Tuberculosis 95 (2015) 515–522

Contents lists available at ScienceDirect

Tuberculosis

journal homepage: http://intl.elsevierhealth.com/journals/tube

Density equalizing mapping of the global tuberculosis research architecture

David A. Groneberg [a, *], Esther Weber [a], Alexander Gerber [a], Axel Fischer [b, c], Doris Klingelhoefer [a], Doerthe Brueggmann [a, d]

[a] Department of Preventive Medicine, Institute of Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-University, Frankfurt, Germany
[b] Department of Medicine, Charité – Universitätsmedizin Berlin, Berlin, Germany
[c] Department of Pediatric Pneumology and Immunology, Charité – Universitätsmedizin Berlin, Berlin, Germany
[d] Department of Obstetrics and Gynecology, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

ARTICLE INFO

Article history:
Received 13 February 2015
Received in revised form
4 May 2015
Accepted 12 May 2015

Keywords:
Tuberculosis
Density equalizing mapping
Scientometrics
Bibliometrics
Citation rate

SUMMARY

Background: Tuberculosis belongs to the lung infectious diseases with the highest impact on global burden of disease. Yet there is no concise scientometric study about tuberculosis research. Therefore, the NewQiS project elected this subject as focus of an in depth analysis to perform density equalizing mapping in combination with scientometrics.
Method: In this retrospective study all publications related to tuberculosis research listed in the Web of Science database between 1900 and 2012 were identified, analyzed and submitted to density equalizing mapping procedures.
Results: In total 58,319 entries on TBC were identified with the USA being the most productive country with 11,788 publications, followed by the United Kingdom (4202), India (3456), France (2541), South Africa (1840), Germany (1747) and China (1427). Concerning the citations rate Denmark leads with 43.7 citations per article, followed by Latvia (39.1), Gambia (38.3), Senegal (34.9), and the Netherlands (31.4). Chart techniques demonstrates a widely ramified international network with a focus the joint work of USA, the UK and South Africa.
Conclusions: This is the first density equalizing and scientometric study that addresses tuberculosis research over a period of 112 years. It illustrates global tuberculosis research architecture and stresses the need for strengthening global research efforts and funding program.

1. Introduction

Tuberculosis belongs to the leading infectious causes of death worldwide. Although there are both effective and cheap treatment options available for most cases, the disease still affects millions worldwide [1]. In 2013, 9.0 million new cases of active tuberculosis worldwide with 1.5 million mortalities [2] were estimated.

Among these cases, multidrug-resistant tuberculosis, caused by organisms resistant to at least isoniazid and rifampin, poses a special thread for global public health. Only in 2013, there were about 315,000 incident cases (3.5%) of multidrug-resistant tuberculosis among patients who were reported to have tuberculosis [2].

Tuberculosis disproportionately affects the poorest people in both high-income and developing countries [1], and also poses a specific major threat to women's health security [3]. Hence, tuberculosis control programs were asked to be sensitive to the constraints faced by these groups [3], and public health initiatives surrounding this problem are of major importance.

In view of the importance of tuberculosis for public health, the New Quality and Quantity Indices in Science (NewQIS) project [4,5] aimed to assess this infectious disease. Our hypothesis was that there is a constant increase in the global scientific activity with an imbalance between the different continents. We used the NewQIS platform technology with a focus on gender mainstreaming and state of the art visualization techniques such as density equalizing mapping [6].

* Corresponding author. Tel.: +49 (0) 69 6301 6650; fax: +49 (0) 69 6301 7053.
E-mail addresses: arbsozmed@uni-frankfurt.de (D.A. Groneberg), weber.esther@web.de (E. Weber), gerber@med.uni-frankfurt.de (A. Gerber), axel.fischer@charite.de (A. Fischer), klingelhoefer@med.uni-frankfurt.de (D. Klingelhoefer), doerthe.brueggmann@med.usc.edu (D. Brueggmann).

http://dx.doi.org/10.1016/j.tube.2015.05.003

2. Methods

2.1. NewQIS platform

As technological basis for the present study the scientometric platform: “New Quality and Quantity Indices in Science” (NewQIS) was used [4,5]. NewQIS was established in 2008/2009 and combines novel visualizing techniques and analyzing tools for bibliometric parameters. A variety of studies on different medical topics and diseases were carried out in this context with reference to different areas of public health, health policy and research funding issues [7–9]. Also clinical areas have been in the focus including respiratory medicine [10,11], respectively oncology [12,13].

2.2. Data source

The scientific online database Web of Science (WoS, Thomson Reuters) was used as data source, as it supplies the Citation Report to extricate the numbers of citations [14]. These values are essential for all analyses based on the amount of the citations, including the citation rate and the h-index. Hence, all bibliometric information on the publications referring to Tuberculosis was retrieved from WoS and afterwards used as data source for the retrospective analyses.

