

Cutaneous Leishmaniasis Based on Climate Regions in Iran (1998-2021): A Systematic Review and Meta-Analysis

Mehri Rejali¹, Nadia Mohammadi Dashtaki¹, Afshin Ebrahimi^{2,3}, Asieh Heidari^{3,4}, Mohammad Reza Maracy^{1,3}

¹Department of Epidemiology and Biostatistics, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran, ²Environmental Health Engineering, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran, ³Environment Research Center, Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran, ⁴Skin Diseases and Leishmaniasis Research Center, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Background: Climate change can facilitate the expansion of leishmaniasis and create the suitable habitat for vector and reservoir species. The objective of this study was to estimate the prevalence of cutaneous leishmaniasis (CL) at the climatic regions of Iran.

Materials and Methods: The literature search was conducted to identify all published studies reporting the prevalence or incidence of CL in humans in Iran. A total of 350 articles that reported leishmaniasis in Iran were retrieved, due to eligibility criteria, only 42 studies were selected to the final systematic review and meta-analysis procedure. Random effects meta-analysis was done with the estimate of heterogeneity being taken from an inverse-variance model. Subgroup analysis was conducted and it stratified the studies according to climatic regions. Between-study heterogeneity was assessed by using I^2 and Cochran's Q method P value of heterogeneity. Meta regression was used to investigate factors potentially contributed the between-study heterogeneity.

Results: Individual studies showed that prevalence per 100,000 population estimated the range from 1.5 to 318.7 with the overall random pooled prevalence of 83.3 (95% confidence interval 74.5–92.1). Subgroup analysis by climatic regions showed that many studies were conducted in the desert areas and also, it has more prevalent than the other climatic regions.

Conclusions: Leishmaniasis was more prevalent in regions with dry and desert climates than the other climatic regions. One of the advantages of this work is that the majority of selected studies have been conducted on population-base. However, some of the studies have been designed poorly or have had a lack of internal validity.

Keywords: Cutaneous leishmaniasis, human reservoirs, Iran, prevalence

Address for correspondence: Dr. Mohammad Reza Maracy, Department of Epidemiology and Biostatistics, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran. Environment Research Center, Research Institute for Primordial Prevention of Noncommunicable Diseases, Isfahan University of Medical Sciences, Isfahan, Iran.

E-mail: mrrmaracy@yahoo.co.uk

Submitted: 25-Apr-2021; **Revised:** 20-Oct-2021; **Accepted:** 02-Nov-2021; **Published:** 26-Dec-2022

INTRODUCTION

Leishmaniasis is one of the most important vector-borne diseases transmitted to humans and other animals through the bite of infected sandflies.^[1,2] It is also the third-most important vector-borne parasitic disease after malaria and lymphatic filariasis.^[2,3] In general, over 350 million persons are at risk globally^[4,5] and 0.7–1.3 million new cases occur annually.^[6,7]

According to the World Health Organization, 2 million new cases are infected with leishmaniasis annually, including 1.5 million of cutaneous leishmaniasis (CL), and 20,000–40,000 die each year.^[6,8] CL which represents a significant public health problem over a wide geographical area,^[9,10] is an endemic parasitic disease in 98 countries of the world.^[11] Most

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Rejali M, Mohammadi Dashtaki N, Ebrahimi A, Heidari A, Maracy MR. Cutaneous leishmaniasis based on climate regions in Iran (1998-2021): A systematic review and meta-analysis. *Adv Biomed Res* 2022;11:120.

Access this article online

Quick Response Code:



Website:
www.advbiores.net

DOI:
10.4103/abr.abr_90_21

cases of CL occur in Afghanistan, Algeria, Brazil, Colombia, Iran, Pakistan, Peru, Saudi Arabia, and Syria.^[12] However, the disease remains a public health problem worldwide.^[13] The estimated world prevalence of all forms of the disease is 12 million annually.^[14-17]

The cutaneous and visceral forms of CL have been mainly reported in 14 countries in the Eastern Mediterranean Region including Iran.^[18] CL is endemic in 17 out of 31 provinces of Iran.^[2,5,12,18] The disease is prevalent in southern Khorasan, Fars, Isfahan, Khuzestan, Kerman, Ilam, and Bushehr provinces. The Western and northwest provinces of Iran have the lowest incidence of CL.^[19] About 20000 cases of CL are reported in many parts of Iran annually.^[20] Isfahan has recorded the highest prevalence of the disease with many endemic foci.^[20] Among the main ecological factors, the average temperature and type of soil can determine the sandflies activities and ultimately the outbreak of CL.^[21] Climate change can facilitate the expansion of leishmaniasis and create the suitable habitat for vector and reservoir species.^[22] Phlebotomine sandflies are assumed to be specific to areas with warmer climatic conditions (mainly to the tropics and subtropics) and so they are generally characterized as thermophilic species.^[23]

Although there has been an increase in the number of studies on CL prevalence across Iran, based on our knowledge, the country does not have an overall estimation of the prevalence of CL at the Iranian's climatic regions. In the present systematic review and meta-analysis, we reviewed and retrieved publications relating to leishmaniasis in Iran based on six climatic regions that classified according to Thermal, humidity and cloudiness, precipitation, wind and dust, and Thunder factors and also the atmosphere pressure.

The objective of this study was to estimate the prevalence of CL in the climatic regions of Iran. This study may help policymakers to develop better control and prevention programs.

MATERIALS AND METHODS

Literature search strategy

The literature search was conducted by three reviewers independently to identify all published studies reporting the prevalence or incidence of CL in Iranian people. The search was conducted in electronic databases of ISI web of sciences, PubMed, Google Scholar, Magiran, Irandoc, IranMedex, Scindirect, Scientific Information Database, and Scopus with no time limitation. The search was performed using such terms as follows: "Leishmania*," "cutaneous Leishmania*," "cutaneous Leishmaniasis and Iran," "Leishmaniasis prevalence and Iran," "Leishmaniasis incidence and Iran" both in Persian and English languages. For instance, the term strategy in ISI is as follows: TS= (Prevalence or incidence) AND TS= (leishmania* OR cutaneous) AND TS= (Iran). The process of search is shown in Figure 1.

Eligibility criteria and data extraction procedure

All articles on CL in Iran were downloaded and added to the Endnote reference manager. Duplicates were rigorously checked and removed. Studies that were conducted out of Iran and also the animal-based studies were removed. The inclusion criteria include on observational studies that report the prevalence or incidence of the disease in Iran. In addition, one of the employed diagnostic approaches such as microscopic, serological, molecular, and culture methods were checked.

Data which were extracted from articles including Author(s) name, years of the study, year of the published paper, sample size, number of positive cases, prevalence, diagnosis method used, type of CL studied, demographic information such as age, sex ratio, and climatic regions. The Iran climatic regions included coastal areas of the Caspian Sea West-East parts, coastal areas of the Persian Gulf and Oman sea west part, coastal areas of the Persian Gulf and Oman sea east part, mountainous and high areas of the central plateau, foothills of the central plateau, and desert areas. Geographical regions of the study also were noted. The above data were recorded and extracted to the preprepared data extraction excel sheets. Based on the intensive literature search, a total of 350 studies that report on CL in Iran were retrieved. Due to eligibility criteria, only 42 studies were selected to the final systematic review and meta-analysis procedure. All of the studies were on human reservoirs. It should be noted that the results of some selected studies have been done in more than 1 year or in more than one province and the results were presented for either separate years or provinces. As a result, the mentioned studies collapsed to the number of reported either year or province results. The summation of them transferred from 42 to 150 included studies for the meta-analysis.

