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## Epidemiological and spatial analysis of scorpion stings in two regions of Morocco: Marrakesh-Tensift-Al Haouz and Souss-Massa-Draa

Moulay Abdelmonaim El Hidan<sup>1</sup>, Oulaid Touloun<sup>1,2</sup>, Rhizlane El Oufir<sup>3</sup>, Ali Boumezzough<sup>1\*</sup><sup>1</sup>Laboratory of Ecology and Environment, Department of Biology, PO Box 2390, Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakesh 40000, Morocco<sup>2</sup>Polyvalent Laboratory of Research & Development LPVRD, Department of Biology, Polydisciplinary Faculty, Sultan Moulay Slimane University, Beni Mellal, Box 23023, Morocco<sup>3</sup>Poison Control and Pharmacovigilance Center of Morocco, Rabat Institute, Madinat Al Irfane, Rabat, Morocco

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## ABSTRACT

**Objective:** To describe and compare the epidemiological features of scorpionism during six years (2005–2010) in two regions of Morocco: Marrakesh-Tensift-Al Haouz and Souss-Massa-Draa.**Methods:** Clinical and epidemiological data were obtained from medical records of the Moroccan Poison Control Center during 2005–2010. The data comprised demographics, sting characteristics and clinical severity classes. Digital maps were produced for envenomation and death incidence with the distribution of all scorpion species present on the studied area.**Results:** A total of 75 313 scorpion sting cases were notified. The incidence of scorpion stings was 244 cases/100 000 population/year and was significantly higher at Marrakesh-Tensift-Al Haouz than Souss-Massa-Draa. The general lethality rate was on an average of 0.28% with a higher rate in Marrakesh-Tensift-Al Haouz compared to Souss-Massa-Draa. There was a different distribution of cases between genders in the two studied regions. With respect to age groups, adults (more than 15 years) were affected most compared to children. When analyzed according to the incidence in each province, the highest envenomation incidence was observed in Chichaoua. Concerning lethality, the highest lethality incidence was observed in the Kelaa. Based on this study, we could distinguish three zones: low scorpion stings occurrence without death, high incidence with low lethality and high scorpion stings rate with high lethality.**Conclusions:** Our data clearly demonstrate the correlation between scorpion stings incidence and the percentage of rural population in the different provinces. Additionally, the lethality incidence could be linked to the scorpion species of the studied area.

## 1. Introduction

Scorpion stings are the most important cause of arachnid envenoming and are responsible for significant morbidity and pediatric lethality in many parts of the Northern Africa, Central and South America, Asia and Middle East[1-8]. Among the 1500 species described, venoms of at least 25 species are of medical

importance for humans and the majority of those species belong to *Buthus*, *Parabuthus*, *Mesobuthus*, *Tityus*, *Leiurus*, *Androctonus* and *Centruroides* genera of Buthidae family[8].

Scorpion stings are the most frequent cause of intoxication in Morocco[7]. More than 50 species or subspecies belonging to two families (the Buthidae and the Scorpionidae), have been identified for the country. The most venomous species appear to be *Androctonus mauritanicus* (*A. mauritanicus*), *Androctonus liouvillei*, *Androctonus amoreuxi*, *Hottentotta gentili* (*H. gentili*), *Buthus malhommei* (*B. malhommei*) and *Buthus occitanus* of the family Buthidae[9-11].

The present investigation was designed to describe and compare the epidemiological features of scorpionism during six years (2005–2010) in two regions of Morocco: Marrakesh-Tensift-Al Haouz and Souss-Massa-Draa.

\*Corresponding author: Ali Boumezzough, Laboratory of Ecology and Environment, Department of Biology, PO Box 2390, Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakesh 40000, Morocco.

Tel: +212 662130564

Fax: +212 524434649

E-mails: aboumezzough@gmail.com, boumezzough@uca.ma

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## 2. Materials and methods

### 2.1. Study area and population

Marrakesh-Tensift-Al Haouz and Souss-Massa-Draa are two regions of the 16 regions of Morocco; they are situated in central part of the country. The majority of their territory presents arid climate, hot in summer and cold in winter.

