The Impact of Climatic Factors on Spatial Distribution of Scorpion Stings in Ardabil Province, North-West of Iran; 2012 - 2017

Eslam Moradiasl 1, Davoud Adham 1, *, Hossein Solimanzadeh 2, Abedin Saghafipour 3 and Hadi Eghbal 2

1Department of Public Health, School of Public Health, Ardabil University of Medical Sciences, Ardabil, Iran
2Institutes of Health Meshkin Shahr, Ardabil University of Medical Sciences, Ardabil, Iran
3Department of Public Health, Faculty of Health, Qom University of Medical Sciences, Qom, Iran

*Corresponding author: Department of Public Health, School of Public Health, Ardabil University of Medical Sciences, Ardabil, Iran. Tel: +98-4533513775, Email: d.adham@arums.ac.ir

Received 2018 April 11; Revised 2018 September 02; Accepted 2018 September 03.

Abstract

Background: Scorpion sting is a major health threatening problem in the world, while most victims in Iran are children. Identification of high-risk areas for scorpion stings and dispersal areas map can help to control, prevent, and take effective measures in a timely manner.

Objectives: The current study aimed at investigating the scorpion stings and determining the distribution status and spatial analysis in Ardabil Province, North-West of Iran.

Methods: The current cross sectional study collected the routine human scorpion stings information from health houses, health-care centers, and hospitals of Ardabil Province from 2012 to 2017 in standard epidemiological surveillance forms. The current study employed Arc GIS 10.2.3 and the space map projection to provide spatial distribution maps of high-risk areas for scorpion stings.

Results: Eight hundred fifteen cases of scorpion stings from all 10 counties of Ardabil Province were reported. During the study period, there was direct significant relationship between the increase of scorpion sting cases and temperature, as with 3°C average annual temperature increase, the incidence rate of scorpion sting increased from 5.45/100,000 in 2012 to 16.32/100,000 in 2017. Two hot zones of scorpion stings were detected in Khalkhal and Germi counties; the Southern and Northern areas of the province, respectively.

Conclusions: According to the current study findings, there were some hot zones of scorpion stings in Southern and Northern areas of the province. In addition, since the increase of temperature and reduction of rainfall and humidity coincide with the increase of scorpion stings, it is expected that with the increase of temperature in the next years with regard to the global warming phenomenon, scorpion stings also increase in this province.

Keywords: Spatial Distribution, Scorpion Sting, Iran

1. Background

Annually, over one million scorpion stings occur in the world (1, 2). Scorpion sting is one of the health threatening problems and 36,000 cases are reported in Iran per year (3). Most of the scorpion sting victims are children. Approximately, the mortality due to the scorpion stings is annually more than 3250 cases in the world, and less than 20 human cases in Iran (4). Scorpion belongs to phylum Arthropoda and class Arachnida and to date 16 families of scorpions are identified worldwide (5, 6). There are three families of scorpions in Iran: Buthidae, Hemiscorpiidae, and Scorpionidae; 1500 species of scorpions are identified in the world of which 50 species are dangerous to humans (7); 23 genus and 44 species are identified in Iran. It is reported that most of the scorpions are scattered in Southern, and Southwestern areas of Iran, and the maximum variation of the scorpions are reported in Khuzestan Province with 19 out of 59 identified species (3, 8, 9). Four scorpion species are scattered in Azerbaijan regions, including Compsobuthus matthiesseni, Mesobuthus caucasicus, Orthochirus Scrobiculosus, and Scorpio maurus Linnaeus (1758) and in Ardabil regions two species were identified: Mesobuthus eupeus and Andrectonus crassicauda (10, 11). Scorpion sting occur in all regions of Iran. There is no complete definition of scorpion sting epidemiology and clinical signs in Iran (12, 13). However, the clinical symptoms of scorpion sting are different depending on the species: The amount of toxins entering the body,
the season of the sting, and age and physical condition of the injured person (14, 15). Geographical information system (GIS) is a powerful tool for the epidemiological surveillance, management, and analysis of many health problems information (16). GIS can analyze the information and distribution rate of the disease in the spatial maps. GIS is very useful to manage, allocate resources, and monitor diseases in high-risk regions (17). The current study aimed at investigating scorpion stings, determining the distribution, and analyzing its spatial status in Ardabil Province to control, survey, and manage scorpion stings by GIS in the North-West of Iran.

