lower extremities [29]. Five studies documented that a percentage of victims (2.9 %-26.5 %) have been previously stung before [21–23,34,38]. Arrival time to the health care facility was reported in 12 studies [5,7,18,21,25–27,29,32,35,36,38], but the patterns were generally inconsistent (< 1 h, < 2 h, and more). Still, five studies reported that 52–79 % of patients arrived in less than one hour after being stung [21,25,32,36,38].

3.3. Clinical severity characteristics

Studies used different tools and approaches to describe the clinical manifestations of scorpion stings at their EDs. One study adopted the Abroug's classification scale, [7] which categorizes the case severity into local manifestations, minor systemic manifestations, major manifestations, and lethal envenomation. Other studies presented clinical severity using envenomation features described by Goytton et al. [19]. Furthermore, four studies referenced the protocols issued by the local Saudi Ministry of Health [22,27,30,38]. The remaining studies did not specify any recognizable assessment scale, but rather presented signs/symptoms by their frequencies. Three studies reported that 20–52 % of scorpion victims arriving to the facility were asymptomatic [29,30,37]. Other studies confirmed that local manifestations, such as pain, erythema, swelling, and burning were present in the majority of their scorpion sting victims (47.4–100 %) [14,18,21,26,29,30,32,37]. Systemic symptoms, such as hypertension, tachycardia, restlessness, cold extremities, GI abnormalities, and priapism, were reported in 15 studies. Two cases in one study manifested bleeding [18]. More complicated cases manifested neurological deteriorations (seizures, neurotoxicity and unconsciousness) [14,22,32], pulmonary edema [14,25,31], and cardiac arrest [14,25]. As for the length of hospital stay, it varied between three hours and four weeks. Four studies reported recovery/discharge within 24 h [7,21,31,36]. In 10 studies, however, a total of 16,631 scorpion sting victims were admitted and hospitalized for more than 24 h [5,7,14,18,21,22,25,35–37]. Six studies mentioned that a

Table 2
The study objectives and main conclusions of the reviewed studies.