2.3. Search routine

The search-term (tubercul* OR tuberkul*) was applied as TITLE search in the WoS search fields to clearly identify overall number publications on tuberculosis and secure the thematic connection. The search by means of the TOPIC-search tool (title, author's keywords, abstract) would lead to an enormous amount of publications that are not directly linked to the tuberculosis research. Additionally, the search was restricted to the document type “article” to focus the analyses on the publications that are defined as original research output. The evaluated time interval covered the years between 1900 (01-01) and 2012 (31-12).

2.4. Data processing

The retrieved data was analyzed related to different parameters, i.e. publication date, number of citations, source title and the author's institutional address that defines the country of origin of the publication. The analysis of the subject areas was based on the original WOS-categories that are corresponding to the areas of the publishing journals.

After data collecting and transferring the including information into different table sheets, the citation rate and the h-index have been calculated. The citation rate is the ratio of the total number of citations to the amount of articles. In this study it was used to evaluate the performance of the individual countries publishing on tuberculosis.

The Hirsch-index (h-index) is a parameter to assess the significance of the publishing performance of a scientific author. It is calculated from the author's number of publications and the number of their citations. That means an author has an index of h, if he has published h papers that are cited h times at least. A modified version of the author's h-index was applied as a country-specific parameter [15,16].

2.5. Geographical analyses

In order to evaluate the country of origin the retrieved information on the authors addresses have been evaluated, so that the analyses of the publishing countries and the amount of cooperating articles could be carry out. The geographical information was used to analyze the number of the publications, the citations and the country-specific h-index. For the visualization of the countries' citation rate and to minimize its overvaluation of single or few publications with a huge amount of citations we established a threshold of at least 30 publications per country.

The findings of the geographical distribution of the analyses were illustrated by means of density-equalizing map projections (DEMP) that are based on an algorithm of Gastner and Newman [6]. Using this approach, territories (countries) were resized in proportion to the different analysis parameters.

Regarding the determination of the international networks, a publication has been defined as a cooperation article if at least two authors, coming from different countries, contributed in its writing. Regarding the combination of subject areas, the WoS-categories have been analyzed according to their assignments to the overall publication output. The number of combinations of the different categories has been evaluated.

For the visualization of this cooperation, respectively combination analyses net diagrams were used that shows the common articles of different nations through connecting lines with different thicknesses.

3. Results

3.1. General indicators

In total, 58,319 articles on tuberculosis were identified in the online database WoS. Until the 1990th the level varies between 100 and 500 published articles per year. Afterwards a steady increase could be stated that shows its highest value in the last year of the analysis (2012) with annual 2658 articles (Figure 1). The analysis of the publication language revealed a clear dominance of English (85.5%), followed by French (5.9%), and German (5%).

The publications originated from 132 countries with the USA being the most productive county (11,788 articles). Amongst the ten most publishing countries the USA is followed by the United Kingdom (UK) with 4202 articles, India (3456 articles), France (2541 articles), South Africa (1840 articles), Germany (1747 articles) and China (1427 articles). Spain ranked 8th with 1380 articles, followed by Japan with 1194 and Brazil with 1172 articles respectively. The DEMP (Figure 2) shows that major parts of Asia except India, Africa except South Africa and South America except Brazil are minimized because of their low publication output, while the USA constitutes the scientific center, followed by European countries.

3.2. Citation analysis

Regarding the findings of the analysis of the total number of citations (Figure 3A), again, the USA represent the leading country with 325,875 received citations, followed by the UK with 119,605 citations. In contrast to the article output, France is ranked third with 51,775 citations, followed by South Africa with 42,218 citations. India is ranked 5th with 40,405 citations followed by the Netherlands (33,043), Germany (32,114), Switzerland (29,526), Canada (24,501) and Denmark (23,601) to describe the best ten.

After the calculation of the country citations rate and transfer to density equalizing mapping a different global picture appears (Figure 3B). Here, Denmark leads with a citation rate of 43.7, followed by Latvia (39.1), The Gambia (38.3), Senegal (34.9), Netherlands (31.4), Switzerland (29.9), Guinea-Bissau (29.2), UK (28.5), Zambia (28.4), Vietnam (28.0) and Peru (29.8). With a

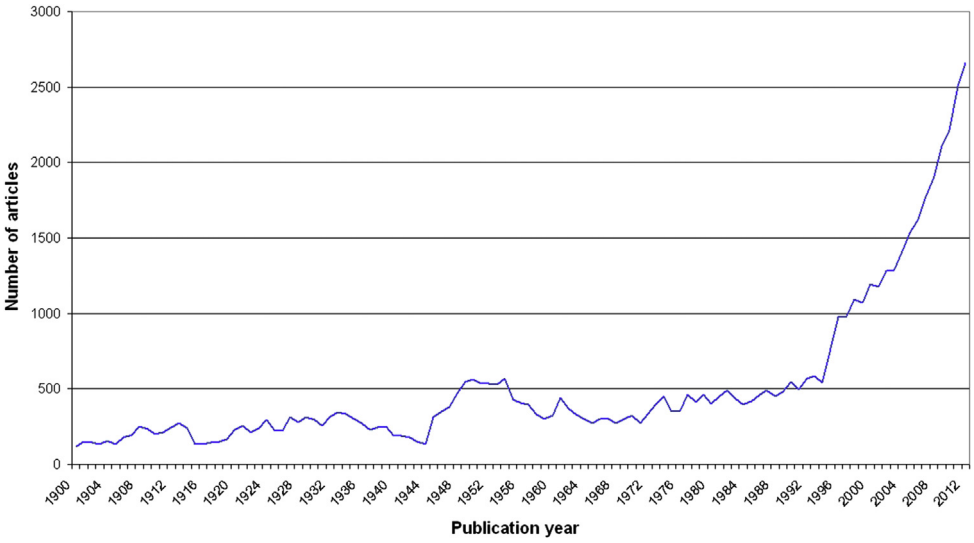

Figure 1. Number of articles over the time.