Quality assessment and publication bias

In this study, the Joanna Briggs Institute critical appraisal was used to evaluate the quality of articles that reported prevalence data (last amended in 2017). This checklist consists of 9 different questions that the minimum and maximum scores for each study varied between 0 and 9. More information is shown in Table 1.

Besides, the quality assessment or publication bias was assessed using the Begg and Eggers test, as well as visual inspection of the funnel plot.

Statistical analyses

Statistical analyses were performed using STATA 14 software (StataCorp LLC; College Station, Texas, USA). Descriptive statistics of data were analyzed to estimate the pooled prevalence and its 95% confidence intervals (CIs). Because substantial heterogeneity was expected, random-effects meta-analysis was performed with the estimate of heterogeneity being taken from an inverse-variance model. Subgroup analysis was conducted and it stratified the studies according to climatic regions affected human hosts.

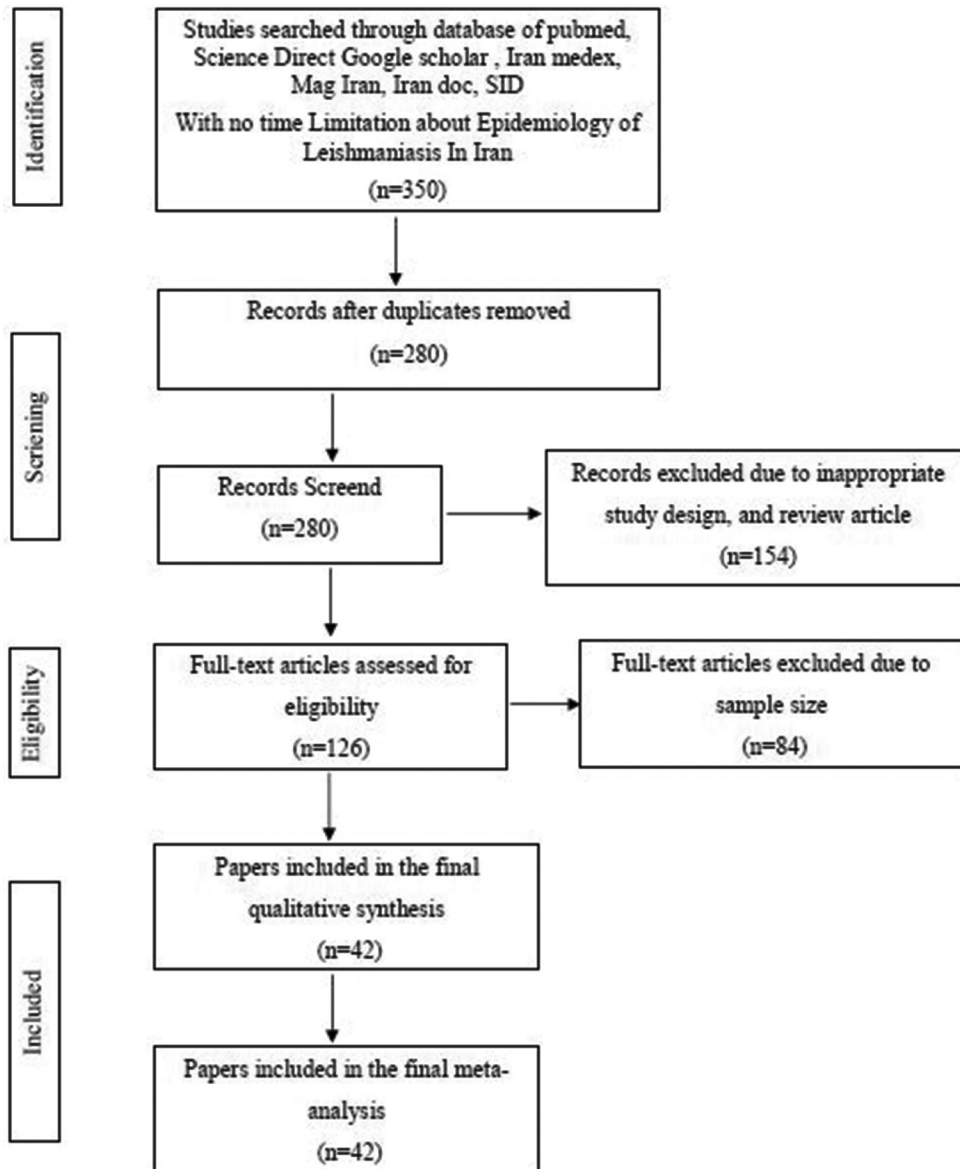


Figure 1: Flowchart of literature search and inclusion/exclusion process

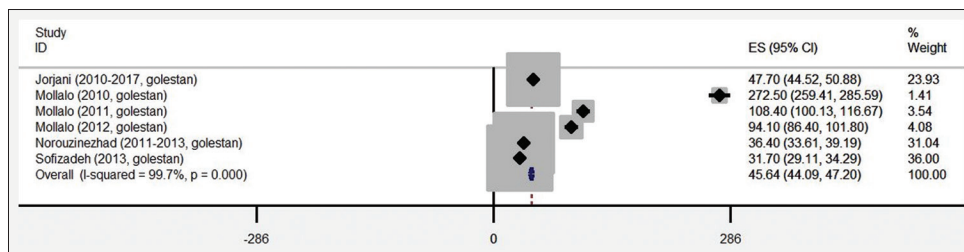


Figure 2: Forest plot of leishmaniasis prevalence per 100,000 population in coastal areas of the Caspian Sea east and west (climatic region 1) part of Iran

Between-studies heterogeneity was assessed using I^2 and Cochran's Q method and P values of 25%, 50%, and 75% that were considered low, moderate, and high heterogeneity respectively. Meta-regression was used to investigate factors potentially contributing to the between-study heterogeneity.

RESULTS

Descriptive results of eligible studies

Descriptive summary statistics were calculated to determine the total number of the population samples and the range of

Table 1: The Joanna Briggs Institute critical appraisal checklist for studies reporting prevalence data

Selected studies	1	2	3	4	5	6	7	8	9	Total score (%)
Jorjani (2019)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Mollalo (2015)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Sofizadeh (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Fekri (2018)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Zare (2001)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Dehghani (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Kassiri (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Kassiri (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Kassiri (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	7 (78)
Azimi (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Akhlagh (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Zohirnia (2009)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Hamzavi (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Ahmadi (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Roghani (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	6 (67)
Nikouee (2017)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Nazari (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Ahmadi (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Saghafipour (2012)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Hashemi (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Khajedaluae (2014)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Nilforoushzadeh (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8 (89)
Abdollahzadeh (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Doroodgar (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8 (89)
Doroodgar (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Shiravand (2018)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Abedi-Astaneh (2016)	Yes	yes	yes	yes	yes	yes	Yes	Yes	Unclear	8 (89)
Nateghi Rostami (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Sharifi (2011)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Razavinasab (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Elyasi (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Shirzadi (2020)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Shirzadi (2019)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Ramezankhani (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Shirzadi (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Athari (2006)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Heydarpour (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Holakouie Naieni (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Khazaei (2015)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	6 (76)
Piroozi (2019)	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	6 (67)
Ayubi (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)
Norouzinezhad (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Unclear	7 (78)

1 - Was the sample frame appropriate to address the target population?. 2 - Were study participants sampled in an appropriate way?. 3 - Was the sample size adequate?. 4 - Were the study subjects and the setting described in detail?. 5 - Was the data analysis conducted with sufficient coverage of the identified sample?. 6 - Were valid methods used for the identification of the condition?. 7 - Was the condition measured in a standard, reliable way for all participants?. 8 - Was there appropriate statistical analysis?. 9 - Was the response rate adequate, and if not, was the low response rate managed appropriately?

prevalence estimates [Table 2]. The flowchart of literature search is shown in Figure 1.