(Family name year)		
(Neale 1990)	Study objectives	An emergency department log reviewed for a five-year period and 205 cases of "scorpion sting syndrome" were found.
	Main conclusion	Although frequently benign, cases of scorpion sting as observed may not be innocuous. Severity is likely to be greater in children and in adults with preexisting hypertension.
(El amin et al. 1990)	Study objectives	The biochemical and hematological profiles of 96 children admitted to the hospital during one year with scorpion stings were analyzed.
	Main conclusion	No hematological problem was encountered. Hypocalcemia occurred in some patients but did not pose a clinical management problem. Cardiotoxicity was an important complication and ECG examination showed features of myocarditis but did not reveal signs of any electrolyte disturbances.
(El-Amin et al. 1991)	Study objectives	Admissions and deaths resulting from scorpion sting over 3 years were analyzed. Features that indicated the severity of the clinical condition were identified.
	Main conclusion	Poor management of fluid therapy was responsible for the frequently unsatisfactory resolution of envenoming. The role of antivenom is questioned and controversy regarding the most appropriate sedative to use is not resolved. An in-depth study of these management issues is urgently required.
(Annobil et al. 1991)	Study objectives	Case study: A 3-year-old boy, who was previously well, developed acute pulmonary edema, fundal hemorrhages, temporary blindness and deafness following a Nebo *Hierochonticus* scorpion sting.
	Main conclusion	Cranial CT scan 8 days after admission showed bilaterally symmetrical multiple hyperdense areas consistent with multiple hemorrhages. Cranial CT scan 8 months showed resorption of the hemorrhages.
(Kumar et al. 1992)	Study objectives	Cardiac function was evaluated by serial echocardiography in 30 children affected by scorpion stings.
	Main conclusion	Myocardial toxicity is a common and serious complication of scorpion stings in children. Systolic function appears to be affected predominantly. Serial echocardiography is useful to follow changes in left ventricular function. Patients who fail to improve within 24–48 h require particularly close observation.
(Annobil 1993)	Study objectives	There appear to be regional variations in the clinical effects of scorpion stings, due to the different species of scorpions found in the various regions of the Arabian Peninsula.
	Main conclusion	Neurological manifestations were the most prominent. One patient had disseminated intravascular coagulopathy and intracranial hemorrhages. One death due to severe pulmonary edema and congestive heart failure. Antivenom was given in all cases with systemic manifestations of envenomation.
(Groshong 1993)	Study objectives	Collect data on the initial presentation of victims of scorpion envenomation during the deployment of US forces to Saudi Arabia in support of Operation Desert Shield.
	Main conclusion	In adult patients without serious prior adverse medical conditions, intervention is best limited to supportive measures.
(Ismail 1994)	Study objectives	A protocol for treatment of scorpion sting based mainly on antivenom therapy was applied nation-wide in Saudi Arabia. At least 5 × 1 ml ampoules of antivenom diluted in 20–50 ml saline were injected slowly i.v. in all patients confirmed to have scorpion stings or suspected stings with systemic manifestations.
	Main conclusion	Incidence of pulmonary edema, hypertension, hypotension, cardiac dysrhythmias and neurological symptoms following antivenom administration was very slight. Hospital stay was reduced; most patients were symptom-free within 1–2 days. Early reaction to antivenom was lower than expected and low in severity.
(Dittrich et al. 1994)	Study objectives	Assess the risk of morbidity and mortality following scorpion envenomation, define patient demographics of the study group and identify high risk groups for systemic toxicity.
	Main conclusion	The great majority of patients can be treated with analgesia, local ice application, and observation dictated by clinical findings. Usage of antivenin should be restricted to patients with signs of serious systemic toxicity.
(Mahaba et al. 1996)	Study objectives	To study the incidence of scorpion stings at Hail region and to evaluate the prognosis in relation to the dose of antivenom received.
	Main conclusion	Treatment with 5 ampoules was not shown to be superior to one ampoule antivenin. High incidence of scorpion stings sets a need to start preventive community programs to decrease the incidence of stings.
(Mahaba 1997)	Study objectives	All cases of scorpion stings (2240)† that attended all primary health care centers and hospitals were recorded and analyzed.
	Main conclusion	Severity of symptoms/signs were marked among infants. Guidelines for the management of scorpion stings are suggested. Local treatment of stings affecting infants and preschool children is IMPORTANT.
(Al-Rashed et al. 1999)	Study objectives	To assess the clinical severity of envenomation in children by scorpion species and the potential benefit of antivenin administration.
	Main conclusion	Higher occurrence of stings in children (> 3 years) and males. Lower half of the body was significantly affected. Manifestations of illness were not severe. Antivenin therapy didn't affect the outcome of the illness.
(Gajre et al. 1999)	Study objectives	To determine whether all scorpion stings need treatment with antivenom, or whether the cases can be categorized so that asymptomatic ones are not given antivenom.
	Main conclusion	Children who were given serum had fewer complications, and shorter hospital stay. No deaths reported. The difference between the two groups with regard to morbidity and hospital stay was highly significant.
(Soormo et al. 2001)	Study objectives	Cases of scorpion stings were admitted and treated with 0–1 ampule of scorpion antivenom then compared to another group after the antivenom policy was changed to 5 or more ampules of antivenom.
	Main conclusion	Mortality rate fell down, and the occurrence of pulmonary edema decreased. The excellent outcome is attributed to scorpion antivenom.
(Dittrich et al. 2002)	Study objectives	A case of cardiac arrest, following scorpion envenomation in a 51-year-old male. This complication of envenomation is highly unusual.
	Main conclusion	Excess sympathetic stimulation and direct effect of venom on the myocardium are responsible for the most serious cardiac manifestations of toxicity. Because scorpion stings are associated with known instances of serious morbidity and mortality, the place for antivenin should be recognized.
(Al-Sadoon et al. 2003)	Study objectives	Evaluated the epidemiological aspects of scorpion stings in different areas of Saudi Arabia.
	Main conclusion	The study showed that there is a low threat to life despite the high number of stings; this is a result of the availability of medical facilities and

(*continued on next page*)

Table 2 (*continued*)

