Epidemiologic evolution of common cutaneous infestations and arthropod bites: A Google Trends analysis

Thierry Simonart, MD, PhD, Xuân-Lan Lam Hoai, MD, and Viviane De Maertelaer, MSc, PhD
Brussels, Belgium

**Background:** Common cutaneous infestations and arthropod bites are not reportable conditions in most countries. Their worldwide epidemiologic evolution and distribution are mostly unknown.

**Objective:** To explore the evolution and geographic distribution of common cutaneous infestations and arthropod bites through an analysis of Google Trends.

**Methods:** Search trends from 2004 through March 2021 for common cutaneous infestations and arthropod bites were extracted from Google Trends, quantified, and analyzed.

**Results:** Time series decomposition showed that total search term volume for pubic lice decreased worldwide over the study period, while the interest for ticks, pediculosis, insect bites, scabies, lice, and bed bugs increased (in increasing order). The interest for bed bugs was more pronounced in the former Union of Soviet Socialist Republics countries, interest for lice in Near East and Middle East countries, and interest for pubic lice in South American countries. Internet searches for bed bugs, insect bites, and ticks exhibited the highest seasonal patterns.

**Limitations:** Retrospective analysis limits interpretation.

**Conclusion:** Surveillance systems based on Google Trends may enhance the timeliness of traditional surveillance systems and suggest that, while most cutaneous infestations increase worldwide, pubic lice may be globally declining. (JAAD Int 2021;5:69-75.)

**Key words:** bed bugs; head lice; infodemiology; pubic lice; scabies; ticks; Google Trends.

**INTRODUCTION**
Cutaneous infestations and arthropod bite reactions are common reasons for consultation with health care providers. Both infestations and bite reactions may result in severe pruritus with dermatologic distress. Head lice may harbor pathogens such as *Bartonella* or pathogenic *Acinetobacter* species, and bed bugs may act as competent vectors for >40 different pathogens; however, in contrast to ticks, their role in infectious disease transmission remains equivocal. It was also recently hypothesized that arthropods may favor SARS-CoV-2 viral transmission. Although these parasites represent a significant public health concern throughout the world, they are not reportable conditions in most countries, limiting the high-quality epidemiologic data collection. Studying the population dynamics of these ectoparasitic organisms using traditional field methods is costly and time consuming, especially over wide geographic areas.

Moreover, traditional studies may be affected by data quality issues, underreporting of cases, and...
reporting delays, or even conflicts of interest, resulting in missed opportunities to respond to trends in disease prevalence. Over the last 2 decades, the use of the web (internet) as an initial information source has become almost ubiquitous in the general population. Google Trends (Google Inc) is an online tracking system of internet search volumes that allows to process and analyze "big data" collected worldwide in a certain amount of time. Since 2004, Google Trends is used to explore web behavior related to a topic or search term across various regions and languages, offering an interesting tool to monitor public attention with regard to specific infectious diseases. The use of Google Trends in health care research programs is increasing, which provides useful information about epidemiologic surveillance, screening, and treatment options. The association between the predictive power of Google Trends and the data of official surveillance systems of various countries has been studied by various authors for different diseases, concluding that there is a statistically significant association and therefore it can offer significant information on population behavior and disease-related phenomena. Previous studies have examined the utility of Google Trends to monitor infectious diseases such as influenza, dengue, Lyme disease, COVID-19, or genital warts. In the present study, we investigated whether Google Trends could reflect possible changes in the epidemiology of common cutaneous infestations and arthropod bites.

**METHODS**

**Google Trends data**

The data have been obtained from Google Trends, using the method recommended by Nuti et al. Google Trends is a public web facility of Google Inc, which has been aggregating data on Google search queries since 2004. Similar application of infoveillance in the investigation of health campaign effectiveness has been described previously. Google Trends generates data and allows the user to compare the relative search volume (RSV) of 2 or more search terms, offering geographic and temporal models based on the specific terms. It shows how frequently a given search term is entered into the Google search engine relative to the site’s total search volume over a given period of time. Google Trends can be used in comparative key word research and to discover event-triggered spikes in key word search volume.

RSV is assigned to the search terms. The values of RSV represent the goal of the research based on the highest point of the plot with respect to a region or a specific period. They do not represent absolute search volume numbers but rather a normalized value reflected on a scale from 0 to 100, where 100 is the point of maximum popularity among the search terms or topics over a specified time frame. The 0 score indicates that no sufficient data were found regarding the search term.