2. Methods

2.1. Study Area

Ardabil Province is located in the North-West of Iran. This area is 17,953 km² and according to the 2015 census, its population was 1,249,000 people. This province has 10 counties and 1477 permanent villages (Figure 1).

2.2. Data Collection

In the current cross sectional study, all information about scorpion stings in all of the counties in Ardabil Province including: Kowsar, Sareyn, Parsabad, Nir, Namin, Meshkin-shahr, Khalkhal, Germi, Bilasavar, and Ardabil were recorded from 2012 to 2017. In the current study, a researcher-made questionnaire was employed to collect the demographic and epidemiologic data. The questionnaire was designed based on variables such as the site of the bite, age and gender of the victim, season, injured limb, village, and location of incidence. The routine human scorpion stings information were collected from health houses, healthcare centers, and hospitals in standard epidemiological surveillance forms designed by Center for Disease Control and Prevention (CDC), Ministry of Health and Medical Education (Iran). The data were provided to the Department of Diseases Prevention and Control, Provincial Healthcare Center in Ardabil, North-West of Iran.

2.3. Ethical Considerations

The current study was approved by the Ethics Committee of Ardabil University of Medical Sciences (ethical code: IR.AUMS.REC.1395.21).

2.4. Inclusion and Exclusion Criteria

The current study only included the patients’ data collected in standard epidemiological surveillance forms and scorpionism characteristics confirmed by physician that were treated with anti-scorpion venom serum provided by the CDC of Ministry of Health. Other victims were not entered into the current study.

2.5. Statistical Analysis

Arc GIS 10.2.3 was employed to draw spatial distribution maps of high-risk areas for scorpion stings. In addition, meteorological data such as relative humidity, annual temperature, rainfall, sunny days, and frost days were obtained from Ardabil Meteorological Office. Separately, variables such as the site of bite, age and gender of the scorpionisms, season, injured limb, rural or urban areas, the mean annual temperature, relative humidity, and altitudes were also analyzed. Unadjusted linear regression and correlation coefficient were used to analyze data with SPSS version 19 in order to find the effect of climatic factors on spatial distribution of scorpion stings.

3. Results

Totally, 815 scorpionism cases were recorded of all counties of Ardabil Province during the study period; 56.5% of the cases were male and the rest (43.5%) were female. Most of the scorpion sting victims (42%) were within the age range of 11 to 30 years and the age range of 70 and above constituted the least cases (19%). 61% of scorpionism cases occurred indoors and 39% outdoors. Hands and feed were the most injured organs (85%); 97% of the victims received anti-scorpion venom serum both intramuscularly and intravenously; 94% of the victims were the new cases and 6% had a history of scorpionism; 87% of scorpions were yellow, 7% dark, and 6% were not identified.

The highest incidence rate of scorpion sting was in 2017 (16.32/100,000) and the lowest in 2012 (5.45/100,000) (Table 1). The scorpion sting peak occurs from August to July and the lowest burden is observed in January and December (Table 2 and Figure 2).

Spatial distribution of scorpionism revealed that most of the cases were reported from Khalkhal (22.6%) and Nir (2.94%) counties with Southern mountainous areas of the province with lower temperature, higher altitude, and higher rainfall in comparison with other counties as well as Germi (22%), located in the Northern areas of the province. The lowest cases belonged to Kowsar (1.35%) and Nir (2.94%) counties with semi-mountainous areas (Figures 3 and 4).

The important environmental factors that affected the scorpion stings in Ardabil Province were temperature and seasonal rainfall (Figure 5). The maximum average annual temperature was recorded in 2017 (13.59°C) and lowest average humidity was recorded in the same year with 61%. The minimum average annual temperature (10.58°C) with the highest annual average humidity (65.3%) was recorded in 2012. From 2012 to 2017, the average total rainfall 85 mm decreased, and the minimum and maximum average temperatures respectively 2.7 and 4.6°C increased.