citation rate of 27.6 the USA is ranked only 11th in respect to the citation rate. Insofar, it is not positioned among the 10 leading countries (threshold = 30 articles).

The modified h-index of the countries shows again a different line up of countries (Figure 4). The USA leads with an h-index of 202, followed by the UK (128), France (97), the Netherlands (91), Switzerland (85), Germany (84), South Africa (83), Denmark (78), Canada (73) and India (71).

3.3. International cooperations

In total, 7366 of all publications were a result of an international cooperation. From which the most part (5372 articles) is resulting from a bilateral cooperation, followed by 1404 articles as output of trilateral cooperations. A cooperation network of 4 countries could be determined in 342 articles, and cooperations out of 5 international partners in 109 articles. While 51 articles have encompassed 6 countries in their common work.

A net diagram shows the intensity of cooperations between the different countries. Again, the USA dominates this parameter with 3045 cooperation articles among its total 11,788 publications (25.83%). The most common cooperation took part between the USA and the UK with 499 joint articles, followed by USA/South African (382) and UK/South African cooperations (368). The UK published 1978 of 4202 articles in collaboration (47.07%) and South Africa has written 49,61% of the tuberculosis articles in an international collaboration (1840 articles/913 cooperation articles) (Figure 5).

3.4. Subject area analysis

The assigned subject areas were analyzed regarding their proportion of the overall published articles on tuberculosis. The category *General & Internal Medicine* represents the most frequent subject area with 13,751 articles. It is followed by *Respiratory System* with 9221 publications. Also, *Infectious Diseases* with 7942 and *Microbiology* with 6091 publications are very frequent categories that are followed by *Immunology* (3511), *Public Environmental & Occupational Health* (3067), *Pharmacology & Pharmacy* (2035) and *Biochemistry & Molecular Biology* (1899).

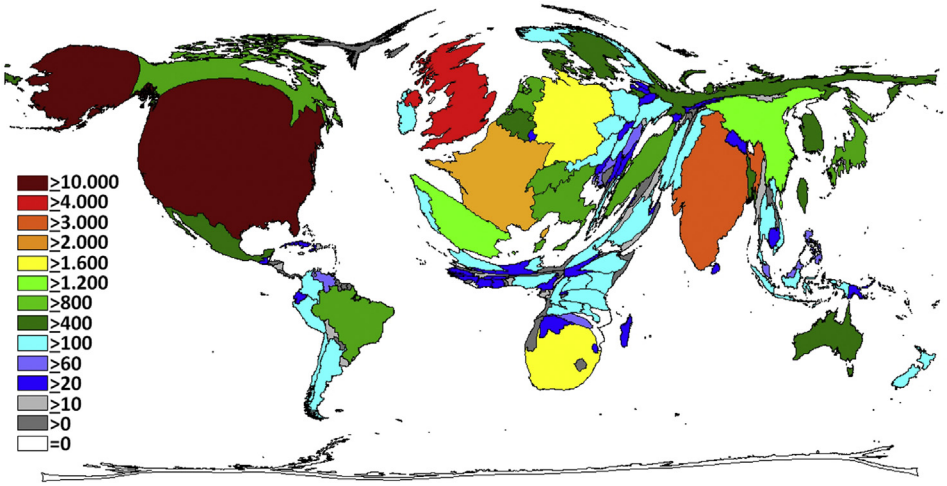

Figure 2. DEMP of the number of publications. Colors encode the numbers of publications.