A "search term" query on Google Trends provides searches for an exact search term, whereas a "topic" query includes related search terms (in any language, including, eg, Spanish, Portuguese, Persian, Ukrainian, and Thai). We focused our analysis on the "Related Searches" section, which shows queries (and not key words) that are related to the entered terms (which are instead true key words). The data have been obtained using "topic" queries, in the "Global" category (all available categories on Google Trends were included), "gale, as disease" ("scabies" in English), "pou du pubis, as insect" ("lice" in English), "pou du pubis, as insect" ("pubic lice" in English), "tiques, as animal" ("ticks" in English), "punaises, as insect" ("bed bugs" in English), and "piqures et morsures d’insectes, as subject" ("insect bites" in English). The data have been obtained in the time frame elapsing from January 1, 2004, to March 31, 2021 (n = 207 months) worldwide and aggregated by month. Ethics approval for this type of study was not required as none of the queries in the Google database can be associated with any identity and/or physical location, as specified in Google’s privacy policy (http://www.google.com/privacypolicy.html).

**Data and statistical analysis**

For the entire period (n = 207 months), decomposition time series multiplicative models (Value = [Mean] × [Trend] × [Seasonality] × [Cycle] ×

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**CAPSULE SUMMARY**

- The worldwide epidemiologic evolution and distribution of common cutaneous infestations and arthropod bites are mostly unknown.
- Surveillance systems based on Google Trends suggest that, while the interest in interest in scabies, bed bugs, ticks, and head lice increases worldwide, pubic lice may be globally declining.
RESULTS

The temporal evolution for the worldwide 17-year Google Trends data (from January 2004 to March 2021) regarding the variables mentioned under the “Methods” section is presented in Fig 1. Because the prevalence of head lice is much higher than that of pubic lice,5,24 we assumed that most searches for the query “lice” are related to pediculosis capitis. Moreover, in the common language, there are generally specific words for phthiriasis (ie, “crabs” in English or “morpion” in French). The trends of the time series decomposition showed that the patients’ interest in pubic lice decreased (trend = −0.0039), while the interest in other common cutaneous infestations increased. The relative importance of the positive trends are in increasing order as follows: ticks (0.0006), insect bites (0.0020), scabies (0.0032), lice (0.0042), and bed bugs (0.0063) (Table I).

The top 5 countries where the queries for lice were the most popular were mostly Near East and Middle East countries, whereas the top 5 countries where the queries for pubic lice were the most popular were South American countries. The top 5 countries where the queries for bed bugs were the most popular were all located in the former Union of Soviet Socialist Republics countries (Table II). Seasonality in worldwide internet searches (reflecting mainly the northern hemisphere, since 90% of the world’s population and most of the internet users live there)15,20 was quantified as the difference between the highest and lowest seasonality coefficients, which were in decreasing order as follows: bed bugs, insect stings, ticks, lice, pubic lice, scabies, and pediculosis (Table I). The peaks of interest for bed bugs, insect stings, and ticks were in October, May, and July, respectively (Table I).

DISCUSSION

Because common cutaneous infestations and arthropod bites are not reportable conditions in most countries, studies on their changing trends and geographic distribution remain scarce. Search engine data have been shown to be truly reliable for the prediction of disease outbreaks12,15,27 and potentially facilitate efficient enhancement of established surveillance-reporting systems. Google Trends, an online tracking system of internet hit-search volumes, has been extensively used in the field of infectious diseases, both for monitoring and surveillance purposes and for investigating public interest for epidemic outbreaks.9,15,28 Freely available internet search data provided by Google Trends were used for this study.

Head lice are believed to infest >100 million people worldwide5 and isolated reports from various countries suggest an increasing prevalence.29 However, these epidemiologic studies were conducted during different seasons, among vastly different populations, using different examination methods, and relied on varying measures to define the basis of an infestation.29 Variations in reported prevalence were found even in data from the same country.30 Our data, generated from surveillance systems based on Google Trends, indicate growing interest among the general public for lice, which corroborates the claims of the increasing prevalence of head lice infestations worldwide.29 Notably, countries with the highest web-based interest for lice were Near East and Middle East countries, which does not support traditional epidemiologic studies suggesting that the highest prevalence of pediculosis capitis is in Central and South America.31