Meta-analysis

Random-effects meta-analysis was carried out using the total sample size and number of positive cases. Effect size (standard error [SE]) was used to estimate the prevalence of CL at the climatic regions. Variation in SE attributed to heterogeneity ($\pi^2 = 3e^{+3}$; heterogeneity $I = 100\%$ with heterogeneity Chi-square = $2.3e^{+4}$

a degree of freedom = 150 and $P < 0.001$). Individual studies showed that prevalence per 100,000 population estimates ranged from 1.5 to 318.7 with the overall random pooled prevalence of 83.3 (95% CI: 74.5–92.1). Studies weighted on individual studies varied from 0.26% to 0.67%. The forest plot aren't shown here.

Subgroup meta-analysis

Subgroup analysis was done for 6 climatic regions. Furthermore, meta-regression analysis was done for selected

variable groups such as sex ratio, age, and the year of study. Subgroup analysis by climatic regions showed that many studies were conducted in the desert areas and also, it has more prevalent than the other climatic regions. More results are shown in Figures 2-7. Based on the selected eligible studies, CL was reported in 6 climatic regions of Iran as (1) Coastal

areas of Caspian sea west, east and central part including 6 study reports, (2) Coastal areas of Persian Gulf and Oman sea east part including 3 study reports, (3) Coastal areas of Persian Gulf and Oman sea west part including 7 study reports, (4) Mountains and high areas of central plateau part including 18 study reports, (5) Foothills of the central plateau

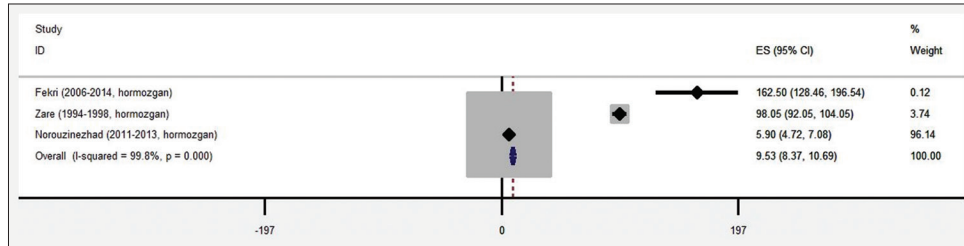


Figure 3: Forest plot of leishmaniasis prevalence per 100,000 population in Persian Gulf and Oman Sea east (climatic region 2) part of Iran

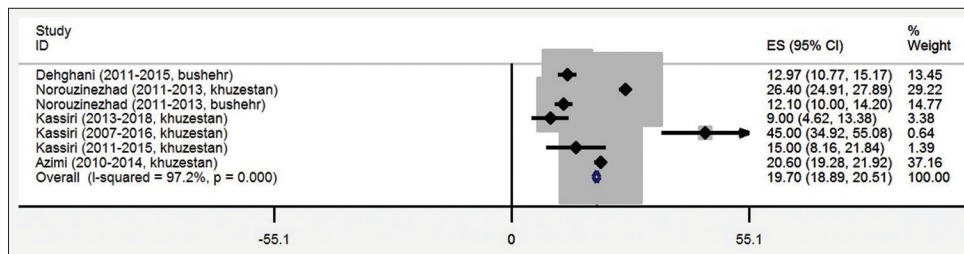


Figure 4: Forest plot of leishmaniasis prevalence per 100,000 population in Persian Gulf and Oman sea West (climatic region 3) part of Iran

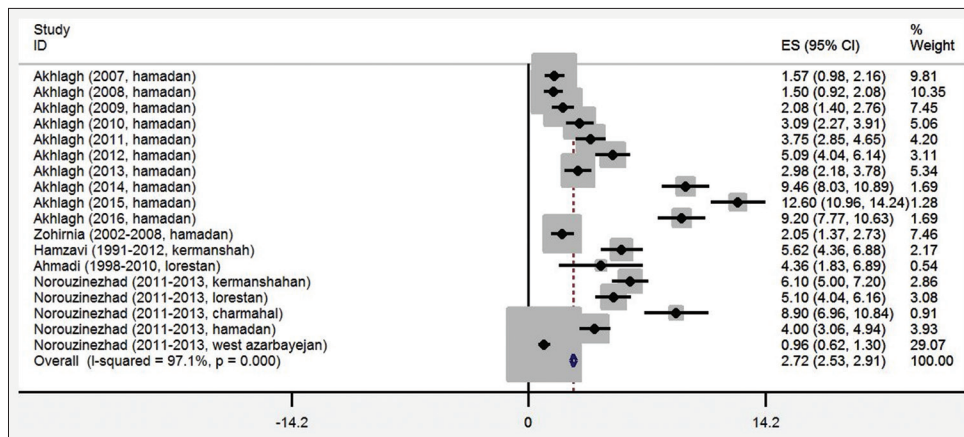


Figure 5: Forest plot of leishmaniasis prevalence Per 100,000 population in mountains and high areas of central plateau (climatic region 4) of Iran

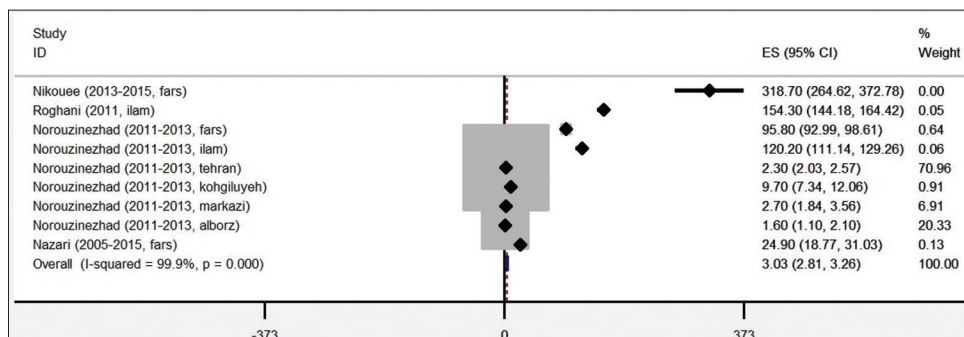


Figure 6: Forest plot of leishmaniasis prevalence per 100,000 population in Foothills of the Central plateau (climatic region 5) of Iran

