



Contents lists available at ScienceDirect

## Journal of Ayurveda and Integrative Medicine

journal homepage: <http://elsevier.com/locate/jaim>

## Original Research Article

## Scientometric analysis of medicinal leech therapy

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## ARTICLE INFO

## Article history:

Received 3 April 2018

Received in revised form

28 October 2018

Accepted 15 November 2018

Available online xxx

## Keywords:

Hirudotherapy

Leech therapy

Medicinal leech therapy

Bibliometrics

Scientometrics

Publication trend analysis

## ABSTRACT

**Background:** Hirudotherapy, also known as medicinal leech therapy, has been used to treat a wide range of disorders for thousands of years since Ancient Egypt. Leech therapy is also mentioned as a minimal invasive technique called *Jalaukavacharana* in the *Sushruta Samhita*, an ancient Sanskrit text of Ayurvedic medicine. Although hirudotherapy has become a popular component of complementary medicine in the last decade, scientometric studies investigating the articles published in this field, do not exist.

**Objective:** In this study, we aimed to perform a detailed scientometric analysis of hirudotherapy literature. **Materials and methods:** We collected data by using four databases provided by Web of Science using the keywords “hirudotherapy”, “leech therapy”, “medicinal leech” and “medicinal leech therapy”.

**Results:** A total of 834 articles were found of which 89.8% were original articles. USA was the leading country with 280 publications, followed by UK, Germany and France (128, 101 and 41 items, respectively). The most productive countries regarding hirudotherapy were the UK (1.93), Slovenia (1.44), and Israel (1.32). The peak publication year for hirudotherapy literature was 2011 with 41 papers.

**Conclusion:** To the best of our knowledge, our study was the first bibliometric and scientometric analysis in this field and we believe that multicenter studies and further searches from developing and least-developed countries are needed in hirudotherapy literature.

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## 1. Introduction

Hirudotherapy or medicinal leech therapy is a traditional, complementary and integrative treatment. The first application of this technique was painted in the hieroglyphics from the ancient Egypt over 3500 years ago [1]. Hirudotherapy was also mentioned in ancient historical documents of Arabic, Chinese, Greek and Roman medicine to treat conditions such as headache, hypertension, osteoarthritis and hemorrhoids [2]. Leech therapy is also an Ayurvedic procedure called *Jalaukavacharana* or *Jalauka* and documented in the *Sushruta Samhita*, an ancient Sanskrit text on medicine and surgery dated 2<sup>nd</sup> BC in India. *Jalaukavacharana* is a painless, minimal invasive technique of controlled bloodletting (*Raktamokshana*) [3]. *Acharya Sushruta*, a physician in ancient India, also known as “father of surgery” (7<sup>th</sup> or 6<sup>th</sup> century BC) stated that one who undergoes *Raktamokshana* periodically does not suffer

with *Sopha roga* (edema), *Twak roga* (skin diseases) and *Granthi roga* (diseases with nodules) [3]. In the last several decades, hirudotherapy has become a popular part of complementary medicine [4]. In recent studies more than 20 bioactive molecules having anti-inflammatory, analgesic, antimicrobial and anticoagulant properties were reported from medicinal leeches [5,6].

Scientometrics also known as “science of science”, is a term used for the evaluation and investigation of all aspects of scientific literature. Scientometric studies are more extensive than bibliometric researches that only analyze the documents in a certain literature [7]. Scientometric studies also examine the characteristics of the countries, organizations, and authors of the articles in the literature. To the best of our knowledge, this study is the first to investigate scientometric features of hirudotherapy literature.

## 2. Materials and methods

The data of this study was collected from four databases (Web of Science Core Collection, Korean Journal Database, Russian Science Citation Index and SciELO Citation Index) provided by Web of

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Peer review under responsibility of Transdisciplinary University, Bangalore.