(Family name year)		
		the multi-center antivenom use in different areas of Saudi Arabia.
(Ismail 2003)	Study objectives	Analysis of the outcome of a protocol for the treatment of scorpion stings based mainly on antivenom therapy was applied nationwide in Saudi Arabia.
	Main conclusion	The incidence of severe venom toxicity following antivenom administration was almost negligible. The length of hospital stay was reduced. The early reaction to antivenom administration was lower than expected.
(Al-Asmari et al. 2004)	Study objectives	Evaluate the incidence of scorpion stings and to draw the attention of clinicians, concerning the dilemma of scorpion sting syndrome and its management in the Kingdom of Saudi Arabia (KSA).
	Main conclusion	The beneficial effect of antivenom in protecting victims against scorpion stings is still questionable. Higher risk groups of systemic toxicity were either those with ages less than 10 years or greater than 50 years.
(Jahan et al. 2007)	Study objectives	Reviewed and analyzed 5-year (1999–2003) surveillance data of scorpion stings in Qassim, Saudi Arabia.
	Main conclusion	Male-to-female ratio for scorpion stings was 1.9:1. The mean age for cases was 23 ± 17 years. The scorpion stings had a higher incidence in the months of May–October.
(Jarrar et al. 2008)	Study objectives	Review and analyses of scorpion sting cases that presented to the emergency department of the hospitals and medical centers in Al-Jouf
	Main conclusion	Findings indicate that scorpion stings are common in Al-Jouf Province, especially during the summer. The overall threat to human health was found to be low.
(Al-Asmari et al. 2008)	Study objectives	Report on the ameliorating effects of prazosin on the cardiovascular CV manifestations and pulmonary edema PE after treatment with antivenom failed to improve the conditions of scorpion stung patients.
	Main conclusion	Polyvalent scorpion antivenom may not be beneficial in all cases of envenomation. Prazosin may be an effective alternative to treat scorpion sting cases with cardiovascular manifestations and pulmonary edema.
(Al-Asmari et al. 2012)	Study objectives	To study the clinical aspects and frequency of scorpion stings in Riyadh region of Saudi Arabia.
	Main conclusion	There is a predominance of weak venomous scorpion species in central region. The protocol of managing patients with antivenom irrespective of the intensity of manifestations warrants a detailed review.
(Al-Hemairi et al. 2013)	Study objectives	To evaluate the epidemiological and clinical characteristics of scorpion envenomation in children.
	Main conclusion	Although most of scorpion envenomations in children have a good prognosis, severe complications and death may occur
(Mallick et al. 2018)	Study objectives	To report a 2-year-old Saudi boy who presented with an acute onset of asymmetric pulmonary edema, moribund state and priapism.
	Main conclusion	The presentation of severe or heavy scorpion intoxication mimics the presentation of sepsis.
(Khan et al. 2020)	Study objectives	To estimate the economic burden and prevalence of bites and stings injuries in Saudi Arabia
	Main conclusion	Bites and stings have a considerable health care burden on our society. Although the vast majority of the cases were not associated with a severe life-threatening condition, many were visit ED and associated with high medical costs. Increased awareness of the hazard of animal-related injuries, especially during spring and summer, where most cases take place may lower its incidence and decrease EDs visits
(Alyahya et al. 2023)	Study objectives	To describe the epidemiology of poisoning and overdose, identify populations at risk, common exposures, the treatments provided and outcomes.
	Main conclusion	The vast majority of toxicology consultations received by the PCC involved the accidental exposure of poisons to children less than five years-of-age.

Table 3
Rates of stings across regions, age groups, gender and scorpion type.

	Number of stings
Regions	
Central	10,540
Northern	4553
Southern	2378
Western	147
Age category	
Pediatrics	140 per year
Adults	494 per year
Gender	
Male	272 per year
Female	164 per year
Scorpion type	
Leiurus Quinquestriatus	34 per 100 cases
Androctonus Crassicauda	36 per 100 cases
Unknown	18 per 100 cases

total of 1371 patients refused treatment and were discharged against medical advice [7,14,21,23,36,38]. Fifteen deaths were reported across 10 studies [14,17,18,22,25,27,30,34,35,38] (see Table 4).

4. Discussion

Scorpion species differ from one environment to the other, making the incidences, characteristics, and outcomes of scorpion envenomation unique to each setting [5]. Certain regions encounter more scorpion sting incidents than others. In Iran, for example, stings by dangerous scorpions and mortality cases are often recorded from southern regions such as the Khuzestan and Hormozgan provinces [39]. In Saudi Arabia, the Ministry of Health (SMOH) recorded 30,854 victims of scorpion sting and snake bite patients (combined) who visited emergency care facilities in 2015, but these figures did not include victims who visited

Table 4
Classification of clinical manifestations reported by the reviewed studies.