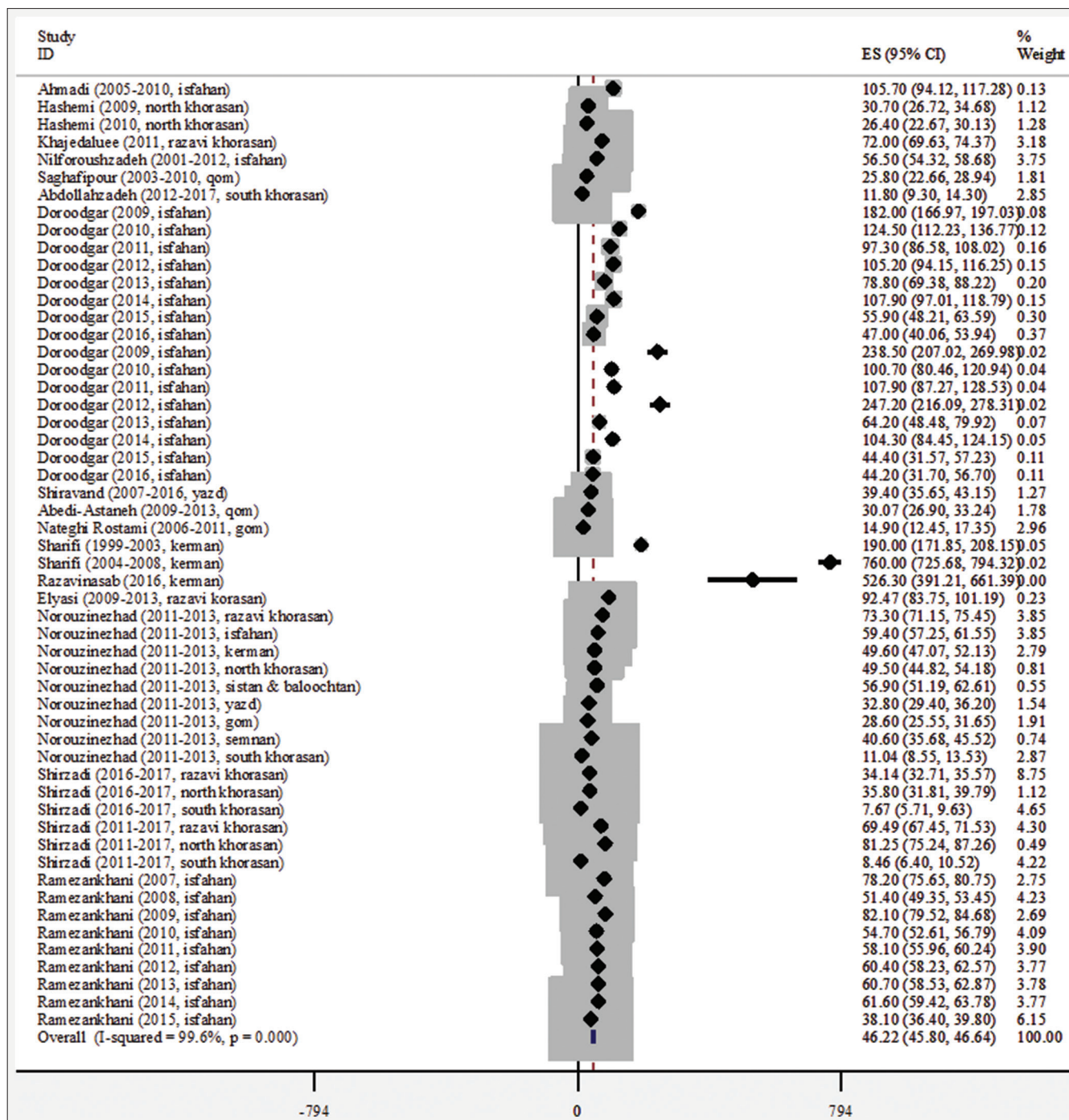


Figure 7: Forest plot of leishmaniasis prevalence per 100,000 population in desert areas (climatic region 6) of Iran

part including 9 study reports, and (6) Desert areas including 54 study reports. Forest plots of CL prevalence (95% CI) per 100,000 population were 45.6 (44.1–47.2), 9.5 (8.4–10.7), 19.7 (18.9–20.5), 2.7 (2.5–2.9), 3.1 (2.8–3.3), and 46.2 (45.8–46.6), respectively, in climatic regions 1–6 [Figures 2–8].

There were 53 reports from the total regions of Iran. The forest plot showed that the prevalence of CL per 100,000 population was 57.5 (57.4–57.6) [Figure 9].

Meta-regression

Meta-regression was done for age means, sex ratio (female/male), and the study year. The study year was not significantly associated with the prevalence of CL in the final multiple meta-regression ($P = 0.762$). The results showed that the sex ratio had a positive correlation with the prevalence of CL ($P = 0.039$). Furthermore, the higher mean age significantly had less CL prevalence ($P = 0.033$).

Biases in the review

We found no specific bias in this review process.