<https://doi.org/10.1016/j.jaim.2018.11.006>

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Science (WoS) (Thomson Reuters, New York, USA). The keywords used were “hirudotherapy”, “leech therapy”, “medicinal leech” and “medicinal leech therapy”. Items published during the period of 1975–2017 were included. Documents published from England, Wales, Scotland and Northern Ireland were mentioned under the “UK” title, while publications from Germany, East Germany, West Germany and Federal Republic of Germany were united under “Germany” and “China” was used as the title for China and People’s Republic of China. The statistical analyses were performed using the SPSS (version 22.0, SPSS Inc., Chicago, IL, USA); licensed for Hitit University, Çorum, Turkey, while for the infographics showing world distribution density of hirudotherapy literature the Gunn-Map free resource was used [8]. Bibliometric networks showing usage density and relationships of the keywords in the documents

was generated, where the more used keywords formed the larger rings than the others with lower usage in network images. Related and connected keywords were placed close to each other with the same color and the VOSviewer software to create network images was used [9].

### 3. Results

#### 3.1. Number of published documents

A total of 834 items were retrieved, 304 of which were indexed in WoS Core Collection. The majority of the publications were original articles (89.8%), followed by case reports (20.98%) and reviews (18.7%) (Table 1). The USA ranked first on total publication

**Table 1**  
Types of publications, top research areas, authors, institutions and journals in hirudotherapy literature.<sup>a</sup>

|  | Number | % of 834 articles <sup>a</sup> |
|--|--------|--------------------------------|
| <b>Document types</b>                            |        |                                |
| Original article                                 | 749    | 89.8                           |
| Case report                                      | 175    | 20.98                          |
| Review   | 156    | 18.7                           |
| Meeting  | 74     | 8.87                           |
| Abstract   | 59     | 7.07                           |
| Letter   | 51     | 6.11                           |
| Editorial material                               | 35     | 4.2                            |
| Clinical Trial                                   | 15     | 1.8                            |
| Biography  | 5      | 0.6                            |
| Other/Unspecified                                | 245    | 29.27                          |
| <b>Research Areas</b>                            |        |                                |
| Zoology  | 438    | 52.52                          |
| Pharmacology/Pharmacy                            | 402    | 48.2                           |
| Biochemistry/Molecular Biology                   | 334    | 40.05                          |
| Cardiovascular System/Cardiology                 | 330    | 39.57                          |
| Food Science Technology                          | 285    | 34.17                          |
| Surgery  | 263    | 31.53                          |
| Hematology                                       | 231    | 27.7                           |
| Physiology                                       | 186    | 22.3                           |
| Infectious Diseases                              | 177    | 21.22                          |
| Pathology  | 177    | 21.22                          |
| <b>Authors</b>                                   |        |                                |
| Baskova IP                                       | 33     | 3.95                           |
| Salzet M   | 19     | 2.28                           |
| Whitaker IS                                      | 18     | 2.16                           |
| Zavalova LL                                      | 17     | 2.04                           |
| Michalsen A                                      | 15     | 1.8                            |
| Gasic GJ   | 14     | 1.68                           |
| Muller KJ  | 13     | 1.56                           |
| Gräf J   | 12     | 1.44                           |
| Lüdtke R   | 11     | 1.32                           |
| Siddall ME                                       | 33     | 3.95                           |
| <b>Institutions</b>                              |        |                                |
| Lomonosov Moscow State University (Russia)       | 27     | 3.24                           |
| University of Lille (France)                     | 26     | 3.12                           |
| Russian Academy of Sciences (Russia)             | 22     | 2.64                           |
| University of California System                  | 16     | 1.92                           |
| Commonwealth System of Higher Education (USA)    | 12     | 1.44                           |
| University of Pennsylvania (USA)                 | 12     | 1.44                           |
| University of Texas System (USA)                 | 12     | 1.44                           |
| National Centre for Scientific Research (France) | 11     | 1.32                           |
| Harvard University (USA)                         | 11     | 1.32                           |
| <b>Journals</b>                                  |        |                                |
| Microsurgery                                     | 22     | 2.64                           |
| Annals of Plastic Surgery                        | 21     | 2.52                           |
| Plastic and Reconstructive Surgery               | 16     | 1.92                           |
| Blood Coagulation & Fibrinolysis                 | 16     | 1.92                           |
| Journal of Reconstructive Microsurgery           | 14     | 1.68                           |
| British Journal of Plastic Surgery               | 12     | 1.44                           |
| British Journal of Oral Maxillofacial Surgery    | 12     | 1.44                           |
| Thrombosis and Hemostasis                        | 10     | 1.2                            |
| Brain Research                                   | 10     | 1.2                            |
| Thrombosis Research                              | 10     | 1.2                            |
| Total  | 834    | 100                            |