Pediculosis pubis is an infectious disease caused by infestation with the parasite Phthirius pubis. It is sexually transmitted and has often been found in combination with other sexually transmitted infections (STIs).32,33 However, while epidemiologic data suggest alarming rising rates of STIs worldwide, potentially fueled by the following: (1) rapid spread of drug resistance for bacterial STIs; (2) unprece-dented impact of recreational drugs and internet for facilitating exposure to multiple sex partners; and (3) growing rates of sexual violence and commercial sex, associated with wars, refugees, migrations, traveling, and sexual tourism;44 few data are available on the global epidemiology of pubic lice. By opposition to most other STIs for which internet searches are increasing,15 our findings indicate decreasing interest among the general public
regarding pubic lice, suggesting that their global incidence is decreasing. It is estimated that 70% to 80% of adults now remove pubic hair in part or entirely, using a variety of methods. It is hypothesized that the destruction of this pubic hair habitat may account for the falling incidence of pubic lice and may possibly lead to its eradication.\textsuperscript{35}

After World War II, bed bugs became uncommon in developed countries due to social and economic progress and insecticide development, whereas infestation in developing countries never decreased.\textsuperscript{3} Since the 1990s, reports of clusters or epidemics from many countries across the world suggest a resurgence of bed bugs.\textsuperscript{3,36-38} Our findings indicate that, during the last 17 years, interest among the general public regarding bed bugs did not stop growing, suggesting a further increase in their prevalence. Notably, we noted that the countries with the highest search volume for bed bugs were all located in the former Union of Soviet Socialist Republics countries, suggesting a higher incidence of this infestation in this geographic area.

Tick bites and associated diseases are important public health concerns. Our data and other previously published infodemiology data show a worldwide increased internet interest for ticks.\textsuperscript{14,39} This is consistent with epidemiologic studies showing that the incidence of tick-borne diseases in humans

![Graph showing data for searches for scabies, pubic lice, lice, insect stings, bed bugs, and ticks. Google Trends time data (17 years; 207 months). To compare the temporal evolution of the searches, data for each search have been downloaded separately and are presented as relative search volume index. They do not represent absolute search volume numbers but rather a normalized value, ranging from 0 (for no searches) to 100 (for the peak of the search). RSV, Relative search volume.](image-url)
increased in many European countries and in the United States since the early 1990s.40 It is disputed which factors are responsible for these trends. Climate trends, the density of key hosts for adult ticks, and changes in the landscape bringing their habitat closer to humans have been pointed as the main factors behind the spread of *Ixodes ricinus*.41

Local reports of scabies outbreaks along with the simultaneous increase in sales of scabies treatments suggest that the incidence of scabies is increasing in several countries.42-46 Our data support these traditional epidemiologic studies and show an increased interest in scabies between 2004 and 2021, which may be related to increasing population density in urban settings, migration, travels, and aging population.

The relative importance of the increase in internet searches for bed bugs, lice, and scabies was more pronounced than the increase in searches for insect bites or tick bites, which might suggest a more prominent role of increasing urban population density than climate changes in these trends.

Google Trends has been shown to be suitable for studying seasonal patterns of various skin problems.47-50 In line with previous studies, we found a seasonal pattern for the internet interest for ticks with peaks of interest in May.49,50 Expectedly, there was a peak of interest for insect stings in July. Additionally, similar to prior work,51 we found a peak of internet searches for bed bugs in October. These results should be interpreted with caution since we analyzed the worldwide interest in ectoparasitoses, including thus the southern and northern hemispheres. This bias is probably minimized since 90% of the world’s population and most of the internet users live in the northern hemisphere.25,26

The main strengths of this study encompass the basic definition of big data, including ‘the 3 Vs’: variety (linkage of many data sets in a single data set), volume (a large number of observations), and/or velocity (real-time or frequent data updates, fully automated).7 Google Trends supports credibility and transparency because these data are openly available, and our analyses are replicable by other investigators. Further, Google Trends topic queries encompass broad literature search terms, search volume data access has remained continuously available since 2008,52 and the search is not restricted by the language.