Souss-Massa-Draa covers an area of 70 880 km<sup>2</sup> and has a population of 3 113 653, with 1 842 692 in rural areas (2004 census) while Marrakesh-Tensift-Alhaouz has a surface of 31 160 km<sup>2</sup> and a population of 3 102 652 with 1 885 939 in rural areas (2004 census) (Table 1).

**Table 1**

Demographic characteristics of each province in the two studied regions (Souss-Massa-Draa and Marrakesh-Tensift-Al Haouz).

Regions	Provinces	Population in rural areas	Population (n)	% of rural population
Souss-Massa-Draa	Agadir Ida Ou Tanan	102967	487954	21.1
	Inezgane Ait Melloul	34002	419614	8.1
	Chtouka Ait Baha	257551	297245	86.6
	Ouarzazate	351443	499980	70.3
	Taroudannt	594190	780661	76.1
	Tiznit	261973	344831	76.0
	Zagora	240566	283368	84.9
	Total	1842692	3113653	59.2
Marrakesh-Tensift-Al Haouz	Marrakesh	227263	1070838	21.2
	Chichaoua	295956	339818	87.1
	Al Houz	432119	484312	89.2
	El Kelaa	573188	754705	75.9
	Essaouira	357413	452979	78.9
		Total	1885939	3102652

### 2.2. Data on scorpion stings and population

Data on scorpion stings included 11 provinces from the two studied regions. We used clinical and epidemiological data obtained from medical records of the Moroccan Poison Control Center during 2005–2010. These data comprised demographics, sting characteristics and clinical severity classes.

Population data were obtained from the 2004 census of Moroccan High Commissioner for Planning.

### 2.3. Scorpion collection and identification

A systematic sampling of scorpions, based on observations and direct captures *in situ* was applied. In each habitat, areas suspected of housing scorpions (under rocks, pieces of wood *etc.*) were systematically explored. Species identification was based on appropriate identification keys.

In this study, we gathered out all point locality data for each species established by our scientific team since 1995 till now. Identified specimens were deposited in the Laboratory of Ecology and Environment (L2E) collections.

### 2.4. Geographical information system (GIS) data base and analysis

Digital maps were produced for envenomation and death incidence with the distribution of all scorpion species present on the studied area, using ArcMap GIS version 10. The output is two maps each depicting the incidence of scorpion stings and death in each province of the two regions associated with species distribution over the whole studied area.

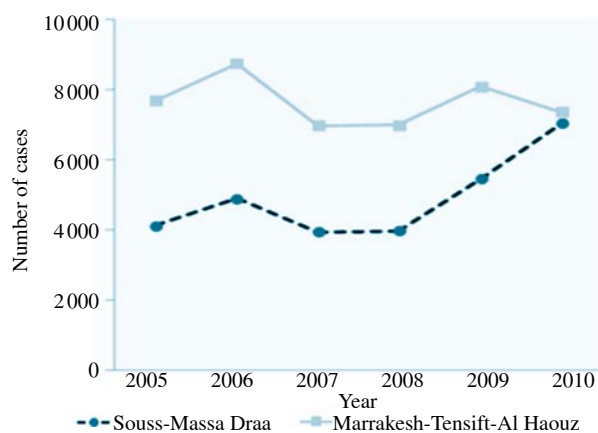
### 2.5. Statistical analysis

All data were analyzed using SPSS software and the Pearson's *Chi*-square method. Results were considered significant when the *P* value was less than 0.05.

## 3. Results

Our study analyzed 75 313 scorpion sting cases reported by medical records of the Moroccan Poison Control Center during 2005–2010. There was no data on scorpion sting in Zagora Province, whereas data were obtained from 11 provinces. Sting cases occurred in all 11 provinces. The median number of reported cases was 12 552. The maximum number of cases (14 403) was reported in 2010, followed by 2009 in which 13 563 cases were reported. The incidence of scorpion stings was 244 cases/100 000 population/year and was significantly higher at Marrakesh-Tensift-Al Haouz (246 cases/100 000 population/year) than at Souss-Massa-Draa (159 cases/100 000 population/year) ( $P < 0.05$ ). Thus, the largest number of cases was reported in Marrakesh-Tensift-Al Haouz Region (60.9%, Table 2), while in Souss-Massa-Draa just 39.1% of total cases was noted.