<sup>a</sup> Total percentage may exceed 100%; certain items were included in more than one category.

number with 280 documents followed by the UK, Germany, France, China, Russia, Canada, Turkey, India and Italy ( $n = 128, 101, 41, 38, 35, 34, 31, 30$  and  $28$  items, respectively). The USA dominated the hirudotherapy literature and covered 33.57% of all the world hirudotherapy literature (Fig. 1).

### 3.2. Productivity of the countries

A productivity score was given for each country publishing in hirudotherapy field, where the formula: production numbers/population  $\times 1,000,000$  was used to measure productivity scores as reported in the literature [10]. The current population data of the countries was retrieved from the United Nations Database [11]. The UK was the most productive country (productivity score = 1.93) followed by Slovenia, Israel, Switzerland, Germany, Bulgaria, Canada, the USA, Sweden and Belgium ( $s = 1.44, 1.32, 1.3, 1.23, 0.99, 0.93, 0.86, 0.71$  and  $0.7$ , respectively). The USA, the country that dominated the hirudotherapy literature with the total publication number (33.57) was eighth in this ranking ( $s = 0.86$ ).

### 3.3. Authors, journals and institutions

Zoology, pharmacology, biochemistry, cardiology and surgery were the most studied research areas (438, 402, 334, 330 and 285 items, respectively) (Table 1). English was the major language of the literature (93.28%). Russian, German and French were the most documented non-English languages (3.23, 2.52 and 1.68%, respectively). Baskova IP from the Lomonosov Moscow State University (Russia) was the most productive author in this field with 33 records. Lomonosov Moscow State University produced the highest number of hirudotherapy publications with 27 articles (Table 1).

The highest number of publications on hirudotherapy were in the journals *Microsurgery*, *Annals of Plastic Surgery*, *Plastic and Reconstructive Surgery* and *Blood Coagulation & Fibrinolysis* (22, 21, 16 and 16 items, respectively) (Table 1). The publications on hirudotherapy were cited 13,485 times (10,165 times without self-citations). Average citation per item was 16.17 and calculated H-index for the literature was 54. A review titled *"The Genus Aeromonas: Taxonomy, Pathogenicity, and Infection"* by Janda JM and

Abbott SL published in 2010 in *Clinical Microbiology Reviews* was the most cited article in this field with 527 citations (Table 2).

### 3.4. Progression of the publications and citations

The peak publication year for hirudotherapy literature was 2011 with 41 items and no correlation was found between publication number and the year of publication. The increase in the number of publications in this area was quite irregular (Fig. 2). A significant correlation between publication year and the cumulative number of hirudotherapy was noted and the peak year of productivity was 2015 with 951 citations. A significant increase of the citations was detected after 2009 (Fig. 2).

### 3.5. Keyword analysis of the publications

A detailed keyword analysis by retrieving all the articles from WoS Core Collection database revealed that the most used keywords were "leech therapy", "leech", "leeches", "*Hirudo medicinalis*", "hirudin", "venous congestion", "hirudotherapy", "osteoarthritis", "medicinal leech" and "Unani medicine". A keyword network infographic generated by using most used keywords according to their frequency showed that the most connected keyword was "leech therapy" (Fig. 3). As we created a relationship network among countries publishing in this field, a linear network centering the USA was found. Connection network analysis of the institutions also revealed a linear pattern. Andreas Michalsen, one of the top productive authors, was the most connected author in the hirudotherapy field from Charité- Universitätsmedizin Berlin in Germany.