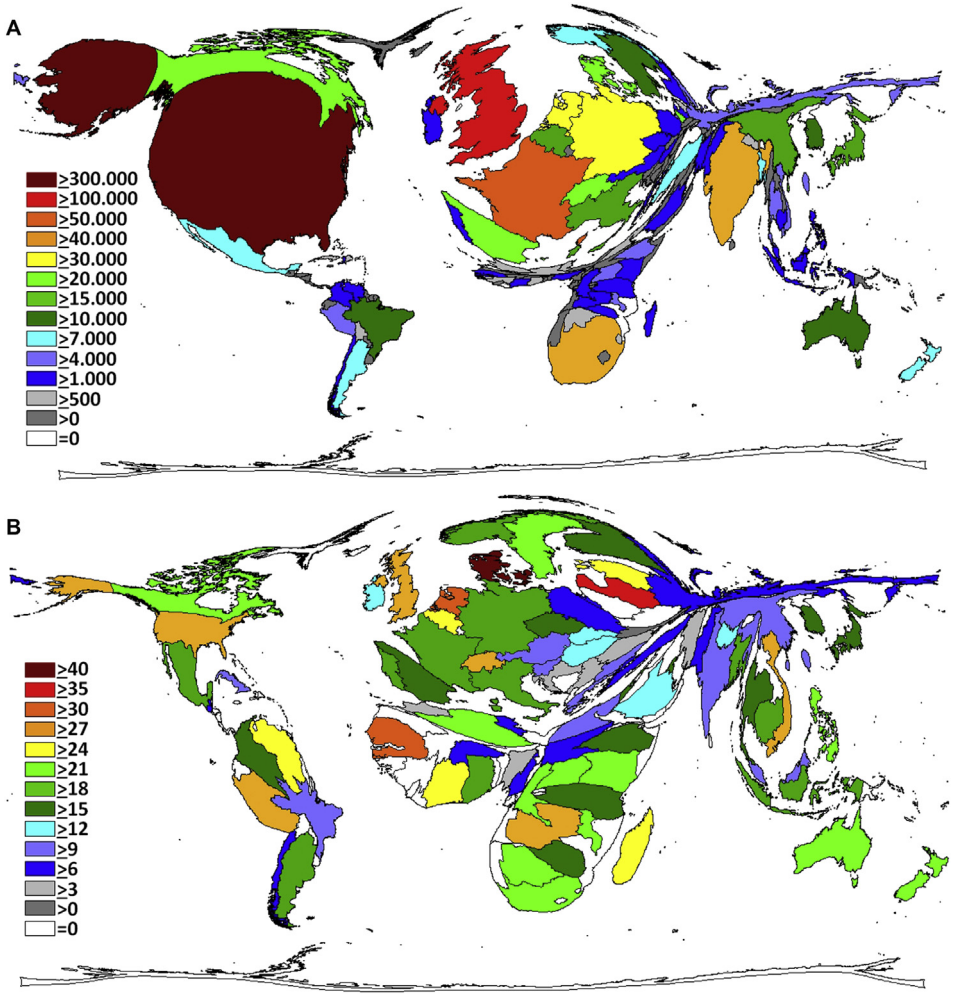

Figure 3. DEMP of the citation analysis. Colors encode citation rate. A) Number of citations. Colors encode numbers of total citations. B) Citation rate (threshold = 30 articles).

The analysis of the combination of the subject areas shows that the combination of *Respiratory System* and *Infectious Diseases* was most frequently assigned (3080 articles). As central area in the tuberculosis research *Infectious Diseases* still has 1723 common articles with *Microbiology* and 1019 with *Immunology* (Figure 6).

4. Discussion

Despite the high importance of tuberculosis regarding the areas of public health, infectious diseases, and pulmonary medicine, there is no thorough scientometric analysis so far. Therefore, the

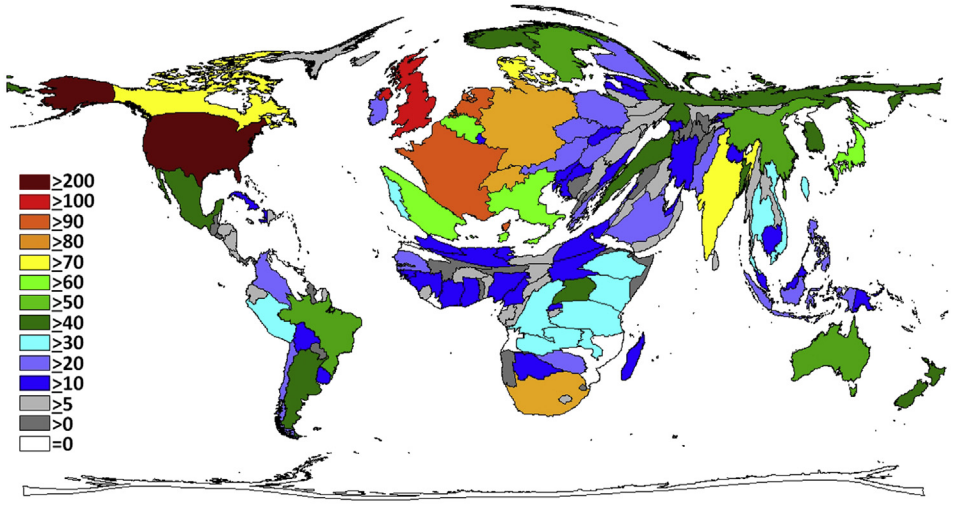

Figure 4. DEMP of the country-specific modified h-index. Colors encode h-index level.