As shown in the Figure 1, the number of envenomation cases varied during time. In Marrakesh-Tensift-Al Haouz, this number fluctuated between 6 979 and 8 747 cases, whereas in Souss-Massa-Draa sting cases increased progressively with a peak of 7 031 cases in 2010.



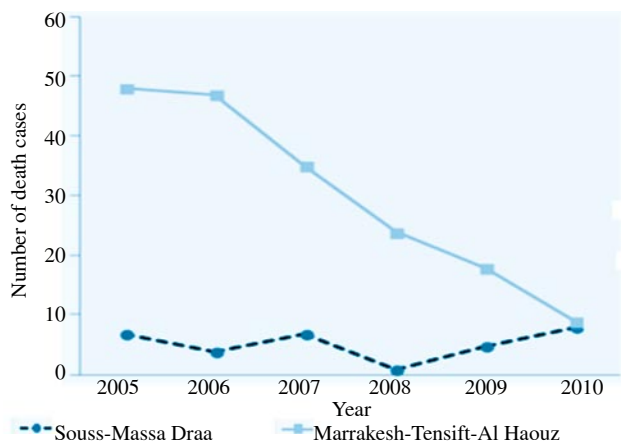
**Figure 1.** Reported cases of scorpion stings by year in Souss-Massa-Draa and Marrakesh-Tensift-Al Haouz regions (2005–2010).

**Table 2**

General comparative table between the two studied regions (Souss-Massa-Draa and Marrakesh-Tensift-Al Haouz).

Region	Stings cases [n (%)]	Death cases (n)	Sting incidence (cases/100000 population/year)	General lethality	Stung number of child [n (%)]
Marrakesh-Tensift-Al Haouz	45 876 (60.9)	181	246	0.39%	13 127 (66)
Souss-Massa-Draa	29 437 (39.1)	32	159	0.11%	6 763 (34)
Total or mean value	T = 75 313	T = 213	M = 244	M = 0.28%	T = 19 890

Of a total of 213 death cases recorded, 181 (85%) occurred in Marrakesh-Tensift-Al Haouz, and the remaining 32 (15%) took place in Souss-Massa-Draa. The general lethality rate was on an average of 0.28% with a higher rate in Marrakesh-Tensift-Al Haouz (0.39%) compared with Souss-Massa-Draa (0.11%) (Table 2). As well as envenomation cases, number of death cases varied during time. In Souss-Massa-Draa, cases of lethality were low and fluctuated between 1 and 8 cases, while in Marrakesh-Tensift-Al Haouz number of death cases in the year 2005 was the highest with 48 cases and declined to 9 cases in 2010 (Figure 2).



**Figure 2.** Death cases reported of scorpion stings by year in Souss-Massa-Draa and Marrakesh-Tensift-Al Haouz regions (2005–2010).

There was an unequal distribution of cases between genders in the two studied regions (52.86% female and 47.15% male). With respect to age groups, adults (more than 15 years) were affected most (73.57%) compared to children (26.39%) (Table 3). It's important to note that the number of envenomed children was significantly

( $P < 0.05$ ) higher in Marrakesh-Tensift-Al Haouz ( $n = 13 127$ ) in comparison to Souss-Massa-Draa ( $n = 6 763$ ) (Tables 2 and 3).

A total of 67 892 (90.15%) patients had mild envenoming (Class I), whereas 6 667 (8.85%) had a moderate (Class II) and 750 (1%) severe envenoming (Class III). The number of severe envenoming cases was significantly ( $P < 0.05$ ) higher in Marrakesh-Tensift-Al Haouz ( $n = 683$ ) than in Souss-Massa-Draa ( $n = 67$ ) (Table 3).