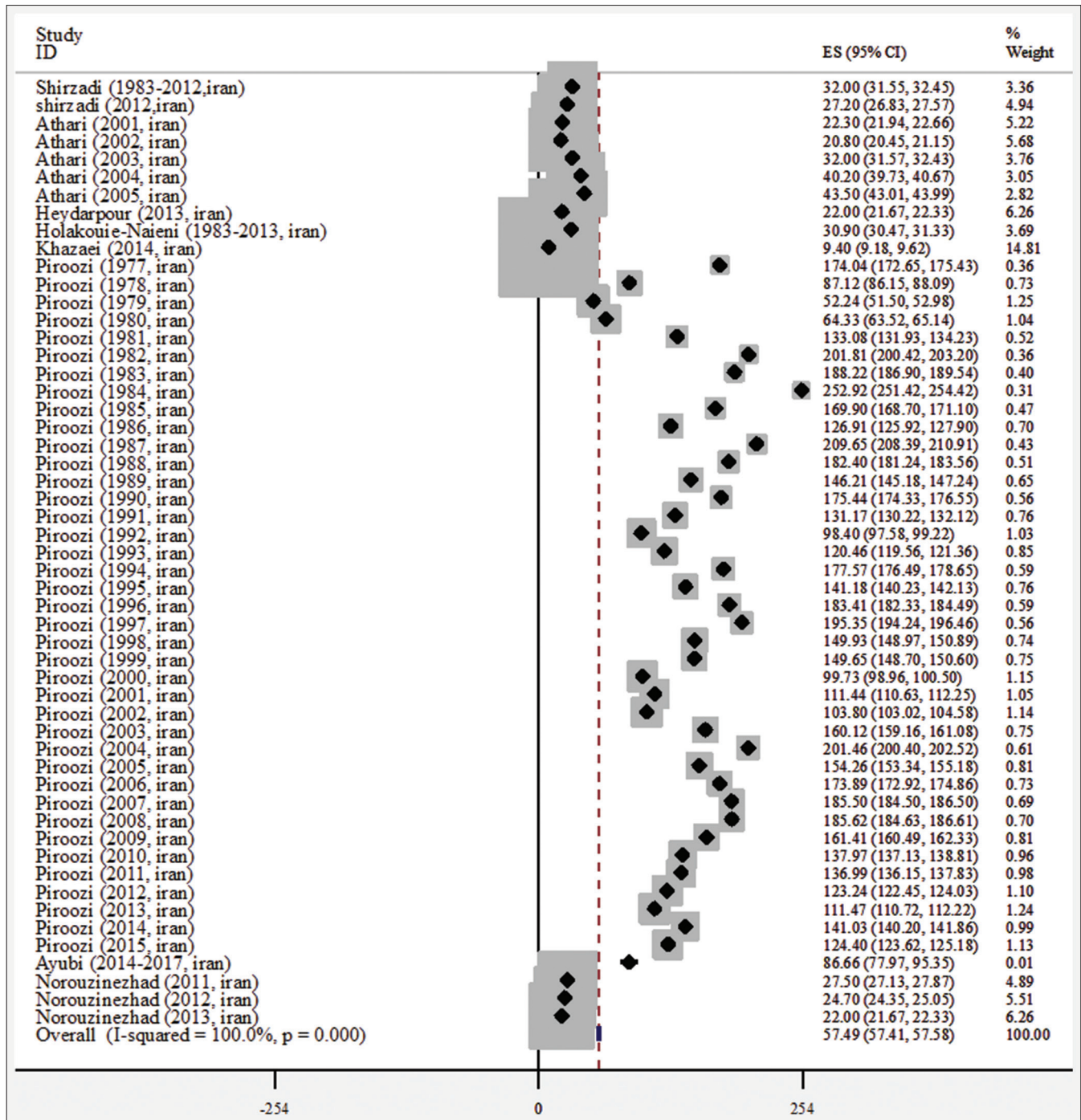


Figure 8: Spatial geographic distribution of climatic regions of Iran

DISCUSSION

According to our knowledge, this is the first systematic review and meta-analysis on the prevalence of CL based on climatic regions of Iran. The final descriptive results and meta-analysis of the prevalence were done on 42 selected articles in humans. The results of the meta-analysis showed high variability between studies using Higgin's I^2 . Because of the considerable variability between studies, the random-effects meta-analysis was used. It was demonstrated that pooled prevalence of CL

was 85/100,000 in Iran which it was most prominently occurred in regions with dry and desert climates. Leishmaniasis was more prevalent (46.2/00,000) in these regions than in the other climatic regions. Most cases in these regions were observed in the provinces of southern Khorasan, Khorasan-e-Razavi, northern Khorasan, Sistan and Baluchestan, Semnan, Isfahan, Qom, and Yazd.^[24-29] According to the current study, it was highly prevalent in the desert area, coastal areas of Caspian sea east, Persian Gulf and Oman sea west, and Persian Gulf and Oman sea east, respectively.

Table 2. Descriptive statistics of included in the final systematic review and meta-analysis

References	Author (publication time)	Date of study	Age, mean \pm SD	Gender proportion (female/male)	Study location	Climatic regions	Diagnosis method	Annual average prevalence (per 100,000)	Number of positive	Sample size	Quality assessment score (%)
[5]	Jorjani <i>et al.</i> (2019)	2010-2017	20.7 \pm 16.9	0.76	Golestan	1	Unclear	47.7	6873	1,813,091	67
[34]	Mollalo <i>et al.</i> (2015)	2010-2012	19.3 \pm 14.4	0.69	Golestan	1	Laboratory	158.3	2893	609,053	67
[35]	Sofizadeh <i>et al.</i> (2016)	2013	18.8 \pm 25.3	0.66	Golestan	1	Unclear	31.7	573	1,813,091	78
[20]	Fekri <i>et al.</i> (2018)	2006-2014	18.6 \pm 17.1	0.82	Hormozgan (Jask)	2	Unclear	162.5	874	53,770	67
[36]	Zare S and Baghestani (2001)	1994-1998	14.5 \pm 14.7	0.74	Hormozgan	2	Clinical laboratory	98.05	4094	1,043,855	78
[21]	Delghani <i>et al.</i> (2019)	2011-2015	21.9 \pm 17	0.68	Bushehr	3	Unclear	12.97	663	1,032,949	78
[37]	Kassiri and Mehr-Aghaei (2018)	2013-2018	24.9 \pm 16.3	0.72	Khuzestan (karun)	3	Laboratory	9	81	180,000	78
[38]	Kassiri <i>et al.</i> (2018)	2007-2016	14.1 \pm 22.4	0.93	Khuzestan (Khorramshahr)	3	Laboratory	45	745	170,000	78
[39]	Kassiri <i>et al.</i> (2018)	2011-2015	25.6 \pm 17.6	0.83	Khuzestan (Abadan)	3	Laboratory	15	179	123,000	78
[40]	Azimi <i>et al.</i> (2017)	2010-2014	-	-	Khuzestan	3	Unclear	20.6	4672	4,531,720	78
[18]	Akhlagh <i>et al.</i> (2019)	2007-2016	34.4 \pm 13.2	0.06	Hamedan	4	Laboratory	5.1	908	1,764,087	78
[41]	Zohrnia <i>et al.</i> (2009)	2002-2008	28.7 \pm 11.7	0.07	Hamedan	4	Clinical laboratory	2.05	210	1,707,317	78
[42]	Hamzavi and Khademi (2015)	1990-2012	37.3 \pm 19.3	0.75	Kermanshah	4	Laboratory	5.62	1684	1,362,018	67
[43]	Ahmadi <i>et al.</i> (2013)	1998-2010	18.8 \pm 10.2	0.09	Lorestan (Borujerd)	4	Laboratory	4.36	137	261,850	78
[7]	Roghani <i>et al.</i> (2013)	2011	-	0.56	Ilam	5	Unclear	154.3	891	577,599	67
[6]	Nikouee <i>et al.</i> (2017)	2013-2015	11.3 \pm 17.2	1.37	Fars (Zarindasht)	5	Unclear	318.7	266	41,729	67
[44]	Nazari <i>et al.</i> (2017)	2005-2015	15.7 \pm 24.1	0.78	Fars	5	Unclear	24.9	700	254,704	78
[45]	Ahmadi <i>et al.</i> (2013)	2005-2010	24.8 \pm 18.1	0.82	Kashan	6	Clinical laboratory	105.7	1599	302,637	78
[26]	Saghafipour <i>et al.</i> (2012)	2003-2009	-	0.73	Qom	6	Clinical laboratory	25.8	1812	1,003,322	78
[24]	Hashemi <i>et al.</i> (2011)	2009-2010	-	0.66	North Khorasan	6	Clinical laboratory	28.3	485	855,957	78
[25]	Khajehdalavi <i>et al.</i> (2014)	2011	25.3 \pm 17.8	0.92	Razavi Khorasan	6	Laboratory	72	3558	4,929,471	78
[46]	Nilforoushzhadeh <i>et al.</i> (2015)	2001-2012	21.9 \pm 0.94	1.62	Isfahan	6	Laboratory	56.5	28,315	4,559,256	89
[47]	Abdollahzadeh <i>et al.</i> (2018)	2012-2017	26.9 \pm 17.7	0.61	South Khorasan	6	Clinical laboratory	11.8	426	724,391	78
[12]	Doroodgar (2018)	2009-2016	32.9 \pm 20.3	0.72	Kashan	6	Laboratory	100.9	2676	331,352	89
[48]	Doroodgar (2019)	2009-2016	27.9 \pm 20.7	0.71	Aran va Bidgol	6	Laboratory	118.9	926	97,330	78
[49]	Shiravand <i>et al.</i> (2018)	2007-2016	31.2 \pm 19.3	-	Yazd	6	Unclear	39.4	4229	1,074,428	67
[50]	Abedi-Astaneh <i>et al.</i> (2016)	2009-2013	-	0.54	Qom	6	Laboratory	30.07	1767	1,151,672	89
[29]	Nateghi Rostami <i>et al.</i> (2013)	2006-2011	28.7 \pm 18.3	0.69	Qom	6	Laboratory	14.9	849	949,664	78
[51]	Sharifi <i>et al.</i> (2011)	1999-2008	15.5 \pm 16.7	0.96	Kerman (Bam)	6	Laboratory	475	11,448	241,011	78
[52]	Razavinasab (2019)	2016	-	1.52	Kerman	6	Laboratory	526.3	58	11,021	78
[53]	Elyasi (2017)	2009-2013	31.1 \pm 20.5	0.76	Razavi Khorasan	6	Clinical laboratory	92.47	2158	466,740	78
[54]	Shirzadi <i>et al.</i> (2020)	2016-2017	-	-	Khorasan	6	Unclear	25.66	2565	8,066,491	67
[55]	Shirzadi <i>et al.</i> (2019)	2011-2017	-	-	Khorasan	6	Clinical laboratory	53.07	31,036	8,066,491	67
[56]	Ramezankhani <i>et al.</i> (2018)	2007-2015	-	-	Isfahan	6	Clinical laboratory	60.4	26,347	48,632,767	78
[57]	Shirzadi <i>et al.</i> (2015)	1983-2012	-	-	Iran	7	Laboratory	32	566,532	60,055,488	78
[58]	Athari and Jalal Lu (2006)	2001-2005	-	0.72	Iran	7	Laboratory	31.8	107,097	67,256,250	78
[59]	Heydarpour <i>et al.</i> (2016)	2013	-	0.78	Iran	7	Unclear	22	16,980	76,945,000	78

Table 2: Contd...

