



STI 2018 Leiden

*23rd International Conference on Science and Technology Indicators
"Science, Technology and Innovation Indicators in Transition"*

STI 2018 Conference Proceedings

Proceedings of the 23rd International Conference on Science and Technology Indicators

All papers published in this conference proceedings have been peer reviewed through a peer review process administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a conference proceedings.

Chair of the Conference

Paul Wouters

Scientific Editors

Rodrigo Costas
Thomas Franssen
Alfredo Yegros-Yegros

Layout

Andrea Reyes Elizondo
Suze van der Luijt-Jansen

The articles of this collection can be accessed at <https://hdl.handle.net/1887/64521>

ISBN: 978-90-9031204-0

© of the text: the authors

© 2018 Centre for Science and Technology Studies (CWTS), Leiden University, The Netherlands



This ARTICLE is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License

Scientific and technological contributions in epidemic outbreaks: the case of zika virus in Latin America and Caribbean countries

Camila Guindalini^{*}, Fernanda Lopes Fonseca^{*}, Marcus Vinicius Pereira da Silva^{**}, Alice Machado da Silva^{***} and Bruna de Paula Fonseca^{*}

**cguindalini@cids.fiocruz.br; ffonseca@cids.fiocruz.br; bfonseca@cids.fiocruz.br*

Centro de Desenvolvimento Tecnológico em Saúde, Fundação Oswaldo Cruz, Fiocruz, Av. Brasil 4036, Rio de Janeiro, 21040-361 (Brazil)

***marcussilva@fiocruz.br*

Casa de Oswaldo Cruz, Fundação Oswaldo Cruz, Fiocruz, Av. Brasil 4036, Rio de Janeiro, 21040-361 (Brazil)

****alice.silva@minas.fiocruz.br*

Instituto René Rachou, Fundação Oswaldo Cruz, Fiocruz, Av. Augusto de Lima, 1715, Belo Horizonte - MG, 30190-002 (Brazil); Centro de Desenvolvimento Tecnológico em Saúde, Fundação Oswaldo Cruz, Fiocruz, Av. Brasil 4036, Rio de Janeiro, 21040-361 (Brazil)

Abstract

Zika virus (ZIKAV) infection has recently become a public health concern, as well as an enduring scientific, and technological (S&T) challenge for researchers worldwide. Especially in Latin America and Caribbean (LAC) countries, greatly affected by the outbreak, understanding the S&T response is essential to guide future research and to direct financial investments. In the present study, we focused on ZIKAV epidemics using combined publication (from international and regional databases: Web of Science, Scopus, PubMed, SciELO and LILACS), patent (Orbit Intelligence) and social network analysis (co-authorship) to contribute to the discussion of the role of S&T knowledge produced and disseminated regionally to address global challenges. International databases searches retrieved 5,421 documents, evidencing a dramatic increase in scientific publications targeting ZIKAV from 2015 onwards. Overall, 70% of the 237 unique documents indexed in SciELO and LILACS, were retrieved in the international databases. United States, France, and Brazil were the top three most central countries of the global network for ZIKAV research. In addition, United States was shown to be the most frequent collaborator of LAC countries. Patent search retrieved 311 patent families. So far, only four are from LAC organizations, all based in Brazil. Our analysis offered a comprehensive representation of ZIKAV's research and development and showed that scientific efforts from LAC countries, in particular from Brazil, had a significant role in the generation of global knowledge. The study highlights the need for a continued interdisciplinary approach in order to improve our ability to prepare for, control and prevent future outbreaks.

Introduction

Zika virus (ZIKAV) infection has recently become a public health concern, being associated with dramatic neurological conditions, including fetal microcephaly and other congenital malformations (Lowe et al., 2018). Epidemiological studies confirmed that the Latin America and Caribbean (LAC) outbreak, which started in Brazil in May 2015, resulted in over one million people infected, with a shocking number of microcephaly cases in fetuses and infants (ECDC, 2016; Singh et al., 2018). To date, the geographical distribution of ZIKAV has expanded globally and 84 countries/territories have reported vector-borne transmission (WHO, 2017a). Consequently, scientific publications on ZIKAV have radically increased in the last few years, evidencing an impressive effort of worldwide researchers to develop effective diagnostic tools, treatment and vaccines, discuss prevention and control approaches, and comprehend the pathogenicity and diverse clinical manifestations of the virus (ECDC, 2016; Lowe et al., 2018).