## 4. Discussion

The terms of "scientometrics" and "bibliometrics" are almost identical and can be used interchangeable. These are statistical analysis of academic literature investigating scientific features of the studied area such as authors, countries, keywords and publication trends. The first bibliometric study was performed by Campbell in 1896 and the term of "bibliometrics" was first used by

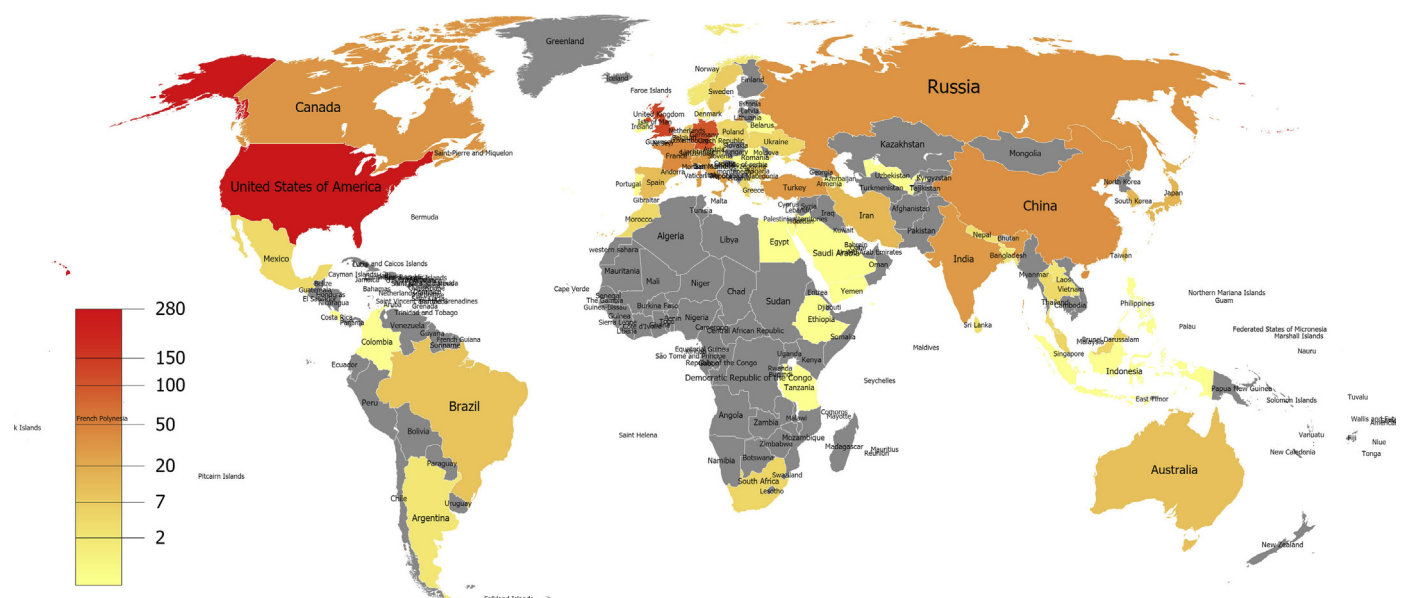


Fig. 1. Global hirudotherapy publication density according to the countries.