The unadjusted linear regression showed significant relationship between scorpion stings and some of the
climatic factors, significant relationship among average, maximum, and minimum temperatures and average sunny days. Also, direct significant relationship was observed between the increase of temperature and the number of sunny days during the period of scorpion sting increase ($P < 0.05$).

Relationship between average relative humidity (RH) and rainfall was indirect, that means with decreased RH and rainfall, the scorpionism rate increased ($P < 0.05$) (Table 3). The number of frost days during the seven years of

**Figure 1.** The geographical location of the study area; Ardabil province; North-West of Iran

**Table 1.** The Incidence Rate of Scorpionism per 100,000 Cases and Association with Climatic Variables

<table>
<thead>
<tr>
<th>Year</th>
<th>Incidence Rate of Scorpionism</th>
<th>Average Temperature, °C</th>
<th>AAMT$^a$, °C</th>
<th>AAMT$^b$, °C</th>
<th>Average Humidity, %</th>
<th>TAP$^c$, mL</th>
<th>ANFD$^d$, d</th>
<th>Average Air Pressure, QFE$^e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>5.45</td>
<td>10.58</td>
<td>-18.50</td>
<td>33.50</td>
<td>65.30</td>
<td>386.15</td>
<td>93.50</td>
<td>870</td>
</tr>
<tr>
<td>2013</td>
<td>10</td>
<td>11.25</td>
<td>-17.85</td>
<td>34.72</td>
<td>64.25</td>
<td>375.62</td>
<td>90</td>
<td>881</td>
</tr>
<tr>
<td>2014</td>
<td>9.53</td>
<td>12.29</td>
<td>-13.96</td>
<td>37.59</td>
<td>63.25</td>
<td>368.68</td>
<td>90</td>
<td>890</td>
</tr>
<tr>
<td>2015</td>
<td>8.81</td>
<td>12.58</td>
<td>-12.48</td>
<td>38.12</td>
<td>61.98</td>
<td>304</td>
<td>82</td>
<td>895</td>
</tr>
<tr>
<td>2016</td>
<td>14.58</td>
<td>13.56</td>
<td>-11.30</td>
<td>39.10</td>
<td>61.5</td>
<td>301.85</td>
<td>80.2</td>
<td>899</td>
</tr>
<tr>
<td>2017</td>
<td>16.32</td>
<td>13.59</td>
<td>-11</td>
<td>39.20</td>
<td>64.3</td>
<td>301.15</td>
<td>80</td>
<td>899</td>
</tr>
</tbody>
</table>

$^a$ Average absolute minimum temperature (AAMT).

$^b$ Average absolute maximum temperature (AAMT).

$^c$ Total annual precipitation (TAP).

$^d$ Average number of frost days (ANFD).

$^e$ Atmospheric pressure (Q) at field elevation.
Table 2. The Trend of Scorpionism in Ardabil Province; North-West of Iran from 2012 to 2017

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>4</td>
<td>7</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>68</td>
</tr>
<tr>
<td>2013</td>
<td>1</td>
<td>7</td>
<td>24</td>
<td>22</td>
<td>27</td>
<td>30</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>2014</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>20</td>
<td>49</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>159</td>
</tr>
<tr>
<td>2015</td>
<td>4</td>
<td>11</td>
<td>32</td>
<td>46</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td>2016</td>
<td>4</td>
<td>7</td>
<td>12</td>
<td>30</td>
<td>34</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>6</td>
<td>10</td>
<td>15</td>
<td>33</td>
<td>35</td>
<td>28</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>48</td>
<td>81</td>
<td>132</td>
<td>243</td>
<td>141</td>
<td>84</td>
<td>31</td>
<td>14</td>
<td>6</td>
<td>5</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.17</td>
<td>8</td>
<td>13.5</td>
<td>22</td>
<td>40.5</td>
<td>21.5</td>
<td>5.17</td>
<td>2.33</td>
<td>1</td>
<td>0.93</td>
<td>0.93</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>1.83</td>
<td>2</td>
<td>5.92</td>
<td>8.36</td>
<td>15.9</td>
<td>12.3</td>
<td>4.66</td>
<td>1.96</td>
<td>1.54</td>
<td>1.97</td>
<td>0.75</td>
<td>51.86</td>
<td></td>
</tr>
<tr>
<td>Average temperature °C</td>
<td>9.25</td>
<td>15</td>
<td>19</td>
<td>22</td>
<td>22.25</td>
<td>22</td>
<td>15.75</td>
<td>9</td>
<td>4.5</td>
<td>3</td>
<td>2.5</td>
<td>6</td>
<td>12.43</td>
</tr>
<tr>
<td>Average relative humidity, %</td>
<td>65</td>
<td>60.75</td>
<td>55.5</td>
<td>54</td>
<td>50</td>
<td>58.5</td>
<td>65.5</td>
<td>71</td>
<td>72.25</td>
<td>63.5</td>
<td>68</td>
<td>68.5</td>
<td>62.07</td>
</tr>
</tbody>
</table>