References	Author (publication time)	Date of study	Age, mean±SD	Gender proportion (female/male)	Study location	Climatic regions	Diagnosis method	Annual average prevalence (per 100,000)	Number of positive	Sample size	Quality assessment score (%)
[27]	Holakouie Natiemi et al.(2017)	1983-2013	-	-	Iran	7	Clinical laboratory	30.9	589,913	63,636,785	78
[28]	Khazaee et al.(2015)	2014	31.4±22.1	0.81	Iran	7	clinical laboratory	9.4	3684	77,800,000	67
[60]	Piroozi et al.(2019)	1977-2015	-	-	Iran	7	Unclear	149.3	3,427,583	58,855,560	67
[61]	Ayubi et al.(2018)	2014-2017	-	-	Iranian army units	7	Unclear	86.66	1144	440,000	78
[62]	Norouzzehad et al.(2016)	2011-2013	28.1±17.4	0.77	Iran	7	Laboratory	24.7	56,546	76,072,338	78

Climatic regions: 1. Coastal areas of Caspian Sea, East, and West part, 2. Coastal areas of the Persian Gulf and Oman Sea, East part, 3. Coastal areas of the Persian Gulf and Oman Sea, West part, 4. Mountains and high areas of central plateau part, 5. Foothills of the central plateau part, 6. Desert areas part, 7. All climates. SD: Standard deviation

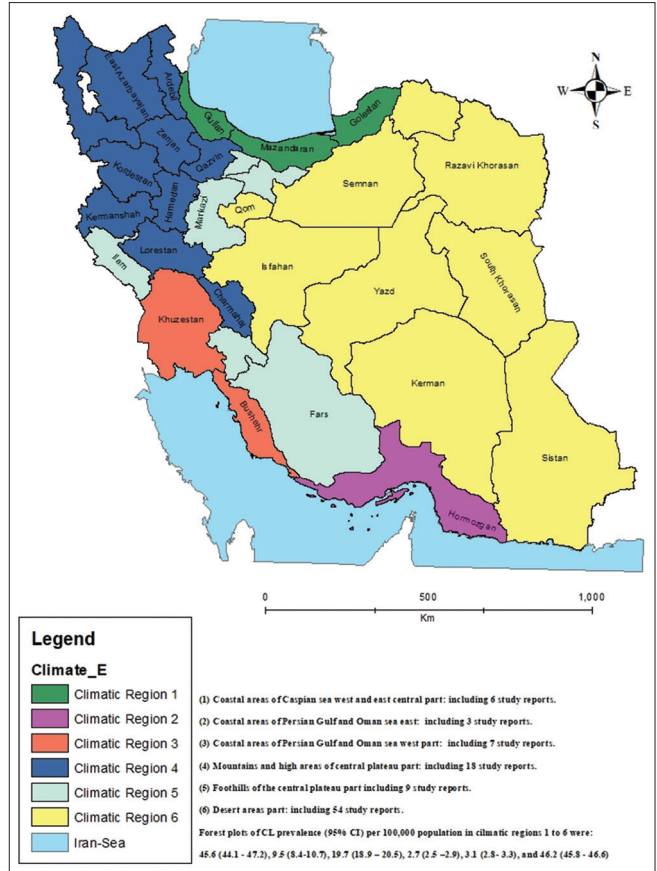


Figure 9: Forest plot of leishmaniasis prevalence per 100,000 population in Iran

A systematic review and meta-analysis was done by Sabzevari et al. on CL in Iran from 2000 to 2019 in which 84 studies were selected. Using random-effect model, the pooled prevalence was estimated about 45/100,000 population. The prevalence was calculated based on both *Leishmania tropica* and *Leishmania major* species were caused by anthroponotic CL and zoonotic CL (ZCL), respectively.^[30] In another systematic review and meta-analysis of CL which was conducted by Panahi et al. in Iran from 2000 to 2016 including 44 selected studies, the pooled prevalence was 77 per 100,000 population based on both *L. tropica* and *L. major* species.^[31] In contrast, the current study prevalence is calculated based on only ZCL. However, the effects of climatic factors on the occurrence of ZCL were similar to CL incidence in previous studies. Therefore, depending on the various *Leishmania* species, the variability of the climate factors may have different impacts on the occurrence of CL.^[32] In a systematic review and meta-analysis of leishmaniasis that was performed in Ethiopia, the overall estimated prevalence was 19.1% in both humans and animals. It was highly prevalent in the northern and southern parts of the country.^[33] Mohammadbeigi et al. in their systematic review study concluded that leishmaniasis is a climate-sensitive disease, and changes in environmental factors such as temperature, rainfall, and humidity can impact the epidemiology of the

disease with the changes they make on population size, distribution, and the survival of sandflies.^[32]

The current study revealed a higher prevalence of CL in females than males. These results were inconsistent with those which were reported by Sabzevari *et al.*^[30] This study demonstrated that there has been an increase in the number and also the quality of works in recent years.