Despite significant advances, ZIKAV remains an enduring scientific and technological (S&T) health challenge. Hitherto there are no vaccines or antiviral therapy readily available, although this may be feasible in the near future (Diamond & Coyne, 2017). ZIKAV is likely to have significant and long-lasting social and economic impacts, specially across LAC countries, greatly affected by the epidemics (Colón-González, Peres, Bernardo, Hunter, & Lake, 2017). A better assessment of how LAC countries responded to the scientific challenge imposed by the outbreak is essential to guide the prioritization of future research, the preparedness for challenges ahead and direction of financial investments.

The assessment of LAC S&T contributions is hindered by the frequently use of international databases, as a unique source of information (Meneghini, Mugnaini, & Packer, 2006; Vélez-Cuartas, Lucio-Arias, & Leydesdorff, 2016). The impact of excluding regional databases is exacerbated by the tendency of LAC-based authors to publish in regional and local journals (Meneghini et al., 2006). This was evident when publications by Brazil were analysed: the country accounted for approximately half of the scientific output of the LAC region in the Science Citation Index in 2015 (RICYT, 2017) and data from 1998-2012 indicates that approximately 40% of its scientific production was published outside the Core Collection of the Web of Science (Mugnaini et al., 2014). Although the inclusion of LAC-edited journals in Web of Science (Wos), Scopus and PubMed databases has increased over time (RICYT, 2017; Testa, 2016), analyses on how different areas/research themes are covered have not been carried out.

In this sense, this paper aims to contribute to the discussion of the role of S&T knowledge produced and disseminated regionally to address global challenges. In the present study, we focused on ZIKAV epidemics using combined publication, patent, and social network analysis methods to address the following questions: i) what was the LAC region's contribution to the worldwide scientific and technological knowledge production on ZIKAV?; ii) what was the international coverage of ZIKAV-related publications indexed in LAC regional databases?; iii) to which extent the LAC region contributed to technological development directed to ZIKAV?

Method

Data collection

ZIKAV-related scientific publications (up to 2017) were retrieved from three different databases: Web of Science (WoS), Scopus and PubMed. The query was directed to the title, abstract and keywords using the search terms “zika OR zikav”. All types of publications were included in the analysis, but replies, errata and comments on existing papers. To account for regionally-focused publications, data from SciELO (Scientific Electronic Library Online) and LILACS (Literature in the Health Sciences in Latin America and the Caribbean) databases were collected. SciELO is originally from Brazil and encompasses publications in LAC countries, whereas LILACS covers specifically medicine and health sciences publications in the LAC region, being maintained by the Latin American and Caribbean Center on Health Sciences Information.

Patent applications were retrieved using Orbit Intelligence, Questel’s commercial Intellectual Property Business Intelligence software. Orbit is a patent search platform with comprehensive worldwide coverage of patent publications from more than 100 patent authorities. Our search query consisted in “zika OR zikv OR zikav” in the title, abstract or claims and earliest priority date up to 31/12/2017. Assignee location was assessed using the field “assignee country”.

Data treatment and processing

Scopus, PubMed and WoS database integration, duplicate removal and data harmonization into a single dataset were carried out using the software VantagePoint (Search Technology Inc.). SciELO and LILACS databases were manually processed.

Patents were individually analyzed to exclude documents outside our search scope. Patent assignee names were harmonized and grouped into subsidiaries using Orbit analysis module.

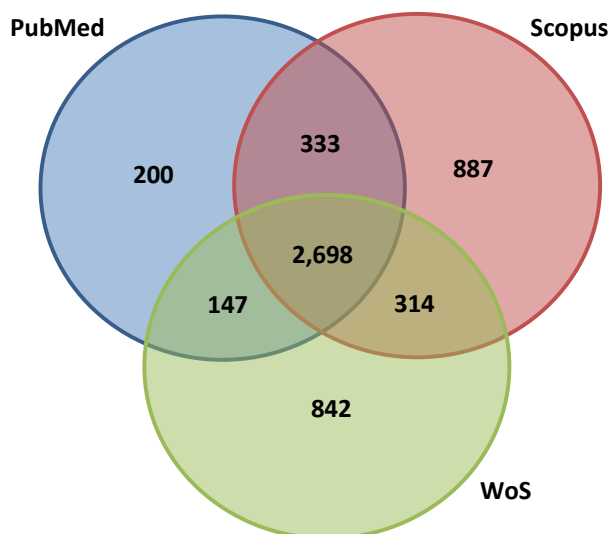
Network analysis and visualization

After treatment and processing, authors’ affiliation data available in scientific publications was used to assess country collaboration dynamics through the analysis of co-authorship networks. In these networks, nodes represent countries, and two or more countries were connected if their members shared authorship of one or more papers. Visualisation of network graphs and statistical analyses were produced with the open-source software Gephi. Countries that had prominent roles were identified by their betweenness centrality, which reflects the extent a node acts as a “bridge” between other nodes (Freeman, 1979).