Classification	Manifestations
Asymptomatic victims	No signs or symptoms Suspected scorpion stings
Class I envenomation (Minor local manifestations at sting site)	Pain, Redness (Hyperemia), Scarification, Itching/burning sensation, Swelling
Class II envenomation (Minor to moderate systemic manifestations involving other body systems)	Gastrointestinal symptoms *(vomiting, Hypersialorrhea, Abdominal pain, Diarrhea)* Rhinorrhea, Lacrymation, Restlessness, Fever, Sweating, Hypothermia, Shivering, Confusion, Myosis, Hallucination, Priapism
Class III envenomation (Life threatening potentially lethal manifestations)	Major hyperthermia, Bronchial congestion, Acute pulmonary edema, Tachypnea, Bradypnea, Tachycardia, Bradycardia, Myocardial toxicity, Collapse, Convulsion, Coma, death

private clinics or those who sought non-conventional home remedies. Regional differences in scorpion types within the Kingdom of Saudi Arabia have been observed, and *Leiurus Quinquestriatus* (yellow scorpion) accounted for the highest number of sting incidents in all four regions. In Turkey, however, a study reported that (46.2 %) of cases were by *Androctonus crassicauda* [40]. The peak times of scorpion stinging incidents, as reported by the majority of the studies, were either during the hot summer season or during the night. Thermoregulation of the scorpion's bodies depends on external elements, so during hot weather, they tend to seek refuge in cooler indoor human accommodations or crawl into a shaded tent, a shoe, or a hole [40]. Furthermore, scorpions are night predators seeking prey that are mainly active during the cooler nights of the hot deserts [41]. These findings are in line with those in nearby countries, that also report higher scorpion sting rates in the summer season and at nights [42]. This implies that emergency care facilities should anticipate scorpion sting cases during these peak times and ensure availability of care resources. The yellow scorpion (*Leiurus Quinquestriatus*) is responsible for the highest number of sting cases in all regions of Saudi Arabia, and in neighboring countries as well [42]. Results were similar in neighboring Arabian Peninsula countries that share almost the same weather and environment conditions. This indicates either that the yellow scorpion is more prone to sting humans in Saudi Arabia, or that its presence near human residence is more prevalent. The revised studies all reported that the leading stinging site was in the lower extremities, followed by the upper extremities, and the upper torso. This finding was similar to one reported in a study conducted in some endemic areas of Iran [43]. It indicates that the victims were probably walking or sitting barefoot or putting on their shoes, as shoes constitute an ideal place for scorpions seeking shelter, as reported by Benmosbah [44]. It is, hence, recommended to inspect any footwear that has been left outdoors and shake it well, just in case a scorpion has crawled inside. Moreover, it is better to refrain from putting bare hands or fingers in holes or crevices. As for ED physicians, they should familiarize themselves with local scorpions, especially those that are potentially more dangerous than others [45].

Across all regions, males were at a higher risk of exposure to scorpion stings when compared to females. This might be attributed to the fact that males mainly perform outdoor activities, such as sports, hiking and camping. This finding was similar to that of a study conducted in Algeria and in Egypt [10,46]. Adults, as well, proved to be more at risk of scorpion stings than children, as reported by studies in Central and Northern regions. In Southern Egypt, for instance, the mean age of scorpion sting victims was 31.9 ± 17.9 years [13]. It is worth mentioning that a popular adult desert activity in Saudi Arabia is game hunting for *Uromastyx* (type of lizard), which involves poking out and hand picking the lizard from borrows and dry creeks. In addition, farmers and cattle keepers are more prone to being stung, in comparison to children. This finding resonated with a study conducted by Selmane et al. [46].