When analyzed according to the incidence in each province, the highest envenomation incidence was observed in Chichaoua (416 cases/100 000 inhabitants/year) and Chtouka-ait-baha (387 cases/100 000 inhabitants/year), followed by Al Haouz (328 cases/100 000 inhabitants/year) and Tiznit (309 cases/100 000 inhabitants/year). The lowest incidence was determined in Inzegane-Ait-Melloul (9 cases/100 000 inhabitants/year) (Figure 3). Concerning lethality, the highest lethality incidence was observed in the Kelaa (1.72 cases/100 000 habitants/year) followed by Marrakesh (1.15 cases/100 000 habitants/year), whereas the lowest incidence occurred in Chichaoua, Ouarzazate and Chtouka-Ait-Baha.

The spatial distribution of scorpion species in the studied area showed that scorpion fauna consisted of 26 species representing 48% of all described scorpion fauna in Morocco. All sampled species are belonging to two families: Buthidae and Scorpionidae and eight genera, *Androctonus*, *Buthus*, *Hottentotta*, *Orthochirus*, *Scorpio*, *Compsobuthus*, *Butheoloides*, *Buthacus*. These surveys revealed the presence of dangerous species such as, *A. mauritanicus*, *Androctonus amoreuxi*, *Androctonus liouvillei*, *H. gentili*, and *B. malhommei* (Figures 3 and 4, Table 4).

Tiznit, Ouarzazate and Al Haouz Provinces had the highest species richness with 8 species followed by Taroudant with 7 species, Kelaa, Essaouira and Agadir Ida Ou Tanan with 5 species. According to

**Table 3**

Epidemiological characteristics of scorpion stings in the studied regions (2005–2010).

Region	Characteristics	2005	2006	2007	2008	2009	2010	Total	%	P	
Souss-Massa-draa	Sex	Male	2 113	2 334	1 855	1 874	2 513	3 189	13 878	47.15	$P < 0.05$
		Female	2 007	2 564	2 085	2 105	2 956	3 842	15 559	52.86	
	Age groups	< 15	972	1 118	1 057	919	1 242	1 455	6 763	22.97	$P < 0.05$
		> 15	3 148	3 780	2 883	3 060	4 227	5 576	22 674	77.03	
	Admission classes	Classe I	3 979	4 728	3 782	3 859	5 269	6 770	28 387	96.43	$P < 0.05$
		Classe II	124	158	149	110	195	248	984	3.34	
Classe III		17	13	9	10	5	13	67	0.23		
Marrakesh-Tensif-Al Haouz	Sex	Male	3 577	4 329	3 436	3 313	3 878	3 451	21 985	47.92	NS
		Female	4 112	4 418	3 543	3 682	4 216	3 921	23 891	52.08	
	Age groups	< 15	2 276	2 510	2 158	2 024	2 030	2 116	13 114	28.58	$P < 0.05$
		> 15	5 413	6 237	4 821	4 971	6 064	5 256	32 762	71.42	
	Admission classes	Class I	6 580	7 663	5 998	6 068	7 085	6 111	39 505	86.11	$P < 0.05$
		Class II	1 036	1 013	928	831	866	1 009	5 683	12.39	
Class III		73	71	53	96	141	249	683	1.50		

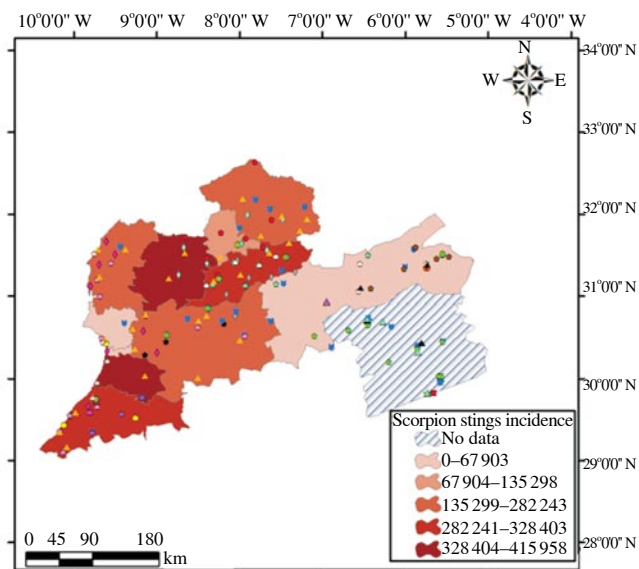
NS: No significance.