This study is limited by several factors. Google Trends provides only an RSV index, not the absolute search volume, and does not provide a way to calculate the search volume index. Google Trends also only provides data on search terms that the researchers chose. Although we chose search terms as inclusive as possible, people searching for diseases on Google may have chosen other terms. The mass media (eg, television, radio) influence the online research of the population.53 The spike in internet searches may be attributed to various factors. It may be due to changes in case numbers in the community and changes given by the mass media or educational purposes. Another limitation is that the participant sample was biased toward internet users who use the Google search engine. However, this bias is mitigated by the fact that as of

| Topic       | Trend slopes | Seasonality | Seasonality coefficients |
|-------------|--------------|-------------|--------------------------|
|             | Lowest       | Highest     | Lowest       | Highest       |
| Pubic lice  | –0.0039      | December    | May          | 0.9359       | 1.0947       |
| Ticks       | 0.0006       | January     | May          | 0.8466       | 1.1903       |
| Insect stings| 0.0020    | December    | July         | 0.8078       | 1.2673       |
| Scabies     | 0.0032       | June        | October      | 0.9637       | 1.0575       |
| Lice        | 0.0042       | December    | August       | 0.9124       | 1.1063       |
| Bed bugs    | 0.0063       | January     | October      | 0.7737       | 1.3773       |

**Table II. Top 5 countries for the queries for ticks, scabies, lice, pubic lice, and bed bugs**

| Ticks       | Scabies | Lice       | Pubic lice  | Bed bugs |
|-------------|---------|------------|-------------|---------|
| Iran        | Venezuela | Libya | Venezuela | Turkmenistan |
| Poland      | Denmark | Syria | Chile | Hungary |
| United States | Norway | Iran | Guatemala | Kazakhstan |
| Canada      | Saudi Arabia | Jordania | Panama | Russia |
| Australia   | Puerto-Rico | Saudi Arabia | Czechia | Ouzbekistan |
March 2015, Google accounted for approximately two-thirds (64.4%) of all internet search traffic, whereas the next most popular search engine accounted for only 20.1% of traffic during a given month.\textsuperscript{54} Although it is common among the whole population to make health-related searches, younger people tend to use the internet more often. Finally, the large amount of data does not eliminate and may amplify sources of systematic error.

In conclusion, our data, generated from surveillance systems based on Google Trends, suggest that, while interest in tick bites, bed bugs, and head lice is increasing worldwide, pubic pediculosis may be globally declining. These results may be explained by several factors, including migration, traveling, climate changes, and/or increasing population density in urban settings. Pubic shaving may account for the decreasing interest in of pubic lice. The potential of this approach could be used in the immediate future as a support to traditional surveillance systems.

Conflicts of interest
None disclosed.