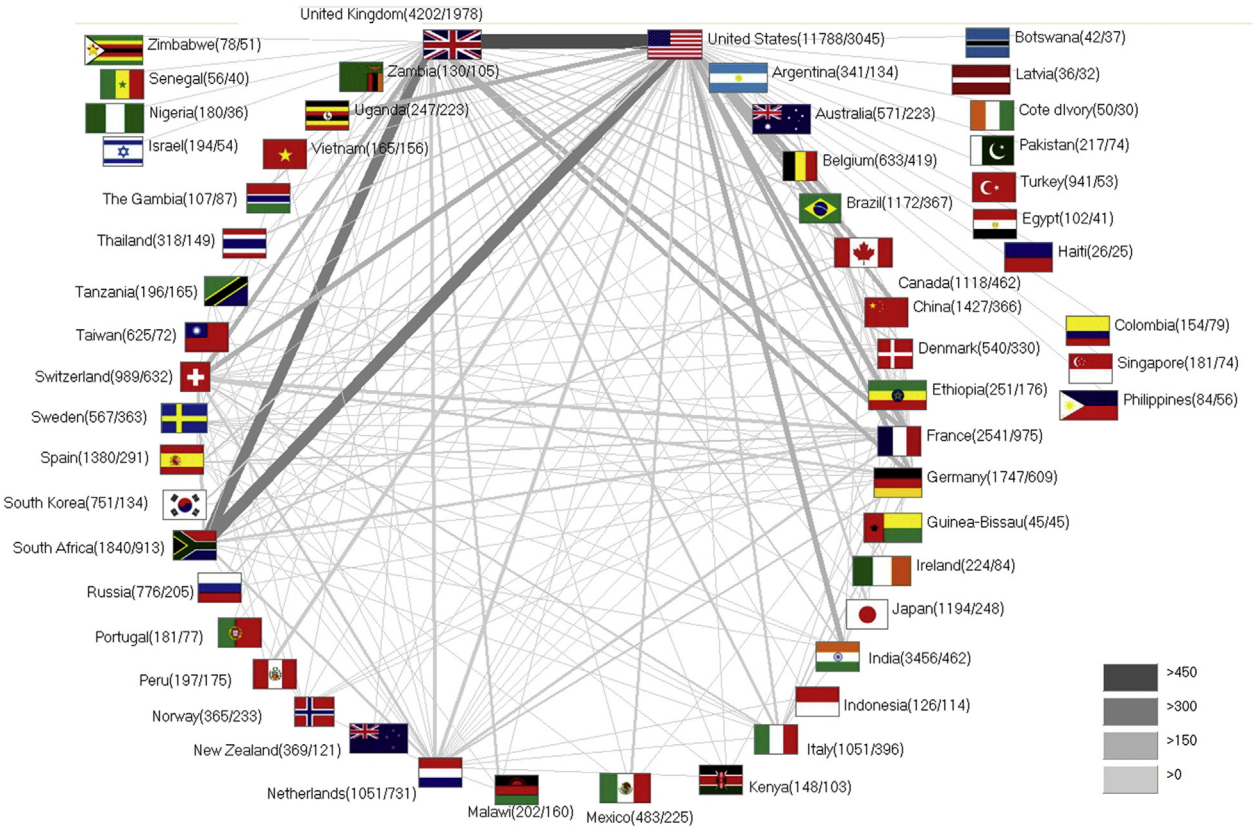

Figure 5. International cooperations. Gray scale and line thickness encode number of collaborations. Numbers in brackets: (total number of publication/total number of collaborations).

present study, which is embedded in the NewQIS study protocol, aimed to fill this gap. So it conducted an in-depth scientometric analysis combined with the visualization technique of DEMP of the global tuberculosis research. The reason why the NewQIS study panel team decided to undertake the study was two-fold. On the one hand the importance of tuberculosis from a global perspective and on the other hand the current problem of increasing multi-drug-resistant-tuberculosis has been leading to setting the focus on this disease.

The applied scientometric approaches with the NewQIS platform show the current and historical situation of tuberculosis research and offers the possibility to make statements of future trends that can lead to a better understanding and a more purposeful scientific progress. Insofar, the findings are important for prospective far-looking scientific decisions, to channel energies and to pool scientific resources that are basically important for assessment of the funding conditions. To understand the global mechanisms of research is necessary for the scientific community to help overcoming the threats of the global health through distinct disease patterns and especially these of tuberculosis.

Our hypothesis of a global imbalance of research activities regarding has been proofed to be correct. A bias of the applied methodology can certainly not be excluded and should be discussed. A first major issue to be addressed is the selection of the database as data source. In principle, the NewQIS studies use the WoS to collect the data. This is due to the possibility of a citation analysis by means of the here available tool “Citation Report”. Since the evaluation of various citation parameters is in the focus, PubMed could not serve as data source. PubMed does not provide tools for retrieving citation data. For this reason even J.E. Hirsch, who comes up with the h-index, suggests WoS as data source for scientometric analyses [15]. So the study could provide semi-qualitative statements about the impact of the publication output in the scientific community.

However, it needs to be taken into account that applying the same search string to the PubMed search would lead to a different – generally a higher – amount of published items. Since the requirements for listed journals are lower, PubMed shows more entries as WoS, but these additional publications to be found are not always of high interest for the research community due to the tremendous flood of new scientific journals and the herewith increasing number of low quality publications.