CONCLUSION

The prevalence of CL in this study that was estimated based on climatic regions showed that it was highly prevalent in Iran. One of the advantages of this work is that majority of selected studies have been conducted on population base. However, disadvantages might be because of poor design of some studies or the lack of interval validity [Table 1]. Moreover, one of the major limitations in this study is that some of the study locations were nested in more than one climate condition. As a result, we considered a dominant climate condition for every province of Iran and then we assigned every climatic region for each province. Finally, we concluded that climatic factors impact on CL incidence and our results revealed that leishmaniasis was more prevalent in dry and arid regions. Therefore, it should be noted that a unified strategy cannot be applied to the whole country, and control programs should be used according to climate change in each region.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- WHO. A Human Rights-Based Approach to Neglected Tropical Diseases. Geneva: WHO; 2012. Available from: http://www.who.ira.neglected-diseases/human-rightsapproach-TO-NTD_Eng-ok.pdf. Accessed in 17 November 2021.
- Mozafari O, Sofizadeh A, Shoraka HR. Distribution of leishmania infection in humans, animal reservoir hosts and sandflies in Golestan Province, Northeastern Iran: A systematic review and meta-analysis. *Iran J Public Health* 2020;49:2308-19.
- Inceboz T. Epidemiology and Ecology of Leishmaniasis. Books on Demand, 2019, London. Available from: <http://ijph.tums.ac.ir>. Accessed in 17 November 2021.
- WHO. Leishmaniasis. Geneva, Switzerland: WHO; 2019. Available from: <http://www.who.int/news-room/factsheets/detail/Leishmaniasis>. Accessed in 17 November 2021.
- Jorjani O, Mirkarimi K, Charkazi A, Shahamat YD, Mehrbakhsh Z, Bagheri A. The epidemiology of cutaneous leishmaniasis in Golestan Province, Iran: A cross-sectional study of 8-years. *Parasite Epidemiol Control* 2019;5:e00099.
- Nikouee F, Soltanian M, Babae F, Motamed-Jahromi M. Cutaneous leishmaniasis: An epidemiological survey in Iran during 2013-2015. *J Nurs Midwifery Sci* 2017;4:58-62.
- Roghani AR, Yasemi M, Jalilian M, Abdi J, Rezai Tavirani K. Epidemiology of cutaneous leishmaniasis in Ilam province. *Res Med* 2013;36:50-3.
- Shoraka HR, Taheri Soodejani M, Allah Kalteh E, Chegeni M, Mahmudimanesh M, Sofizadeh A. Prevalence of leishmania major Yakimoff and Schokhor (Kinetoplastida: Trypanosomatidae) in sandflies in Iran: A systematic review and meta-analysis. *J Med Entomol* 2021;58:26-36.
- Postigo JA. Leishmaniasis in the World Health Organization Eastern Mediterranean region. *Int J Antimicrob Agents* 2010;36 Suppl 1:S62-5.
- Sabzevari S, Mohebbali M, Hashemi A. Cutaneous and visceral leishmaniasis: Parasites, vectors and reservoir hosts in endemic foci of North Khorasan, Northeastern Iran – A narrative review. *J Med Microbiol Infect Dis* 2020;8:40-4.
- Kone AK, Niare DS, Thera MA, Kayentao K, Djimde A, Delaunay P, *et al.* Epidemiology of the outbreak, vectors and reservoirs of cutaneous leishmaniasis in Mali: A systematic review and meta-analysis. *Asian Pac J Trop Med* 2016;9:985-90.
- Doroodgar M, Doroodgar M, Mahboobi S, Doroodgar A. Epidemiological aspects of cutaneous leishmaniasis during 2009-2016 in Kashan city, Central Iran. *Korean J Parasitol* 2018;56:21-4.
- Pavli A, Maltezou HC. Leishmaniasis, an emerging infection in travelers. *Int J Infect Dis* 2010;14:e1032-9.
- Soltani S, Foroutan M, Hezarian M, Afshari H, Kahvaz MS. Cutaneous leishmaniasis: An epidemiological study in southwest of Iran. *J Parasit Dis* 2019;43:190-7.
- Riyad M, Chiheb S, Soussi-Abdallaoui M. Cutaneous leishmaniasis caused by leishmania major in Morocco: Still a topical question. *East Mediterr Health J* 2013;19:495-501.
- World Health Organization. Investing to Overcome the Global Impact of Neglected Tropical Diseases: Third WHO Report on Neglected Tropical Diseases 2015. Geneva, Switzerland: World Health Organization; 2015.
- Moradzadeh R, Golmohammadi P, Ashraf H, Nadrian H, Fakoorziba MR. Effectiveness of paromomycin on cutaneous leishmaniasis in Iran: A systematic review and meta-analysis. *Iran J Med Sci* 2019;44:185-95.
- Akhlagh A, Salehzadeh A, Zahirmia AH, Davari B. 10-year trends in epidemiology, diagnosis, and treatment of cutaneous leishmaniasis in Hamadan province, West of Iran (2007-2016). *Front Public Health* 2019;7:27.
- Fattahi Bafghi A, Eftekhari M, Ahmadi S, Moghateli M. Epidemiological pattern of cutaneous leishmaniasis in the province of Fars, Iran (since 2010-2014). *J Community Health Res* 2016;5:240-8.
- Fekri S, Hanafi-Bojd AA, Salari Y, Davoodian P, Safari R, Dadvand H, *et al.* Situational analysis of cutaneous leishmaniasis in an endemic focus of the disease, Southeastern Iran. *J Arthropod Borne Dis* 2018;12:76-84.
- Dehghani A, Lotfi MH, Falahzadeh H, Vahdat K, Shabani Z. Epidemiological study and spatial modeling of cutaneous leishmaniasis in Bushehr province Using the Geographic Information System (GIS) during 2011-2015. *J Community Health Res* 2019;8:156-63.
- González C, Wang O, Strutz SE, González-Salazar C, Sánchez-Cordero V, Sarkar S. Climate change and risk of leishmaniasis in North America: Predictions from ecological niche models of vector and reservoir species. *PLoS Negl Trop Dis* 2010;4:e585.
- Koch LK, Kochmann J, Klimpel S, Cunze S. Modeling the climatic suitability of leishmaniasis vector species in Europe. *Sci Rep* 2017;7:13325.
- Hashemi N, Hejazi SH, Hashemi M. Epidemiology of cutaneous leishmaniasis in North Khorasan province during 2009-2010. *J North Khorasan Univ Med Sci* 2011;3:101-5.
- Khajehdalavi M, Yazdanpanah MJ, Seyednozadi SM, Fati A, Joya MR, Masoudi MH, *et al.* Epidemiology of cutaneous leishmaniasis in Khorasan Razavi province in 2011. *Med J Mashhad Univ Med Sci* 2014;57:647-54.
- Saghafipour A, Akbari A, Rasi Y, Mostafavi R. Epidemiology of cutaneous leishmaniasis in Qom province, Iran, during 2003-2009. *Qom Univ Med Sci J* 2012;6:83-8.
- Holakouie-Naieni K, Mostafavi E, Bolorani AD, Mohebbali M, Pakzad R. Spatial modeling of cutaneous leishmaniasis in Iran from 1983 to 2013. *Acta Trop* 2017;166:67-73.
- Khazaei S, Mohammadian Hafshejani A, Saatchi M, Salehiniya H, Nematollahi S. Epidemiological aspects of cutaneous leishmaniasis in Iran. *Arch Clin Infect Dis* 2015;10:e28511.
- Nateghi Rostami M, Saghafipour A, Vesali E. A newly emerged cutaneous leishmaniasis focus in central Iran. *Int J Infect Dis* 2013;17:e1198-206.
- Sabzevari S, Teshnizi SH, Shokri A, Bahrami F, Kouhestani F. Cutaneous leishmaniasis in Iran: A systematic review and meta-analysis. *Microb*