REFERENCES

1. Kamath S, Kenner-Bell B. Infestations, bites, and insect repellents. Pediatr Ann. 2020;49(3):e124-e131.
2. Alter SJ, McDonald MB, Schloemer J, Simon R, Trevino J. Common child and adolescent cutaneous infestations and fungal infections. Curr Probl Pediatr Adolesc Health Care. 2018;48(1):3-25.
3. Delaunay P, Blanc V, Del Giudice P, et al. Bedbugs and infectious diseases. Clin Infect Dis. 2011;52(2):200-210.
4. Lai O, Ho D, Glück S, Jagdeo J. Bed bugs and possible transmission of human pathogens: a systematic review. Arch Dermatol Res. 2016;308(8):531-538.
5. Coates SJ, Thomas C, Chosidow O, Engelman D, Chang AY. Ectoparasites: pediculosis and tungiasis. J Am Acad Dermatol. 2020;82(3):551-560.
6. Tatu A, Nadasy T, Nwabudike LC. Chitin-lipid interactions and the potential relationship between Demodex and SARS-CoV-2. Dermatol Ther. 2021;34(3):e14935.
7. Baro E, Degoul S, Beuscant R, Chazaud E. Toward a literature-driven definition of big data in healthcare. Biomed Res Int. 2015;2015:639021.
8. Google. Google Trends. Accessed March 31, 2021. http://www.google.com/trends
9. Ho HT, Carvajal TM, Bautista JR, et al. Using Google Trends to examine the spatio-temporal incidence and behavioral patterns of dengue disease: a case study in Metropolitan Manila, Philippines. Trop Med Infect Dis. 2018;3(4):118.
10. Pollett S, Boscardin WJ, Azziz-Baumgartner E, et al. Evaluating Google Flu Trends in Latin America: important lessons for the next phase of digital disease detection. Clin Infect Dis. 2017;64(1):34-41.
11. Sousa-Pinto B, Anto A, Czarlewski W, Anto JM, Fonseca JA, Bousquet J. Assessment of the impact of media coverage on COVID-19-related Google Trends data: infodemiology study. J Med Internet Res. 2020;22(8):e19611.
12. Syamuddin M, Fakhruddin M, Sahetapy-Engel JTM, Soewono E. Causality analysis of Google Trends and dengue incidence in Bandung, Indonesia with linkage of digital data modeling: longitudinal observational study. J Med Internet Res. 2020;22(7):e17633.
13. Samaras L, Garcia-Barriocanal E, Sicilia MA. Syndromic surveillance models using web data: the case of influenza in Greece and Italy using Google Trends. JMIR Public Health Surveill. 2017;3(4):e90.
14. Pesälti S, Virtanen MJ, Sane J, Mustonen P, Kaila M, Helve O. Health information-seeking patterns of the general public and indications for disease surveillance: register-based study using Lyme disease. JMIR Public Health Surveill. 2017;3(4):e86.
15. Simonart T, Lam Hoai XL, De Maertelaer V. Impact of human papillomavirus vaccine in reducing genital warts: a Google Trends analysis. J Am Acad Dermatol. 2021. https://doi.org/10.1016/j.jaad.2021.03.091
16. Nuni SV, Wayda B, Ranasinghe I, et al. The use of google trends in health care research: a systematic review. PLoS One. 2014;9(10):e109583.
17. Simpson TW. Evaluating Google as an epistemic tool. Metaphilosophy. 2012;43(4):426-445.
18. Ling R, Lee J. Disease monitoring and health campaign evaluation using Google search activities for HIV and AIDS, stroke, colorectal cancer, and marijuana use in Canada: a retrospective observational study. JMIR Public Health Surveill. 2016;2(2):e156.
19. Schootman M, Toor A, Cavazos-Rehg P, et al. The utility of Google Trends data to examine interest in cancer screening. BMJ Open. 2015;5(6):e006678.
20. Russo GI, di Mauro M, Cacciari R, et al. Consulting “Dr Google” for sexual dysfunction: a contemporary worldwide trend analysis. Int J Impot Res. 2020;32(4):455-461.
21. Cacciamani GE, Bassi S, Sebben M, et al. Consulting “Dr. Google” for prostate cancer treatment options: a contemporary worldwide trend analysis. Eur Urol Oncol. 2020;3(4):481-488.
22. Leetaru K. Understanding what you’re searching for in a multilingual world. Forbes. Posted October 18, 2015. Accessed March 31, 2021. https://www.forbes.com/sites/kalevleetaru/2015/10/18/understanding-what-youre-searching-for-in-a-multilingual-world/?sh=755a148e3e0f
23. Box GE, Jenkins GM, Reinsel GC, Ljung GM. Analysis: Forecasting and Control. 5th ed. John Wiley and Sons Inc. 2015:712.
24. Patel PU, Tan A, Levell NJ. A clinical review and history of pubic lice. Clin Exp Dermatol. 2021. doi:10.1111/ced.14666
25. Lutz A. Map of the day: pretty much everyone lives in the northern hemisphere. Business Insider. Posted May 4, 2012. Accessed March 31, 2021. https://www.businessinsider.com/90-of-people-live-in-the-northern-hemisphere-2012-5
26. List of countries by number of internet users: revision history. Accessed March 31, 2021. https://en.wikipedia.org/wiki/List_of_countries_by_number_of_Internet_users
27. Obeidat R, Alsmadi I, Bani Bakr O, Obeidat L. Can users search trends predict people scares or disease breakout? An examination of infectious skin diseases in the United States. Infect Dis (Auckl). 2020;13:1178633720928356.
28. Carneiro HA, Mylonakis E. Google trends: a web-based tool for real-time surveillance of disease outbreaks. Clin Infect Dis. 2009;49(10):1557-1564.
29. Muncuoglu KY, Pollack RJ, Reed DL, et al. International recommendations for an effective control of head louse infestations. Int J Dermatol. 2021;60(3):272-280.
30. Falagas ME, Matthaiou DK, Rafailidis PI, Panos G, Pappas G. Worldwide prevalence of head lice. Emerg Infect Dis. 2008;14(9):1493-1494.

31. Hatam-Nahavandi K, Ahmadpour E, Pashazadeh F, et al. Pediculosis capitis among school-age students worldwide as an emerging public health concern: a systematic review and meta-analysis of past five decades. Parasitol Res. 2020;119(10):3125-3143.