A second important issue to be addressed is the language bias. We here show a dominance of English publications. Like other online-databases too, the WoS has a clear preference for journals written in English. Therefore it is easier for English publishing journals to be listed. The limitation regarding the required Impact Factor for the inclusion of journals in WoS sets the focus on articles with a specific impact. These are more often English journals as well.

A third major issue is the described Matthew effect [17] that emphasizes the advantage of authors with an already high reputation, because they receive often credits out of portion through the reward system of science [17]. Thus, the Matthew effect may serve to heighten the visibility of contributions to science by scientists of acknowledged standing and to reduce the visibility of contributions by authors who are less well known.

The analysis revealed a number of 58,319 publications related to tuberculosis with a steady increase of the total number of published articles since the 1990s.

The country ranking with regard to the total amount of publications differs considerably from the countries' citation rates. In this respect, the superiority position of the USA cannot be

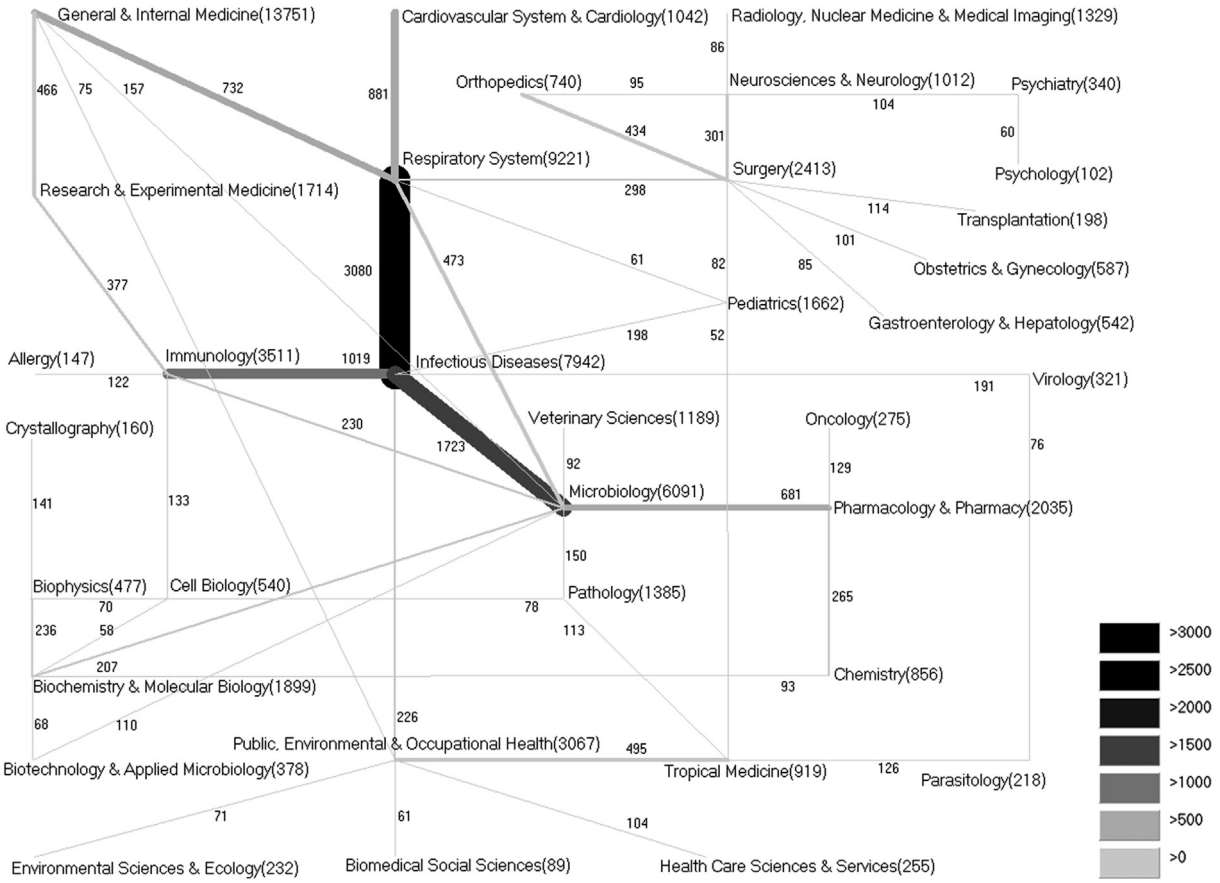

Figure 6. Subject area analysis according to the WoS-categories. Gray scale and line thickness encode the number of combinations. Numbers in brackets: (total number of subject area assignments within the tuberculosis articles).

confirmed. European countries like Denmark, Latvia and the Switzerland are among leading countries, while the USA only ranked 12th. Denmark gained 4091 citations with taking part – even with a much less significant contribution as the UK and France – in the leading publication on "deciphering the biology of *Mycobacterium tuberculosis* form the complete genome sequence" that was published in 1998 (Nature) [18]. Despite the outstanding individual impact of this article, the country-specific h-index of Denmark with a value of 78 puts it among the best ten countries. Conversely, Latvia has achieved its position through an article that is also related to the genetics of the *M. tuberculosis* in an international collaboration with other 23 nations [19]. That can be shown by the considerably lower modified h-index (18). Here, the overvaluation of few or single publications with a huge amount of citations that resulted from the application of the citation rate, has been compensated through the comparison of the calculation of the h-index.

