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Contents lists available at ScienceDirect
Asian Pacific Journal of Tropical Disease
journal homepage: www.elsevier.com/locate/apjtd

Epidemiological investigation doi: 10.1016/S2222-1808(16)61165-9

Modelling the scorpion stings using surveillance data in El Bayadh Province, Algeria

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ARTICLE INFO

Article history:
Received 30 Aug 2016
Received in revised form 20 Sep, 2nd revised form 8 Oct, 3rd revised form 12 Oct 2016
Accepted 18 Oct 2016
Available online 27 Oct 2016

Keywords:
Algeria
Climate
Count data
Epidemiology
Forecasting
Scorpionism
Scorpion sting

ABSTRACT

Objective: To examine some epidemiological features of scorpion envenomations, analyse and interpret the recorded data, find any relationship between the incidence of scorpion stings and climatic factors, and finally develop a statistical model to estimate the variability among future cases in El Bayadh Province, Algeria.
Methods: To assess the effects of climate variability on the scorpion envenomations, we applied the count data regression models to the monthly recorded scorpion stings in El Bayadh Province from 2001 to 2012.
Results: The epidemiological analysis of data revealed that scorpion stings occured mainly in rural areas, round the clock, all year long with the highest seasonal incidence in summer, and the lowest in winter, all ages with male predominance. The ends of upper and lower limbs were the most affected parts of the human body. The majority of cases (95.7%) were classified as mild envenomations and systemic toxicity was observed in 4.3% of cases. The use of count data regression models showed that the negative binomial regression was appropriate to forecast cases and the fitted data agreed considerably with the actual data. Moreover, the model had predicted the monthly scorpion sting cases for the year of 2013, with satisfactory accuracy.
Conclusions: This study shows an optimism for forecasting scorpion stings by modelling and calibration with surveillance data and climate information. This knowledge could help to contain any unusual situation and assist health decision-makers to strengthen the prevention and control measures and to be in a state of readiness.

1. Introduction

Scorpionism is an actual public health problem, at various levels, in North-Saharan and South and East Africa, Middle-East, South India, Brazil, Mexico and Amazonian basin. The scorpions mainly predominate in arid, semi-arid or Saharan areas of the world in a band not exceeding 50° latitude, both south and north, and their distribution is dependent on a number of factors including climatic and environmental factors. Even though scorpionism is geographically limited, the world's population at risk of scorpion envenomations is almost two and a half billion people. It is noteworthy that epidemiological data remain scanty due to the under-reporting in many affected regions in the world. The human, scorpion, climate and environment are the main factors that determine the epidemiology of scorpion envenomations. Human have a great responsibility in scorpion accidents through negligence, ignorance or both. People offer to scorpion a supportive environment by building directly on top of scorpion shelters without land reclamation creating ideal habitats near houses. Moreover, human contributes to the reduction of cannibalism and to the proliferation of scorpions. Indeed, the detritus is littered in the streets and public spaces, thereby promoting cockroach outbreaks, flies and other arthropods, providing abundant preferred preys to scorpions. The risk exists in both urban and rural areas and is significantly higher in rural areas[1].

By its vast geographical scope and the diversity of its climate and its ecosystems, Algeria possesses a diverse fauna of scorpions and is seriously affected by scorpionism. More than 28 species are catalogued for the country. The four dangerous scorpion species to humans are *Androctonus australis* identified in the southern highlands and Saharan Atlas, *Buthus tunetanus* identified in septentrional edge of the Sahara, *Androctonus aeneas* identified in the highlands and Saharan Atlas, and *Androctonus crassicauda* identified in Tindouf. Regarding the north of the

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The journal implements double-blind peer review practiced by specially invited international editorial board members.

country, the scorpion fauna research is non-existent[2]. The scorpion envenomation was recognized in the mid-80s as a public health problem because of the morbidity and mortality it causes and the financial burden it imposes. Since the launch of the national committee against the scorpion envenomations in 1986, several initiatives were undertaken to address this issue. The recording of sting cases, therapeutic care and death investigations are the main undertaken actions. The epidemiological investigations in 2012 revealed that 81% of the provinces are concerned by the accidents of scorpion stings leading to an estimated at risk population of 74% of the country's population. The Sahara and Highlands are the most affected regions of the country and 90% of stung patients and all deaths occurred in these regions. For the period of 2001–2012, the mean incidence was 152 scorpion stings per 100 000 population and the mean mortality was 0.23 per 100 000 population. The incidence scorpion stings remains lowest in the Northern provinces with less than 7 scorpion stings per 100 000 population and highest in the Southern provinces with more than 1 000 scorpion stings per 100 000 population[3].