Results

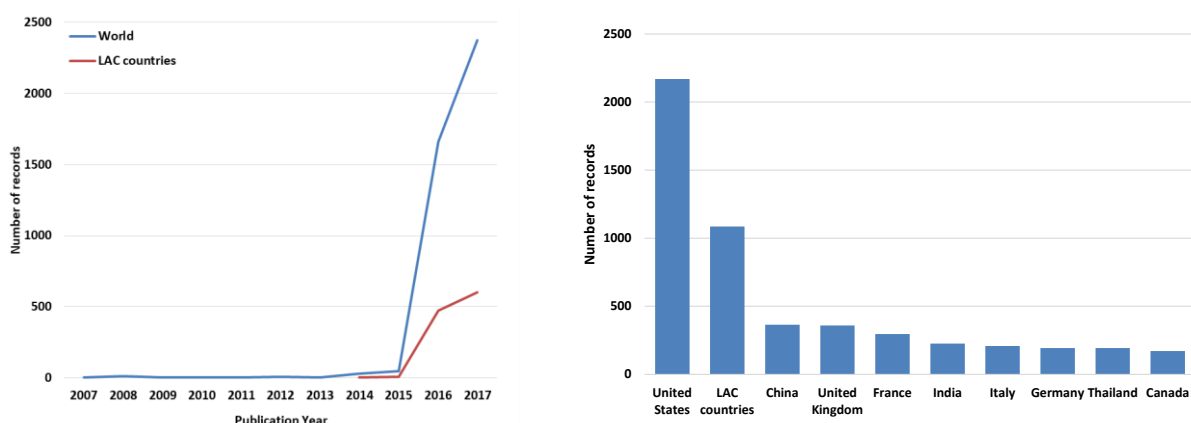
To assess the contribution of LAC countries to the worldwide knowledge production on ZIKAV, searches for scientific publications were carried out in international databases. Such searches retrieved 4,232 documents from Scopus, 3,378 from PubMed and 4,001 from WoS. After data integration, standardization, and treatment, 5,421 unique documents were included in the analysis. A database overlap analysis (Figure 1) showed that Scopus and WoS had the highest number of unique records, with approximately 16% of all publications on ZIKAV exclusively indexed in each database. Overall, 50% of publications retrieved were indexed in the three databases.

Figure 1: Overlap between PubMed, Scopus and WoS databases.



Our data evidenced a dramatic increase in scientific publications targeting ZIKAV over the last years, particularly from 2015 onwards (Figure 2, left panel). Authors from the United States (n=2,169), LAC countries (n=1,086) and China (n=365) were the most frequent contributors in the period evaluated (Figure 2, right panel). Among LAC countries, Brazil was involved in approximately 67% of all LAC publications (n=1086), accounting for 13% of the world’s scientific publications on ZIKAV. Other LAC countries had minor contributions, such as Colombia (n=140), Venezuela (n=36) and Argentina (n=35).

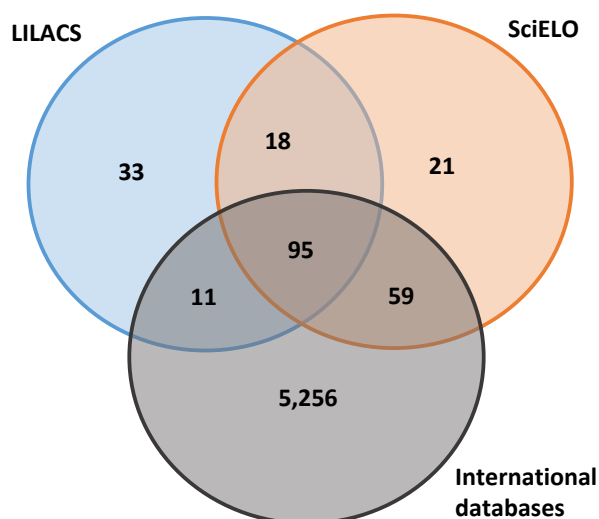
Figure 2: General profile of ZIKAV research indexed in international databases. Left panel: annual number of published articles on ZIKAV (2007-2017); Right panel: Top ten most active countries/regions (up to 2017).