Even African countries like Gambia, Senegal and Guinea-Bissau play an important role in the hierarchy of countries by evaluating their citation rates. While in Latvia, i.e., few very often cited publications leads to the high value, in the leading African Countries some multinational institutions play a very important role in the multinational network mostly with their former colonial countries. They produce a steady performance of frequently cited articles on tuberculosis. Here, the MRC Laboratories in Gambia can be mentioned. This is a British founded institute with a medical focus and subsidiaries in Guinea-Bissau. A efficient network with the University in Senegal is also existing. Additionally, the IRD (institute de recherché pour le développement) publish a couple of high cited articles. This is a French institute located in Senegal, The Gambia and Guinea-Bissau and contributes in this manner to the publication output of these countries.

In comparison to the research output on other infectious diseases the total number of published articles on tuberculosis is extremely high. Similar analyses have been carried out on yellow fever [20], influenza [21] and hepatitis B [22]. Only a number of 5053 publications on yellow fever could be identified [20] in the WoS, whereat the USA have had also the highest publication rate with 42% (751 publications), followed by Brazil with 203 publication, after all [20]. This large discrepancy between 58,319 publications on tuberculosis and 5053 on yellow fewer is most probably due to the higher epidemiological relevance of tuberculosis in relation to yellow fever, which is not prevalent in large parts of the world [23]. With regard to yellow fever, the USA is centered in the collaborating network with joint publications with Brazil and France. By contrast, the findings on tuberculosis shift the common works of USA and South Africa in the center of the international cooperations.

Conversely, the results on influenza were similar to the findings of the present study concerning the magnitude of research output. Influenza seems to be regarded as a major infectious health threat too, which led to a concentration of research activity that is comparable to tuberculosis research within a time span of over 100 years of research. As to that a number of 51,418 publications on influenza could be identified in the WoS that have been published from 151 different countries. Again, the USA accounted for the highest number of publications (19,194), followed by the UK (4614) and it has also been confirmed as main part of the international network too, together with Canada and Japan [21].

As another major infectious disease is hepatitis B [22] has been analyzed regarding the research output, but only in a relatively short time interval of 40 years from 1971 to 2011 so far. Interestingly, despite the lesser time span, as for this extreme high number of 49,166 items were published by 250 countries. The USA contributed her as well the largest part with 13,706 publications of the overall amount (28%), followed in considerable distance by Germany (3855). Together with China, the United Kingdom and France the main part of the international cooperating articles has been published.

The juxtaposition of these analyses confirms the leading position of the USA throughout a variety of different infectious diseases. In fact, one recent study analyzed the country-specific overall number of publications concerning single organs and other constituent parts oft the human organism with the following set: Brain, heart, artery, vein, lung, muscle, eye, nose, ear, throat, neck, skin, breast, stomach, intestine, pancreas, kidney, genital, hormone, arm, and feet [24]. Here, it was shown that the USA was the most productive country for every single issue. A remarkable difference was present in the individual focus of each country analyzed in the Scopus database [24]. The USA had a clear ranking with the primary focus on studies related to heart (1), brain (2), Muscle (3), liver (4) and lung (5). A similar focus is shared by Western countries such as the United Kingdom, Germany or Switzerland with an identical top 3 focus. However, the second most productive country Japan had its primary focus on articles related to the liver [24]. Countries that also primarily focus on the liver were China, Taiwan, South Korea and India [24]. This indicated a global research focus pattern which however, does not seem to influence tuberculosis research.

In conclusion, we here present the first in-depth scientometric analysis in combination with DEMP on tuberculosis research. The data demonstrate a high level of research activity over a period of 112 years that will be continuing for the foreseeable future.

Authors' contributions

DAG and DB have initiated the study, supervised the project and participated in the analyses and interpretation. EW has carried out the main data analysis and interpretation within her doctoral thesis. AG, AF and DK have participated in the discussion of the results and drafting of the manuscript. All authors have read and approved the final manuscript.

Acknowledgments

We thank Cristian Scutaru for his contribution in establishing NewQIS.

Funding

None.

Competing interests

The authors declare that they have no competing interests.

Ethical approval

Not required.

References

[1] Zumla A, Raviglione M, Hafner R, von Reyn CF. Tuberculosis. N Engl J Med 2013;368:745–55. http://dx.doi.org/10.1056/NEJMra1200894.

[2] WHO. Tuberculosis report 2014. WHO library cataloguing-in-publication data. 2013. NLM classification: WF 300.

[3] Connolly M, Nunn P. Women and tuberculosis. World Health Stat Q 1996;49:115–9.

[4] Groneberg-Kloft B, Quarcoo D, Scutaru C. Quality and quantity indices in science: use of visualization tools. EMBO Rep 2009;10:800–3. http://dx.doi.org/10.1038/embor.2009.162.