32. Anderson AL, Chaney E. Pubic lice (Phthirus pubis): history, biology and treatment vs. knowledge and beliefs of US college students. Int J Environ Res Public Health. 2009;6(2):592-600.

33. Pierzchalski JL, Bretl DA, Matson SC. Phthirus pubis as a predictor for chlamydia infections in adolescents. Sex Transm Dis. 2002;29(6):331-334.

34. Soriano V, Del Romero JD. Rebound in sexually transmitted infections following the success of antiretrovirals for HIV/AIDS. AIDS Rev. 2018;20(4):187-204.

35. Dholakia S, Buckler J, Jacobs JP, Pillai A, Eagles N, Dholakia S. Pubic lice: an endangered species? Sex Transm Dis. 2014;41(6):388-391.

36. Dehghani R, Hashemi A, Takhtfiroozeh SM, Chimehi E. Bed bug (Cimex lectularis) outbreak: a cross-sectional study in Polour, Iran. Iran J Dermatol. 2016;19(1):16-20.

37. Akhoundi M, Sereno D, Durand R, et al. Bed bugs (Hemiptera, Cimicidae): overview of classification, evolution and dispersion. Int J Environ Res Public Health. 2020;17(12):4576.

38. Zorrilla-Vaca A, Silva-Medina MM, Escandón-Vargas K. Bed bugs, Cimex spp.: their current world resurgence and health-care impact. Asian Pac J Trop Dis. 2015;5(S):342-352.

39. Walker MD. Can Google be used to study parasitic disease? Internet searching on tick-borne encephalitis in Germany. J Vector Borne Dis. 2018;55(4):327-329.

40. Lindgren E, Jaenson T. Lyme borreliosis in Europe: influences of climate and climate change, epidemiology, ecology and adaptation measures. Europe World Health Organization. Accessed March 31, 2021. http://www.euro.who.int/__data/assets/pdf_file/0006/96819/E89522.pdf

41. Medlock JM, Hansford KM, Borman A, et al. Driving forces for changes in geographical distribution of Ixodes ricinus ticks in Europe. Parasit Vectors. 2013;6:1.

42. Romani L, Steer AC, Whitfeld MJ, Kaldor JM. Prevalence of scabies and impetigo worldwide: a systematic review. Lancet Infect Dis. 2015;15(8):960-967.

43. Sunderkötter C, Aebischer A, Neufeld M, et al. Increase of scabies in Germany and development of resistant mites? Evidence and consequences. J Dtsch Dermatol Ges. 2019;17(1):15-23.

44. Lugovic-Mihić L. The increase in Croatia's scabies incidence: how did refugees and traveling contribute? Travel Med Infect Dis. 2019;29:74.

45. Amato E, Dansie LS, Groneng GM, et al. Increase of scabies infestations, Norway, 2006 to 2018. Euro Surveill. 2019;24(23):190020.

46. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1545-1602.

47. Kardes¸ S. Seasonal variation in the internet searches for psoriasis. Arch Dermatol Res. 2019;311(6):461-467.

48. Zhang H, Wang Y, Zheng Q, et al. Research interest and public interest in melanoma: a bibliometric and Google Trends analysis. Front Oncol. 2021;11:629687.

49. Scheerer C, Ruth M, Tizek L, Köberle M, Biedermann T, Zink AJ. Googling for ticks and borreliosis in Germany: nationwide Google search analysis from 2015 to 2018. J Med Internet Res. 2020;22(10):e18581.

50. Kassiri H, Nasirian H. New insights about human tick infestation features: a systematic review and meta-analysis. Environ Sci Pollut Res Int. 2021;28(14):17000-17028.

51. Kantor J. Seasonal variability in bed-bug (Cimex lectularius) activity in Western Europe, the United States, and Australia using search engine query data as a surrogate outbreak measure. J Am Acad Dermatol. 2016;75(3):627-629.

52. Google Trends Help. Accessed May 13, 2019. https://support.google.com/trends#topic=6248052

53. Odone A, Signorelli C. When vaccine hesitancy makes head-lines. Vaccine. 2017;35(9):1209-1210.

54. Reston VA. Comscore Releases March 2015 U.S. Desktop Search Engine Rankings. Comscore, Inc. Posted April 15, 2015. Accessed December 5, 2016. http://www.comscore.com/Insights/Rankings/comScore-Releases-March-2015-US-Desktop-Search-Engine-Rankings