**Table 4**

Species distribution according to the provinces of the studied regions.

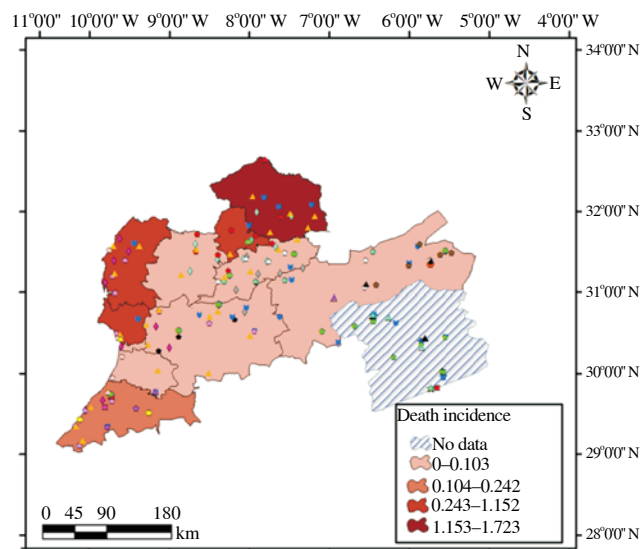
Species	Souss-Massa-Draa							Marrakesh-Tensift-Al Haouz					
	Agadir	Ida Ou Tanan	Inezgane Ait Melloul	Chtouka Ait Baha	Ouarzazate	Taroudant	Tiznit	Zagora	Marrakesh	Chichaoua	Al Haouz	El Kelaa	Essaouira
<i>Butheoloides slimanii</i>											+		
<i>A. mauritanicus</i>	+					+	+		+	+	+	+	+
<i>Androctonus amoreuxi</i>					+			+					
<i>Androctonus liouvillei</i>					+			+					
<i>Buthus elmoutaouakili</i>							+						
<i>Buthacus leptochelys</i>							+						
<i>Buthacus occidentalis</i>							+						
<i>Butheoloides littoralis</i>							+						
<i>Butheoloides maroccanus</i>						+	+				+	+	
<i>Buthus atlantis</i>				+			+						+
<i>Buthus barbouri</i>	+												
<i>Buthus boumalenii</i>					+								
<i>Buthus draa</i>					+			+					
<i>Buthus lienhardi</i>					+	+					+		
<i>B. malhommei</i>									+	+	+	+	
<i>Buthus mardochei</i>						+	+						+
<i>Buthus paris</i>					+						+		
<i>Buthus parroti</i>						+							
<i>Compsobuthus williamsi</i>	+				+								
<i>H. gentili</i>	+			+	+	+		+			+	+	+
<i>Orthochirus innesi</i>								+					
<i>Scorpio fuliginosus</i>						+							
<i>Scorpio mogadorensis</i>	+												+
<i>Scorpio weidholzi</i>										+	+	+	

the number of dangerous species, Kelaa, Al Haouz, Ouarzazate and Zagora could be considered as provinces with high risk of scorpion envenomation, as they had at least 3 dangerous species (Table 4).