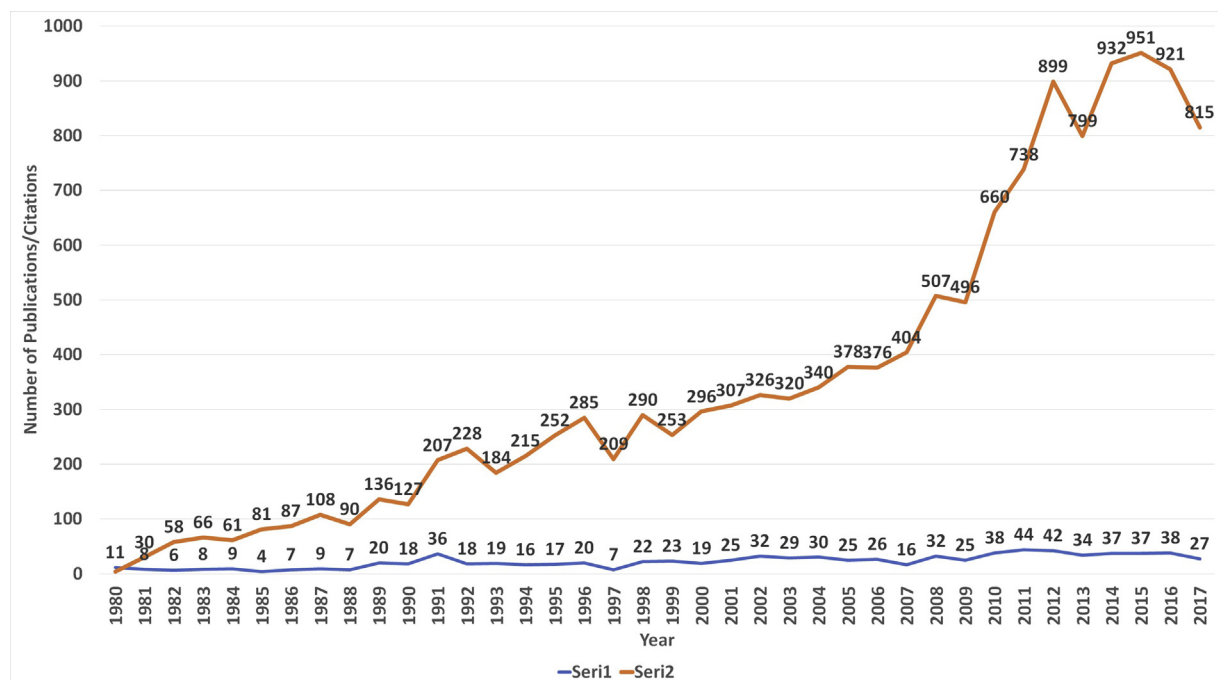
**Table 2**  
The 10 most cited manuscripts in the hirudotherapy literature.

| Article  | Author   | Journal Name                    | Total Citation | Average Citations per Year |
|--|--|---------------------------------|----------------|----------------------------|
| The Genus <i>Aeromonas</i> : Taxonomy, Pathogenicity, and Infection  | Janda, JM and Abbott, SL                       | Clinical Microbiology Reviews   | 527            | 58.56                      |
| Central pattern generators and the control of rhythmic movements   | Marder, E and Bucher, D                        | Current Biology                 | 357            | 19.83                      |
| Isolation and Characterization of Antistasin - An Inhibitor of Metastasis and Coagulation  | Tuszynski, GP; Gasic, TB; Gasic, GJ            | Journal of Biological Chemistry | 176            | 5.5                        |
| Anaphylactic and anaphylactoid reactions associated with lepirudin in patients with heparin-induced thrombocytopenia               | Greinacher, A; Lubenow, N; Eichler, P          | Circulation                     | 147            | 9.19                       |
| Embryonic-Cell Lineages in The Nervous-System of The Glossiphoniid Leech <i>Helobdella-Triserialis</i>                             | Weisblat, DA; Harper, G; Stent, GS; et al.     | Developmental Biology           | 142            | 3.64                       |
| Embryonic Origins of Cells in The Leech <i>Helobdella-Triserialis</i>  | Weisblat, DA; Kim, SY; Stent, GS               | Developmental Biology           | 137            | 3.91                       |
| Hirudin And Derivatives as Anticoagulant Agents  | Markwardt, F                                   | Thrombosis and Hemostasis       | 134            | 4.79                       |
| Antistasin, A Leech-Derived Inhibitor of Factor-Xa - Kinetic-Analysis of Enzyme-Inhibition and Identification of The Reactive Site | Dunwiddie, C; Thornberry, NA; Bull, HG; et al. | Journal of Biological Chemistry | 126            | 4.2                        |
| Pharmacology of Hirudin - 100 Years After The 1st Report of The Anticoagulant Agent in Medicinal Leeches                           | Markwardt, F                                   | Biomedica Biochimica Acta       | 124            | 3.65                       |
| <i>Aeromonas</i> spp. clinical microbiology and disease  | Parker, JL and Shaw, JG                        | Journal of Infection            | 107            | 13.38                      |

Pritchard in 1969 [12]. We found only one conference proceeding investigating scientometric feature of hirudotherapy literature. In this report, only 172 documents published between 1975 and 2016 retrieved from WoS database were included. The USA was found to be the leading country as detected in our study [13].