Arrival time to health care facilities is a key outcome indicator, since earlier treatment helps treat symptoms and resolve scorpion envenomation. Delayed arrivals, on the other hand, can be attributed to incidents occurring in the distant Saudi Arabia outback. Another reason might be the absence of scorpion antivenom at primary health care centers in rural areas. The Saudi Ministry of Health is, therefore, urged to ensure that both supportive measures and scorpion antivenom are readily available at proximity to high-risk areas (city suburbs). In addition, public awareness on first aid interventions post-scorpion stings and on the location of facilities with antivenom should be a public health care priority. The Saudi Ministry of Health always advises paramedics, who attend to scorpion sting victims, to calm the patient down, apply a pressing bandage on top of the sting, then transport the victim to the nearest hospital [47].

Signs and symptoms reported in the revised studies are similar to findings in published literature [41,44], although not all studies presented the signs/symptoms using a standardized scale. This lack of consistency makes it difficult to meta-analyze the data. In addition, and from a cost analysis point of view, it can be beneficial that hospitals and third parties (insurance companies) determine the actual severity level of scorpion envenomation cases. In Egypt, some studies rated the severity of signs/symptoms of scorpion envenomation using the Abroug scale, while others used a tool proposed by the Scorpion Consensus Expert Group [13,48]. In other countries, such as Iran, a clinical severity grading for Iranian scorpion envenomation was developed [42]. Scorpion envenomation is one of the recognized diagnoses enlisted in the International Classification of Diseases (2018 ICD-10-CM Diagnosis Code T63.2X1A), issued by the World Health organization (WHO) [49]. A regional study associated mortality among children stung by scorpions with cardiac, respiratory, neurological, renal, hematologic, or hepatic failures [10]. In upper Egypt, cardiac markers remain the most important factor for determining the severity and the outcome of scorpion envenomation [50]. Therefore, hospitals are advised to classify scorpion sting cases using internationally recognized severity scales, making it more efficient to predict hospital bills associated with scorpion sting admissions.

The length of hospital stay for scorpion victims, as per this review study, varied between three hours and four weeks, which is also in line with the published literature [51]. Both the lengths of stay and mortality rates reflect the severity of clinical manifestations. They are influenced by numerous factors, such as the degree of venom toxicity related to scorpion type, size, and the intensity/number of stings [2]. Furthermore, pre-existing medical conditions of the victims [52], arrival time, and administration/dosage of antivenom play an important role in the outcome[53]. Clinicians and researchers, thus, have a duty to focus on the changeable factors, which if modified, can decrease complications, accelerate discharge, and boost survival rates.

Findings reported in this study were compared to other systematic reviews published in the past five years. First, it is important to note that scorpion species differed between Saudi Arabia and other countries. In Brazil, for example, *Tityus serrulatus, Tityus stigmurus, Tityus bahiensis*, and *Tityus obscurus* are generally accountable for most of the scorpion stings in different regions [54]. In Morocco, *Androctonus, Buthus* and *Hottentotta* scorpion stings are mostly common in central and southern regions, and with greater lethality reported in children [55]. In colder countries such as France, sixty-seven scorpion species have been identified, the most important being *Buthus, Centruroides* and *Tityus*, and with sting rates reaching 90 stings per 100,000 inhabitants annually [56]. In Eastern and Southern Africa, more than 79,000 stings are recorded yearly, resulting in approximately 245 deaths – a rate higher than that reported in Saudi Arabia [57]. Last but not least, scorpion envenomation is commonly reported in subtropical and tropical regions [58].

According to other systematic reviews, adults are most frequently stung, but envenomation is more severe in children across many countries [57,59]. The group most at-risk in India was farmers, laborers, and inhabitants of rural areas, which differed from scorpion victims in Saudi Arabia, who were generally people practicing outdoor recreational activities [59]. In Southern and Eastern African countries, those living in poverty-stricken areas are among the most vulnerable to getting stung by scorpions [57]. Interestingly, risk of scorpion envenomation for French soldiers on deployment was low in Mali, Chad, and Niger, as per the French military health service [60]. A systematic review of studies on scorpion envenomation in Brazil showed that most individuals sought medical attention within 3 h of the incident, yet in Saudi Arabia, 52–79 % of victims arrived in less than one hour after being stung. This might be due to the distance of remote areas in Brazil, as well as delayed accessibility to emergency medical services [61].