Searches were then carried out in regional LAC databases to evaluate the international coverage of ZIKAV-related publications indexed in LAC regional databases. Regional database searches retrieved 193 records from SciELO and 157 from LILACS. After treatment and processing, 237 unique publications were included in the analysis, with an overlap of

48% between databases (Figure 3). Overall, 30% of ZIKAV publications retrieved in the regional databases were not indexed in the international databases.

Figure 3: Overlap between SciELO, LILACS and international databases.



Data retrieved from international databases was used to build the global network for ZIKAV research. The network involved 157 countries, reflecting the solid international collaborative research efforts for disease control. The top three most central countries, according to their betweenness centrality, were the United States, France, and Brazil (Table 1).

Table 1: ZIKAV global research network's top five central countries

Rank	Country	Betweenness centrality
1	United States	0.117
2	France	0.055
3	Brazil	0.043
4	United Kingdom	0.029
5	Switzerland	0.027

Co-authorship network analyses showed that the United States was the most frequent collaborator of LAC countries, co-authoring 30% (n=361) of all LAC publications (Figure 4). Other frequent collaborating countries include France, Canada, and Germany (each with 98, 47 and 44 publications in co-authorship with LAC countries, respectively). Collaboration between LAC countries was not frequent. Brazilian researchers co-authored 34 publications with Colombian and 30 papers with Venezuelan authors.

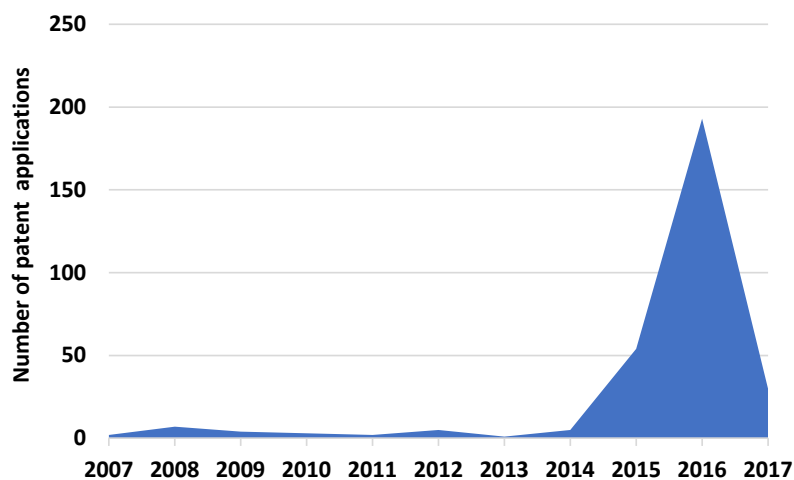
Figure 4: International collaboration in ZIKV research networks involving LAC-based authors. Country links were mapped based on authors' affiliations. Each node represents one

country and two countries were considered connected if their researchers shared the authorship of a paper. The thickness of links indicates the frequency of collaboration between two nodes. Nodes are color-coded according to author's continent.



A patent search was carried out as a means to assess potential technological development towards ZIKAV. Our search of patent documents retrieved a total of 323 patent families (encompassing 937 individual patent filings) with earliest priority date up to 31/12/2017. Patent families that were not related to ZIKAV were removed, and a total of 311 families remained. It is noteworthy that approximately 90% of the remaining families have earliest priority date from 2015 onwards (Figure 5). This percentage is even more expressive considering that patents are usually published 18 months after the earliest priority claimed. Prior to these 18 months, unless publication is specifically requested by the patent owner, the application is confidential to the national intellectual property office and will not be retrieved in our search, meaning that data for 2016 and 2017 are incomplete.

Figure 5: Annual evolution of Zika-related patent applications (2007-2017).



So far, only four patents retrieved from our search are from LAC organizations, all based in Brazil. One of them was filed in 2015 and three in 2016. Two of them were filed in the Patent Cooperation Treaty (PCT) and may enter national phase in other countries.