- Pathog 2021;152:104721.
31. Panahi S, Abbasi M, Sayehmiri K, Safaripour S, Abdi J. Prevalence of cutaneous leishmaniasis in Iran (2000-2016): A systematic review and meta-analysis study. *Infect Disord Drug Targets* 2021;21:173-9.
 32. Mohammadbeigi A, Khazaei S, Heidari H, Asgarian A, Arsanjani S, Saghafipour A, *et al.* An investigation of the effects of environmental and ecologic factors on cutaneous leishmaniasis in the old world: A systematic review study. *Rev Environ Health* 2021;36:117-28.
 33. Assefa A. Leishmaniasis in Ethiopia: A systematic review and meta-analysis of prevalence in animals and humans. *Heliyon* 2018;4:e00723.
 34. Mollalo A, Alimohammadi A, Shirzadi M, Malek M. Geographic information system-based analysis of the spatial and spatio-temporal distribution of zoonotic cutaneous leishmaniasis in Golestan Province, north-east of Iran. *Zoonoses Public Health* 2015;62:18-28.
 35. Sofizadeh A, Vatandoost H, Rassi Y, Hanafi-Bojd AA, Rafizadeh S. Spatial analyses of the relation between rodent's active burrows and incidence of zoonotic cutaneous leishmaniasis in Golestan province, Northeastern of Iran. *J Arthropod Borne Dis* 2016;10:569-76.
 36. Zare S, Baghestani S. Cutaneous leishmaniasis in Hormozgan, Iran. *Int J Dermatol* 2001;40:629-31.
 37. Kassiri H, Mehr-Aghaei M. First report on various aspects of a focus of cutaneous leishmaniasis in Southwestern Iran. *Entomol Appl Sci Lett* 2018;5:103-11.
 38. Kassiri H, Najafi S, Kazemi S, Lotfi M. Ten years investigation on situation analysis of cutaneous leishmaniasis in an endemic area, Southwestern Iran. *Entomol Appl Sci Lett* 2018;5:27-34.
 39. Kassiri H, Farhadinejad R, Lotfi M. Survey on epidemiological status and incidence rate of cutaneous leishmaniasis in Abadan County, Khuzestan Province, southwestern Iran. *Entomol Appl Sci Lett* 2018;5:62-9.
 40. Azimi F, Shirian S, Jangjoo S, Ai A, Abbasi T. Impact of climate variability on the occurrence of cutaneous leishmaniasis in Khuzestan Province, Southwestern Iran. *Geospat Health* 2017;12:478.
 41. Zohirnia AH, Moradi AR, Nourouzi NA, Bathaei SJ, Erfani H, Moradi A. Epidemiological survey of cutaneous leishmaniasis in Hamadan province (2002-2008). *Sci J Hamadan Univ Med Sci Health Serv* 2009;16:43-7.
 42. Hamzavi Y, Khademi N. Trend of cutaneous leishmaniasis in Kermanshah province, west of Iran from 1990 to 2012. *Iran J Parasitol* 2015;10:78-86.
 43. Ahmadi NA, Modiri M, Mamdohi S. First survey of cutaneous leishmaniasis in Borujerd county, western Islamic Republic of Iran. *East Mediterr Health J* 2013;19:847-53.
 44. Nazari M, Nazari S, Hanafi-Bojd AA, Najafi A, Nazari S. Situation analysis of cutaneous leishmaniasis in an endemic area, south of Iran. *Asian Pac J Trop Med* 2017;10:92-7.
 45. Ahmadi N, Ghafarzadeh M, Jalali Galosang A, Hjolami Parizad E. Evaluation of epidemiological status of cutaneous leishmaniasis with emphasis on its incidence in Kashan. *Sci J Ilam Univ Med Sci* 2013;21:1-9.
 46. Nilforoushzadeh M, Shirani-Bidabadi L, Hosseini S, Fadaei-Nobari R, Jaffary F. The epidemiology of cutaneous leishmaniasis in Isfahan province, Iran, during 2001-2011. *J Isfahan Med Sch* 2015;32:2241-51.
 47. Abdollahzadeh R, Shayesteh M, Khoubfekr H, Jamavar MR, Dastgardi E, Sarbishgi Moghadam M. Epidemiology of cutaneous leishmaniasis and factors affecting it in south Khorasan province, 2012-2016. *Pars J Med Sci* 2018;16:59-66.
 48. Moein D, Masoud D, Mahmood N, Abbas D. Epidemiological trend of cutaneous leishmaniasis in an endemic focus disease during 2009-2016, Central Iran. *Turk Parazitol Derg* 2019;43:55-9.
 49. Shirvand B, Tafti AA, Hanafi-Bojd AA, Almodaresi SA, Mirzaei M, Abai MR. Modeling spatial risk of zoonotic cutaneous leishmaniasis in Central Iran. *Acta Trop* 2018;185:327-35.
 50. Abedi-Astaneh F, Hajjaran H, Yaghoobi-Ershadi MR, Hanafi-Bojd AA, Mohebbali M, Shirzadi MR, *et al.* Risk mapping and situational analysis of cutaneous leishmaniasis in an endemic area of Central Iran: A GIS-based survey. *PLoS One* 2016;11:e0161317.
 51. Sharifi I, Nakhaei N, Aflatoonian M, Parizi MH, Fekri A, Safizadeh H, *et al.* Cutaneous leishmaniasis in bam: A comparative evaluation of pre- and post-earthquake years (1999-2008). *Iran J Public Health* 2011;40:49-56.
 52. Razavinasab SZ, Sharifi I, Aflatoonian MR, Babaei Z, Mohammadi MA, Salarkia E, *et al.* Expansion of urban cutaneous leishmaniasis into rural areas of southeastern Iran: Clinical, epidemiological and phylogenetic profiles explored using 7SL high resolution melting-PCR analysis. *Transbound Emerg Dis* 2019;66:1602-10.
 53. Elyasi H, Masoudyar E, Salouri S. Epidemiological of cutaneous leishmaniasis in Sabzevar (IRAN) from 2009-2013. *Pharmacophore* 2017;8:66-71.
 54. Shirzadi MR, Javanbakht M, Vatandoost H, Jesri N, Saghafipour A, Fouladi-Fard R, *et al.* Impact of environmental and climate factors on spatial distribution of cutaneous leishmaniasis in northeastern Iran: Utilizing remote sensing. *J Arthropod Borne Dis* 2020;14:56-67.
 55. Shirzadi MR, Javanbakht M, Jesri N, Saghafipour A. Spatial distribution of cutaneous leishmaniasis cases referred to health centers of three Khorasan provinces in Iran using geographical information system. *Iran J Public Health* 2019;48:1885-92.
 56. Ramezankhani R, Sajjadi N, Nezakati Esmaeilzadeh R, Jozi SA, Shirzadi MR. Climate and environmental factors affecting the incidence of cutaneous leishmaniasis in Isfahan, Iran. *Environ Sci Pollut Res Int* 2018;25:11516-26.
 57. Shirzadi MR, Esfahania SB, Mohebbalia M, Ershadia MR, Gharachorlo F, Razavia MR, *et al.* Epidemiological status of leishmaniasis in the Islamic Republic of Iran, 1983-2012. *East Mediterr Health J* 2015;21:736-42.
 58. Athari A, Jalal Lu N. Five-year epidemiological study of cutaneous leishmaniasis in Iran (2001-2005). *J Isfahan Med Sch* 2006;24:8-13.
 59. Heydarpour F, Sari AA, Mohebbali M, Shirzadi M, Bokaie S. Incidence and disability-adjusted life years (Dalys) attributable to leishmaniasis in Iran, 2013. *Ethiop J Health Sci* 2016;26:381-8.
 60. Piroozi B, Moradi G, Alinia C, Mohamadi P, Gouya MM, Nabavi M, *et al.* Incidence, burden, and trend of cutaneous leishmaniasis over four decades in Iran. *Iran J Public Health* 2019;48 Suppl 1:28-35.
 61. Ayubi E, Barati M, Dabbagh Moghaddam A, Reza Khoshdel A. Spatial modeling of cutaneous leishmaniasis in Iranian army units during 2014-2017 using a hierarchical Bayesian method and the spatial scan statistic. *Epidemiol Health* 2018;40:e2018032.
 62. Norouzinezhad F, Ghaffari F, Norouzinejad A, Kaveh F, Gouya MM. Cutaneous leishmaniasis in Iran: Results from an epidemiological study in urban and rural provinces. *Asian Pac J Trop Biomed* 2016;6:614-9.