One systematic review revealed that clinical manifestations of scorpion envenomation can be mediated sympathetically and parasympathetically, depending on the species of scorpion [58]. Myocarditis associated with scorpion envenomation was usually reported in children presenting with cardiopulmonary symptoms, including pulmonary edema, shock or hypotension [62]. Mortality in confirmed

scorpion-related myocarditis cases was estimated at 7.3 % [62]. In rare cases, Takotsubo syndrome might occur in severe scorpion envenomation, as reported in four cases from Brazil [63]. In terms of allergic reactions triggered by scorpion envenomation, one review study stated that, between 1966 and 2021, 30 cases reported urticaria, pruritus, flushing, angioedema, wheezing, rhinorrhea, sneezing, altered level of conscious, and gastrointestinal and cardiovascular alterations [64]. In Saudi Arabia, few cases reported signs of allergies, such as rhinorrhea and lacrimation.

4.1. Methodological biases, limitations and deficiencies

In the past ten years, only five manuscripts were published on the clinical outcomes of scorpion envenomation, making the majority of available studies outdated. Most publications reported results from a single setting, a non-representative small sample size, or case reports. Some published their preliminary findings in non-peer reviewed conference papers. In addition, certain methodological biases were present, such as not specifying the pre-calculated sample size. The data analysis plan in most studies was limited to basic descriptive or bivariate analyses, and none of the studies adjusted for potential confounders. Most of the studies did not adopt consistent operational definitions or did not express variables in recognizable categories. For instance, none of the 24 reviewed studies used the Canadian triage scale and pain assessment scales. Few studies stated the allergy history of the patients. A lack of consistency in using a standardized envenomation classification scaling system was observed, as well. In some regions of Saudi Arabia such as the Eastern regions, scorpion studies have not been conducted and published.

4.2. Strengths and limitations

This systematic review study has to be seen in light of few strengths and limitations. Evaluating the current body of research on scorpion envenomation and its clinical outcomes in Saudi Arabia serves as a guide to both ED physicians and researchers by identifying knowledge gaps, research priorities, and under-researched regions and populations. In terms of space, the search strategy was limited to one country, which might limited the ability to generalize the findings elsewhere. Nevertheless, the diverse environments and scorpion species in Saudi Arabia are common with neighboring Persian Gulf countries. In terms of selection bias, this study reviewed all qualified publications on scorpion envenomation in Saudi Arabia, and a librarian was consulted on this matter. The scales to report the severity of scorpion envenomation were inconsistent between the revised studies, so two well-trained reviewers independently abstracted the data under close supervision. Blinding was not possible during the review, but study investigators reported no previous ties with the authors of the revised studies. An electronic data management program was used to organize and analyze the information retrieved, thus enhancing the accuracy and efficiency of the review process.

5. Conclusions

A significant number of studies concluded that scorpion envenomation was more severe in children and among adults with pre-existing clinical conditions. Males were more prone to stings than females, and the summer season was associated with higher incidences of scorpion envenomation. Four studies showed that cardiac toxicity and myocarditis are common complications, and that although electrolyte imbalances do occur in certain cases, they do not pose serious clinical problems. Hemorrhages, as well, were documented post-scorpion envenomation, but most cases were treatable. Death due to scorpion envenomation is mostly associated with acute pulmonary edema and heart failure. In general, however, studies showed that scorpion stings have low death rates, thanks to the availability of medical facilities. Still, however, it is crucial to raise community awareness regarding location and availability of antivenom remedies.

Abbreviations

MeSH : Medical subject headings
IRB: Institutional Review Board
SMOH: Saudi Ministry of Health
ED: Emergency department
PROSPERO: International Database of Prospectively Registered Systematic Reviews
CINAHL: Cumulative Index to Nursing and Allied Health Literature
PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses
WHO: World Health Organization

CRediT authorship contribution statement

Mohammed Alhelail: Writing – review & editing, Conceptualization. **Raghad Alkanhal:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Areej Albelali:** Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Mahmoud Salam:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Contributions of each author

MAH, AAB and RAK conceptualized the study. All authors drafted the study protocol and obtained its approval. AAB, RAK, and MS registered the protocol in PROSPERO. AAB and RAK were accountable for the data acquisition and initial review. MAH and MS conducted the second phase of review and verification. AAB. RAK and MS were accountable for data entry. MS conducted data analyses and tabulation of results. All authors drafted the manuscript and are accountable for its content.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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