**Figure 3.** Distribution of scorpion stings according to the provinces of the two studied regions.

The risk of scorpionism was assessed based on the sting incidence cases number/100000 population ratio with scorpion species distribution along the studied area. ♦: *Scorpio fuliginosus*; ♦: *Scorpio weidholzi*; ♦: *Scorpio mogadorensis*; ☆: *Orthochirus innesi*; ♣: *H. gentili*; ⬢: *Compsobuthus williamsi*; ⬢: *Buthus parroti*; ⬢: *Buthus paris*; ⬢: *Buthus mardochei*; ⬢: *B. malhommei*; ⬢: *Buthus lienhardi*; ⬢: *Buthus elmoutaouakili*; ⬢: *Buthus draa*; ⬢: *Buthus boumalenii*; ⬢: *Buthus barbouri*; ⬢: *Buthus atlantis*; ⬢: *Butheoloides slimanii*; ⬢: *Butheoloides maroccanus*; ⬢: *Butheoloides littoralis*; ⬢: *Butheoloides aymerichi*; ⬢: *Buthacus occidentalis*; ⬢: *Buthacus leptochelys*; ⬢: *A. mauritanicus*; ⬢: *Androctonus amoreuxi*; ⬢: *Androctonus sergenti*; ⬢: *Androctonus liouvillei*.



**Figure 4.** Marrakesh-Tensift-Al Haouz and Souss-Massa-Draa regions with their provinces according to occurrence of the death incidence.

Distribution of scorpion fauna was also reported to identify the relationship between lethality incidence and scorpion species. ♦: *Scorpio fuliginosus*; ♦: *Scorpio weidholzi*; ♦: *Scorpio mogadorensis*; ☆: *Orthochirus innesi*; ♣: *H. gentili*; ⬢: *Compsobuthus williamsi*; ⬢: *Buthus parroti*; ⬢: *Buthus paris*; ⬢: *Buthus mardochei*; ⬢: *B. malhommei*; ⬢: *Buthus lienhardi*; ⬢: *Buthus elmoutaouakili*; ⬢: *Buthus draa*; ⬢: *Buthus boumalenii*; ⬢: *Buthus barbouri*; ⬢: *Buthus atlantis*; ⬢: *Butheoloides slimanii*; ⬢: *Butheoloides maroccanus*; ⬢: *Butheoloides littoralis*; ⬢: *Butheoloides aymerichi*; ⬢: *Buthacus occidentalis*; ⬢: *Buthacus leptochelys*; ⬢: *A. mauritanicus*; ⬢: *Androctonus amoreuxi*; ⬢: *Androctonus sergenti*; ⬢: *Androctonus liouvillei*.

**4. Discussion**

Previous epidemiological studies have shown that the most of scorpion stings occurred in the south and central-south provinces of

the country, where the highest lethality rate was reported[12]. In this first comparative study, we used the GIS techniques and statistical analysis to establish the extent of scorpion envenomation in two high risk regions: Souss-Massa-Draa and Marrakesh-Tensift-Al Haouz.

Our results suggest that scorpion stings are an important health problem in the two studied regions. In fact, the median number of envenomation cases was 12552 which represents 50% of the reported cases every year in Morocco (average 25 000 cases)[13]. However, the annual incidence of scorpion stings was significantly higher in Marrakesh-Tensift-Al Haouz (437 cases/100 000 population/year) than in Souss-Massa-Draa (243 cases/100 000 population/year) ( $P < 0.05$ ). This difference may be explained the highest density (60.8%) of rural population in Marrakesh-Tensift-Al Haouz in contrast to Souss-Massa-Draa (59.2%). Analysis of the scorpion's stings distribution patterns showed that envenomation occurred throughout all periods of study, with the highest incidence occurred in 2010. Though, there is a significant difference in the distribution patterns between the two studied regions. In fact, in Marrakesh-Tensift-Al Haouz, stung patient numbers were approximately stagnant, whereas in Souss-Massa-Draa the number of stings increased gradually and reached its peak in 2010. This could be explained by the difference of the timing in the sensitization programs conducted by the Poison Control Center of Morocco in the two regions.

The high death incidence due to scorpion stings observed in Marrakesh-Tensift-Al Haouz in comparison to Souss-Massa-Draa is in part due to the high vulnerability of children, who seem to be the most envenomed. According to the literature, a high lethality rate is always observed among the children due to the immaturity of both physiological systems and body's defenses and the ratio between venom dose injected and body weight[14]. Beside the death number, the general lethality rate is an important indicator to evaluate the envenomation severity in an area or a country[12]. In Morocco, the general lethality rate was on an average of 0.40% over the five years of monitoring[12]. In our studied area, the general lethality rate was lower than the national rate (average 0.28%). Nevertheless, the general lethality rate in Marrakesh-Tensift-Al Haouz (0.39%) was closer to the national rate. In Algeria, this rate was lower than that of our studied area and estimated as 0.10% in 2009[2]; in Argentina, according to a study in 2003, this rate was 0.59% higher than that of our studied area[15].