Discussion

On February 1, 2016, the World Health Organization declared the cluster of ZIKAV-associated microcephaly cases and other neurological disorders a Public Health Emergency of International Concern (WHO, 2016). This action induced a global response in several areas, which also reflected in S&T efforts (Albuquerque et al., 2017). Our assessment of scientific publications, integrating three international and two regional databases, coupled to patent analyses, offered a comprehensive representation of ZIKAV's research and development (R&D) community and showed that, prior to 2015, it was a relatively neglected pathogen. This great increase in R&D activities may have been bolstered by an increase in funding directed to the epidemics by several international agencies (CDC, 2014; WHO, 2017b).

As the LAC region was the most affected area, Brazil in particular, understanding the overlaps and disparities between bibliographic databases is an essential tool for a comprehensive analysis of regional contributions. Our international database analyses showed that scientific efforts from Brazil had a significant role in the generation of global knowledge on ZIKAV. In fact, Brazilian scientists were responsible for seminal work on outbreak characterization (e.g. Campos, Bandeira, & Sardi, 2015) and their research was critical to document the anomalous high incidence of microcephaly and other newborn malformations that were associated with ZIKAV infecting pregnant women (Brasil et al., 2016). However, regional database analyses showed that 30% of scientific contributions indexed in LAC databases were internationally "invisible". The global importance given to ZIKAV along with the high incidence of cases in LAC countries urges that knowledge produced regionally is made noticeable. Although SciELO has been included in WoS and Scopus indexes several LAC journals, providing a more inclusive representation of regional scientific publications, coverage of Social Sciences and Arts and Humanities areas are limited in international databases (Mongeon & Paul-Hus, 2016). In addition, the usability of regional databases, which usually provide limited tools to download data and to analyze the results output remains a challenge for bibliometricians.

During an epidemic, the role played by countries in a knowledge-generating network is an important parameter for influencing response, decision-making, preparedness, and empowerment. Our co-authorship network analyses allowed for a better understanding of the markedly cooperative context in which ZIKAV scientific knowledge was generated and identified key leading countries. In such analyses, a node with high betweenness centrality would potentially have more control over the network. This parameter suggests a prominent role for Brazil in facilitating access to novel information or resources, transferring the knowledge generated and coordinating efforts across the network, potentially acting as a "bridge" in the scientific community. Indeed, when a network of international scientists suggested that Brazil's 2016 Olympic Games should be put off because of the "Zika problem" (Attaran, 2016), it was a report from Brazilian scientists that brought evidence that the epidemics had receded, indicating that the games would not have to be cancelled or postponed (Codeço et al., 2016).

Patent analyses also evidenced a globally low interest in technological development related to ZIKAV prior to 2015 and a markedly increase in patent filings after the 2015 outbreak. To date, it may seem the intense scientific activity in the ZIKAV field is still more focused on basic science research, as concluded from the small number of patent applications retrieved compared to the intense activity in scientific publications. However, given the peculiarities of the international patent system, it will only be possible to evidence the real effect of the last ZIKAV outbreak on patent filings in the next years. Moreover, specifically for the analyses of LAC countries' contributions, common delays in the publication of patent filings must be taken into consideration. For instance, publication of patent applications in Brazil may take longer than the usual 18 months, unless filed by the international PCT or specifically requested.

We intend to advance these analyses by looking into publication and patent content, detecting key leading institutions and identifying gaps in knowledge and technological development. This information may be used to adequately inform the international public health community and national policymakers, as well as to highlight the need for a continued interdisciplinary approach to improve our ability to prepare for, control and prevent future outbreaks.