Figure 2. Monthly reports of scorpionism cases in Ardabil province; North-West of Iran from 2012 to 2017

Figure 3. Geographical distribution of scorpionism in all counties of Ardabil province from 2012 to 2017

4. Discussion

Ardabil Province is located in a temperate region in North-West of Iran. According to the increasing average temperature and average relative humidity, the study decreased 13.3 days. The average air pressure (QFE) in different years were rising (Table 1).
global temperature and its impact on insects’ lives, the incidence of scorpionism in such areas is increasing; therefore, the average annual temperature increase from 2012 to 2017 was 3°C. In addition, the prevalence of scorpionism increased to 10.87 per 100,000 people that means it increased more than three times. This increase is a health threat in this area, since with the increase of temperature and decrease of humidity, the prevalence of scorpionism increased. In Hormozgan Province, South of Iran (18), Morocco (19), and Brazil (20) scorpionism also increased. More than 70% of the cases occurred in June, July, and August. Scorpion stings mostly occurred in hot months. In Ardabil Province, the average temperature increased from 33.5°C in 2012 to 39.2°C in 2017; furthermore, average absolute minimum temperature decreased from -18.5 to -11. Therefore, these climatic changes and increase in the min-
Figure 5. Temperature seasonality distribution map (A) and rainfall seasonality distribution map (B) of scorpionism in different counties of Ardabil province; North-West of Iran from 2012 to 2017.
and Southern (Khalkhal) regions of the province. Results of the current study could be applied to determine and map high risk foci of scorpion stings areas, plan for training programs to prevent the occurrence of scorpionism by the health care system, and suitably distribute the relevant anti-scorpion venom serum and other therapeutic requirements according to high-risk areas. Some of the limitations of the current study were illegible and incomplete forms, which were excluded and difficulty to extract data from the hospital archives. Field studies should be conducted to identify the dangerous scorpions species in the region. Also, studies with different health education models should be conducted to promote awareness of at risk people and prevent scorpionism.

4.1. Conclusion

According to the current study results, there were two hot zones for scorpion sting in Ardabil Province, one of them was Khalkhal County in the Southern mountainous areas of the province with lower temperature higher altitude, and high rainfall, in comparison with other counties; and the other one was Germi County located in the Northern areas of the province. In addition, due to the co-occurrence of temperature increase and reduction of rainfall and humidity with the increase of scorpionism, it is expected that the increase of temperature in the next years with regard to the global warming phenomenon, affects the prevalence of scorpionism in the studied province.

Acknowledgments

The authors are grateful to the staff of the health centers especially Dr. Mohamad Amani and Mrs. Sarvi and E-mail Ghorbani.

Footnotes

Authors’ Contribution: Eslam Moradiasl and Davoud Adham co-designed the study, Eslam Moradiasl and Abedin Saghafipour, were the project designers of the research and wrote the manuscript. Hossein Solimanzadeh, Abedin Saghafipour, Hadi Eghbal participated in collecting the data and Eslam Moradiasl analyzed the results. All authors read, modified, and approved the final version of the manuscript.

Funding/Support: This project has been financially supported by Student Research Committee of Ardabil University of Medical Sciences with project number4225.

Ethical Considerations: This study was approved by the ethics committee of Ardabil University of Medical Sciences (IRAUMS.REC.1395.21).

References