As well as the envenomations, the number of death cases varies during time. In Souss-Massa-Draa, cases of lethality are lower and almost stable, while in Marrakesh-Tensift-Al Haouz they are higher with 48 cases observed in 2005. However, the number of death cases showed a sharp decline after 2005. This may be attributed to the establishment of clinical audit system in the case of death in some provinces with high death incidence, in order to identify any irregularity in the adopted therapeutic procedures for envenomed patients and to solve it by improving the actions to be taken[12].

Moreover, we observed a different distribution of cases between genders in the two studied regions, a finding similar to the reported distribution from Morocco, Iran, and Saudi Arabia[4,16-19]. However,

according to other studies, in Mexico and Brazil there was no preference in regard to the gender of the affected persons[20].

With respect to age groups, adult (more than 15 years) were affected the most compared to children. This result complies with those obtained from the analysis of the epidemiological data during the period stretching between 2001 and 2005 at national level[9]. Conversely, the study conducted by Hmimou *et al.* in the Kelaa Des Sraghna Province showed a higher envenomation frequency in children aged less than 15 years[21].

The present study has brought evidence that stung persons had mild (90%), followed by moderate (8.85%) and finally severe envenoming (1%). These results corroborate with previous findings showing that the most of stung persons belong to the first class with mild envenomation[22]. However, in a study conducted in scorpion stings in children in Fez, it showed a high rate of patients with severe envenoming (Class III)[23].

Interestingly, the number of severe envenoming cases (Class III) was significantly higher in Marrakesh-Tensift-Al Haouz than Souss-Massa-Draa. This difference could be attributed to the presence and density of very dangerous species in Marrakesh-Tensift-Al Haouz Region such as *A. mauritanicus*, *B. malhommei* and *H. gentili*.

The spatial analysis of scorpion stings incidence in different provinces of the two studied regions, reveals that the highest envenomation incidence is observed in Chichaoua followed by Chtouka-ait-baha, Al Haouz and Tiznit. This could be associated to the elevated percentage of rural population in these areas. In fact, a high positive correlation exists between the scorpion stings incidence and percentage of rural population. Furthermore, several studies have shown that the risk of scorpion stings is definitely higher in rural than urban areas[24]. Moreover, in those areas, a specific study showed that the incidence can exceed 1 000 scorpion stings per 100 000 inhabitants. In fact, in the province of ha'it, in Saudi Arabia, the incidence of scorpion stings had reached 1 870 stings per 100 000 inhabitants[25].

Interestingly, the highest lethality incidence was not observed in the province with high scorpion stings incidence (Chichaoua) but in the Kelaa Province. This could be explained by the difference of scorpion fauna in the two provinces and the presence of venomous species in the Kelaa Province. In fact, the presence of the most venomous scorpion species in Morocco (*A. mauritanicus*) with high density and other dangerous species such as *H. gentili* and *B. malhommei* in Kelaa province, qualified it as the most province at high risk of death due to scorpion envenomation.

In conclusion, our data reveal that scorpion envenomation is an important health problem in Morocco especially in Marrakesh-Tensift-Al Haouz Region. In the light of our findings, we could distinguish three zones: low incidence without death (Inzegane-Ait-Melloul), high scorpion stings incidence with low lethality (Chichaoua) and high scorpion stings incidence with high lethality (Kelaa). We clearly demonstrate the correlation between scorpion stings incidence and the percentage of rural population in the different provinces. Additionally, the lethality incidence could be

linked to the scorpion species of the studied area. Thus, the use of spatial analysis is a useful tool for determination of zone with high envenomation risk.

### Conflict of interest statement

We declare that we have no conflict of interest.

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