Since the first definition of scientometrics in the research by Nalimov and Mulchenko, only a few bibliometric and scientometric studies have been reported in the complimentary literature and almost all of which were on the acupuncture field [14]. Ma et al. found 13,320 documents of the acupuncture literature retrieved from PubMed database and reported that China (47.4%), the USA (17.5%) and UK (8.2%) were the top contributors in this field [15]. Zhou et al. performed a bibliometric assessment on the literature of acupoint herbal patching, which had been widely used in Chinese medicine for thousands of years, reported that a total of 937 articles were published in this field and nearly all studies were from China

(99.89%) [16]. Koo reported a recent bibliometric analysis on aromatherapy literature by searching WoS database and found 549 published items. The USA was the leading country with 107 articles (19.5%) and Complementary Therapies in Medicine published the most cited documents in this area [17]. Although these recent studies provided a bibliometric evaluation on traditional and complementary medicine, most of them did not rank countries according to productivity scores. Şenel and Demir performed a scientometric evaluation of apitherapy literature and noted that Brazil was leading country with 889 of 6917 publications in this field followed by the USA and China. As the authors measured the productivity of the countries in apitherapy literature they found that the most productive countries were Switzerland (2.98), Croatia (2.07), Bulgaria (1.84) and Slovenia (1.46) [18]. In the present study it was also found that Switzerland and Slovenia were the most productive countries in hirudotherapy literature although they



**Fig. 2.** Number of hirudotherapy publications and citations by year.

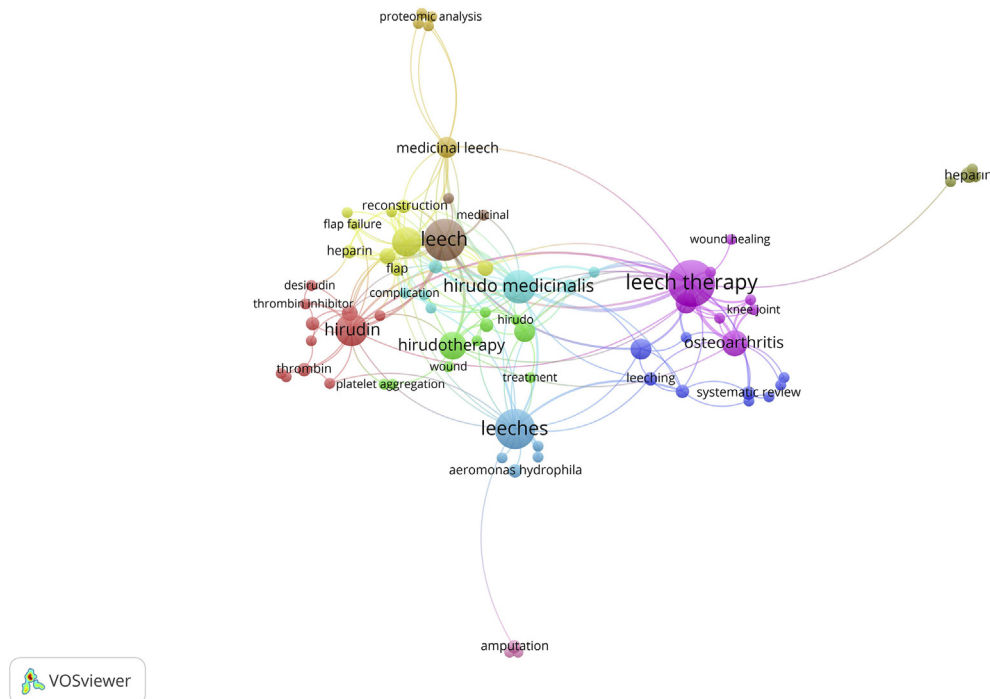


Fig. 3. Keyword network in hirudotherapy literature.

were not in the list of top ten countries according to the total number of publications.

One of the limitations of this study was that only WoS database was searched, which is one among the most reliable databases for academic literature. Due to the fact that the majority of the publications were written in English (93.28%), only English keywords were used in the current study. The present search showed only a limited number of articles in a language other than English, e.g., only one article including the keyword “*Jalaukavacharana*” was found [19], while the keyword “*Jalauka*” showed no records.