References

- Albuquerque, P. C., Castro, M. J. C., Santos-Gandelman, J., Oliveira, A. C., Peralta, J. M., & Rodrigues, M. L. (2017). Bibliometric Indicators of the Zika Outbreak. *PLOS Neglected Tropical Diseases*, *11*(1), e0005132.
- Attaran, A. (2016). Off the podium: why public health concerns for global spread of zika virus means that Rio de Janeiro's 2016 olympic games must not proceed. *Harvard Public Health Review*. Retrieved from <http://harvardpublichealthreview.org/off-the-podium-why-rios-2016-olympic-games-must-not-proceed/>.
- Brasil, P., Pereira, J. P. J., Moreira, M. E., Ribeiro Nogueira, R. M., Damasceno, L., Wakimoto, M., Rabello, R. S., et al. (2016). Zika Virus Infection in Pregnant Women in Rio de Janeiro. *New England Journal of Medicine*, *375*(24), 2321–2334.
- Campos, G. S., Bandeira, A. C., & Sardi, S. I. (2015). Zika Virus Outbreak, Bahia, Brazil. *Emerging Infectious Diseases*, *21*(10), 1885–1886.
- CDC. (2014, November 5). Zika Virus. *CDC*. Retrieved April 6, 2018, from <https://www.cdc.gov/zika/specific-groups/funding.html>
- Codeço, C., Villela, D., Gomes, M. F., Bastos, L., Cruz, O., Struchiner, C., Carvalho, L. M., et al. (2016). Zika is not a reason for missing the Olympic Games in Rio de Janeiro: response to the open letter of Dr Attaran and colleagues to Dr Margaret Chan, Director - General, WHO, on the Zika threat to the Olympic and Paralympic Games. *Memórias do Instituto Oswaldo Cruz*, *111*(6), 414–415.
- Colón-González, F. J., Peres, C. A., Bernardo, C. S. S., Hunter, P. R., & Lake, I. R. (2017). After the epidemic: Zika virus projections for Latin America and the Caribbean. *PLOS Neglected Tropical Diseases*, *11*(11), e0006007.
- Diamond, M. S., & Coyne, C. B. (2017, December 4). Vaccines in 2017: Closing in on a Zika virus vaccine. *Nature Reviews Immunology*. Comments and Opinion, . Retrieved March 31, 2018, from <https://www.nature.com/articles/nri.2017.132>
- ECDC. (2016, May 23). Rapid risk assessment: Zika virus disease epidemic: potential association with microcephaly and Guillain–Barré syndrome - 6th update, 23 May 2016. *European Centre for Disease Prevention and Control*. Retrieved March 28, 2018, from <http://ecdc.europa.eu/en/publications-data/rapid-risk-assessment-zika-virus-disease-epidemic-potential-association-4>

- Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social networks*, 1(3), 215–239.
- Lowe, R., Barcellos, C., Brasil, P., Cruz, O. G., Honório, N. A., Kuper, H., & Carvalho, M. S. (2018). The Zika Virus Epidemic in Brazil: From Discovery to Future Implications. *International Journal of Environmental Research and Public Health*, 15(1).
- Meneghini, R., Mugnaini, R., & Packer, A. L. (2006). International versus national oriented Brazilian scientific journals. A scientometric analysis based on SciELO and JCR-ISI databases. *Scientometrics*, 69(3), 529–538.
- Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 106(1), 213–228.
- Mugnaini, R., Digiampetri, L. A., Mena-Chalco, J. P., Mugnaini, R., Digiampetri, L. A., & Mena-Chalco, J. P. (2014). Scientific communication in Brazil (1998-2012): Indexing, growth, flow and dispersion. *Transinformação*, 26(3), 239–252.
- RICYT. (2017). El estado de la ciencia. Principales Indicadores de Ciencia y Tecnología Iberoamericanos / Interamericanos. Retrieved April 4, 2018, from http://www.riicyt.org/files/Estado%20de%20la%20Ciencia%202017/El_Estado_de_la_Ciencia_2017_Completo.pdf
- Singh, R. K., Dhama, K., Karthik, K., Tiwari, R., Khandia, R., Munjal, A., Iqbal, H. M. N., et al. (2018). Advances in Diagnosis, Surveillance, and Monitoring of Zika Virus: An Update. *Frontiers in Microbiology*, 8. Retrieved March 28, 2018, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5780406/>
- Testa, J. (2016). A view from Web of Science: Journals, articles, impact. *Information Services & Use*, 36(1–2), 99–104.
- Vélez-Cuartas, G., Lucio-Arias, D., & Leydesdorff, L. (2016). Regional and global science: Publications from Latin America and the Caribbean in the SciELO Citation Index and the Web of Science. *El Profesional de la Información*, 25(1), 35–46.
- WHO, W. H. O. (2016). WHO Director-General summarizes the outcome of the Emergency Committee regarding clusters of microcephaly and Guillain-Barré syndrome. *WHO*. Retrieved March 28, 2018, from <http://www.who.int/mediacentre/news/statements/2016/emergency-committee-zika-microcephaly/en/>
- WHO, W. H. O. (2017a). Fifth meeting of the Emergency Committee under the International Health Regulations (2005) regarding microcephaly, other neurological disorders and Zika virus. Retrieved March 28, 2018, from <http://www.who.int/mediacentre/news/statements/2016/zika-fifth-ec/en/>
- WHO, W. H. O. (2017b). Zika: Response funding. *WHO*. Retrieved April 6, 2018, from <http://www.who.int/emergencies/zika-virus/response/contribution/en/>