The identification of the scorpion fauna and the classification of the epidemiological features of scorpion stings have been undertaken in several endemic regions, such as Algeria, Brazil, Iran, Mali, Mexico, Morocco, Nigeria, Saudi Arabia, Turkey[4-15].

The present study aims to examine the epidemiological features of scorpion envenomations as well as the identification of any association between the incidence of scorpion stings and climatological variables, and ultimately to provide the best regression model to estimate the variability among future sting cases in El Bayadh, one of the endemic provinces in Algeria for the scorpion envenomations.

2. Materials and methods

2.1. Scorpions

Scorpions are venomous arthropod animals affiliated to the class Arachnida. They sting, usually when they are disturbed inadvertently, yet their natural tendencies are to hide and escape[2]. They use their venom for both prey capture and defence. The scorpion has the ability to control the venom flow and the existence of scorpion sting with mild envenomation, or even, without the inoculation of venom has been established in several studies. The stings by a dangerous scorpion species can be life-threatening, especially for children and older individuals[1].

2.2. The study region

El Bayadh Province is located west of Algeria, at 33°40′49″ N and 1°01′13″ E. As 2012, the province accommodated an estimated population of 291 600. The province consists of three distinct zones: high plains, near Saharan and Saharan Atlas. Climatologically, the province is characterised by two main periods, a harsh winter with frequent snowfalls and a hot and dry summer.

2.3. Data

The study data included the epidemiological data and meteorological data. The climate variables possessed great influence on the scorpion distribution and activity[16].

The monthly recorded scorpion sting cases between January 2001 and December 2013 in El Bayadh's Province were used in statistical modelling, the breakdown by gender, by anatomical sting site, by age group, by place, and by time slot used in the epidemiological survey for the year of 2012, as well as the monthly recorded scorpion sting cases for the 22 municipalities that maked up the province were provided by El Bayadh's Department of Public Health.

Monthly mean, maximum, and minimum temperature, monthly mean relative humidity (RH), the monthly precipitation amount and monthly mean wind speed (km/h) were gained from the website (http://en.tutiempo.net/climate/ws-605500.html) which compiles and stores data from meteorological stations around the world[17].

2.4. Modelling method

Count data are common in many fields, particularly, in health and in epidemiology. The number of disease cases ranks among common examples. Poisson and negative binomial regression models is amongst the mathematical models intended to analyse these kinds of data. The Poisson model is the most commonly used model when it comes to count events arising within a specific period. One of the key features of the Poisson model is that the variance equals the mean. However, with real life data, the equality between the mean and the variance does not always occur. In most cases, the observed variance is larger than the assumed one, which is known as overdispersion. If the overdispersion is ignored, statistical inference results in an inaccurate conclusion by underestimating the variability of the data. Poisson regression can be adjusted to correct for a modest overdispersion of data, leading to a scaled Poisson model. An alternative method and often preferred solution is the negative binomial regression and such method adjusts the overdispersion[18-20].

2.4.1. Poisson model

The basic count model used to associate a count variable with one or more explanatory predictors is the Poisson regression model. The counts in the response variable are to be understood by virtue of one or more predictors. In Poisson regression, we suppose that the number of occurrences of an event (Y) had a Poisson distribution given the independent variables $X_1, X_2, \ldots, X_m$:

$$P(Y = a \mid X_1, X_2, \ldots, X_m) = \frac{e^{-\mu}\mu^a}{a!}, \qquad a = 0,1,2,\ldots$$

where the log of the mean (μ) is supposed to be a linear function of the independent variables

$$\log(\mu) = \alpha + \beta_1 X_1 + \ldots + \beta_m X_m$$

The parameters are estimated using the maximum likelihood method[18,20].

2.4.2. Scaled Poisson model

A dispersion parameter is added to the Poisson variance to correct for overdispersion, thus scalling the Poisson model. This technique provides an appropriate inference only for modest overdispersion. The dispersion parameter is estimated by deviance or Pearson's χ^2 test statistic divided by its degree of freedom from the fitted model. The variance in a scaled Poisson model is of the form:

$$Var(Y) = k\mu$$

The model was fitted as in Poisson model and the estimated variance was inflated to adjust for overdispersion, while the parameter estimates were not affected by the value of k[18,20].

2.4.3. Negative binomial model

Another count data model to correct for overdispersion in the data is negative binomial model. A multiplicative random effect is added to the Poisson regression model to represent unobserved heterogeneity. The relationship between the mean and the variance is of the form:

$$Var(Y) = \mu + k\mu^2$$

where the negative binomial dispersion parameter k is estimated by