## 5. Conclusion

To the best of our knowledge, our study is the first scientometric and bibliometric analysis in hirudotherapy literature. Network analyses showed that multicenter studies were very seldom in this field. As revealed in this analysis leading countries with the highest number of publications were developed countries and additional searches should be conducted from countries such as Russia, India and China.

## Source of Funding

None.

## Conflicts of interest

None.

## References

- [1] Whitaker IS, Rao J, Izadi D, Butler PE. Historical article: *Hirudo medicinalis*: ancient origins of, and trends in the use of medicinal leeches throughout history. *Br J Oral Maxillofac Surg* 2004;42:133–7.
- [2] Eldor A, Orevi M, Rigbi M. The role of the leech in medical therapeutics. *Blood Rev* 1996;10:201–9.
- [3] Yadav CR, Guguloth R. A case study of leech therapy (*Jalaukavacharana*) in *Khalitya W.S.R. Alopecia*. *Int J Pharmacogn Chinese Med* 2017;1(3):000115.
- [4] Cherniack EP. Bugs as drugs, part two: worms, leeches, scorpions, snails, ticks, centipedes, and spiders. *Altern Med Rev* 2011;16:50–8.
- [5] Herlin C, Bertheuil N, Bekara F, Boissiere F, Sinna R, Chaput B. Leech therapy in flap salvage: systematic review and practical recommendations. *Ann Chir Plast Esthétique* 2017;62:e1–13.
- [6] Abdulkader AM, Ghawi AM, Alaama M, Awang M, Merzouk A. Leech therapeutic applications. *Indian J Pharm Sci* 2013;75:127–37.
- [7] Muslu Ü. The evolution of breast reduction publications: a bibliometric analysis. *Aesthetic Plast Surg* 2018. <https://doi.org/10.1007/s00266-018-1080-7>.
- [8] GunnMap 2. <http://lert.co.nz/map/>. Accessed 13 Jun 2019.
- [9] Vosviewer. VOSviewer - visualizing scientific landscapes. 2017. <http://www.vosviewer.com/>. [Accessed 22 October 2017].
- [10] Şenel E, Demir E, Alkan RM. Bibliometric analysis on global Behçet disease publications during 1980–2014: is there a Silk Road in the literature? *J Eur Acad Dermatol Venereol* 2017. <https://doi.org/10.1111/jdv.13897>.
- [11] World Population Prospects 2017, United Nations. <https://population.un.org/wpp/Download/Standard/Population>. [Accessed 13 June 2019].
- [12] Pritchard A. Statistical bibliography or bibliometrics? *J Doc* 1969;25:348–9.
- [13] Demir E, Gureser A, Karasartova D, Taylan Ozkan A, Mumcuoglu K. Scientometric analysis of literature on leeches and hirudotherapy between the years 1975 and 2016. In: 10th Int. Conf. Biother. Bio-medicine – Biodiagnosis Biother. Istanbul, Turkey; 2017. p. 33.
- [14] Hood WW, Wilson CS. The literature of bibliometrics, scientometrics, and informetrics. *Scientometrics* 2001;52:291–314.
- [15] Ma Y, Dong M, Zhou K, Mita C, Liu J, Wayne PM. Publication trends in acupuncture research: a 20-year bibliometric analysis based on PubMed. *PLoS One* 2016. <https://doi.org/10.1371/journal.pone.0168123>.
- [16] Zhou F, Yang D, Lu JY, Li YF, Gao KY, Zhou YJ, et al. Characteristics of clinical studies of summer acupoint herbal patching: a bibliometric analysis. *BMC Complement Altern Med* 2015;15:381. <https://doi.org/10.1186/s12906-015-0905-z>.
- [17] Koo M. A bibliometric analysis of two decades of aromatherapy research. *BMC Res Notes* 2017;10:1–9.
- [18] Şenel E, Demir E. Bibliometric analysis of apitherapy in complementary medicine literature between 1980 and 2016. *Complement Ther Clin Pract* 2018;31:47–52.
- [19] Javed D. Effect of leech application in prolapsed thrombosed hemorrhoid: a case study. *Int J Ayurvedic Med* 2016;7:238–40.