[5] Groneberg-Kloft B, Fischer TC, Quarcoo D, Scutaru C. New quality and quantity indices in science (NewQIS): the study protocol of an international project. J Occup Med Toxicol 2009;4:16. http://dx.doi.org/10.1186/1745-6673-4-16.

[6] Gastner MT, Newman ME. Diffusion-based method for producing density-equalizing maps. Proc Natl Acad Sci U S A 2004;101:7499–504. http://dx.doi.org/10.1073/pnas.0400280101.

[7] Groneberg DA, Schilling U, Scutaru C, Uibel S, Zitnik S, Mueller D, Klingelhoefer D, Kloft B. Drowning – a scientometric analysis and data acquisition of a constant global problem employing density equalizing mapping and scientometric benchmarking procedures. Int J Health Geogr 2011;10:55. http://dx.doi.org/10.1186/1476-072x-10-55.

[8] Groneberg-Kloft B, Scutaru C, Fischer A, Welte T, Kreiter C, Quarcoo D. Analysis of research output parameters: density equalizing mapping and citation trend analysis. BMC Health Serv Res 2009;9:16. http://dx.doi.org/10.1186/1472-6963-9-16.

[9] Groneberg-Kloft B, Kreiter C, Welte T, Fischer A, Quarcoo D, Scutaru C. Interfield dysbalances in research input and output benchmarking: visualisation by density equalizing procedures. Int J Health Geogr 2008;7:48. http://dx.doi.org/10.1186/1476-072x-7-48.

[10] Groneberg-Kloft B, Dinh QT, Scutaru C, Welte T, Fischer A, Chung KF, Quarcoo D. Cough as a symptom and a disease entity: scientometric analysis and density-equalizing calculations. J Investig Allergol Clin Immunol 2009;19:266–75.

[11] Groneberg-Kloft B, Scutaru C, Dinh QT, Welte T, Chung KF, Fischer A, Quarcoo D. Inter-disease comparison of research quantity and quality: bronchial asthma and chronic obstructive pulmonary disease. J Asthma 2009;46:147–52. http://dx.doi.org/10.1080/02770900802503115.

[12] Glynn RW, Lowery AJ, Scutaru C, O'Dwyer T, Keogh I. Laryngeal cancer: quantitative and qualitative assessment of research output, 1945–2010. Laryngoscope 2012;122:1967–73. http://dx.doi.org/10.1002/lary.23401.

[13] Healy NA, Glynn RW, Scutaru C, Groneberg D, Kerin MJ, Sweeney KJ. The h index and the identification of global benchmarks for breast cancer research output. Breast Cancer Res Treat 2011;127:845–51. http://dx.doi.org/10.1007/s10549-011-1436-z.

[14] Gerber A, Klingelhoefer D, Groneberg DA, Bundschuh M. Silicosis: geographic changes in research: an analysis employing density-equalizing mapping. J Occup Med Toxicol 2014;9:2. http://dx.doi.org/10.1186/1745-6673-9-2.

[15] Hirsch JE. An index to quantify an individual's scientific research output. Proc Natl Acad Sci U S A 2005;102:16569–72. http://dx.doi.org/10.1073/pnas.0507655102.

[16] Hirsch JE. Does the H index have predictive power? Proc Natl Acad Sci U S A 2007;104:19193–8. http://dx.doi.org/10.1073/pnas.0707962104.

[17] Merton RK. The Matthew effect in science: the reward and communication systems of science are considered. Science 1968;159:56–63. http://dx.doi.org/10.1126/science.159.3810.56.

[18] Cole ST, Brosch R, Parkhill J, Garnier T, Churcher C, Harris D, Gordon SV, Eiglmeier K, Gas S, Barry 3rd CE, Tekaia F, Badcock K, Basham D, Brown D, Chillingworth T, Connor R, Davies R, Devlin K, Feltwell T, Gentles S, Hamlin N, Holroyd S, Hornsby T, Jagels K, Krogh A, McLean J, Moule S, Murphy L, Oliver K, Osborne J, Quail MA, Rajandream MA, Rogers J, Rutter S, Seeger K, Skelton J, Squares R, Squares S, Sulston JE, Taylor K, Whitehead S, Barrell BG. Deciphering the biology of *Mycobacterium tuberculosis* from the complete genome sequence. Nature 1998;393:537–44. http://dx.doi.org/10.1038/31159.

[19] Brudey K, Driscoll JR, Rigouts L, Prodinger WM, Gori A, Al-Hajoj SA, Allix C, Aristimuno L, Arora J, Baumanis V, Binder L, Cafrune P, Cataldi A, Cheong S, Diel R, Ellermeier C, Evans JT, Fauville-Dufaux M, Ferdinand S, Garcia de Viedma D, Garzelli C, Gazzola L, Gomes HM, Guttierez MC, Hawkey PM, van Helden PD, Kadival GV, Kreiswirth BN, Kremer K, Kubin M, Kulkarni SP, Liens B, Lillebaek T, Ho ML, Martin C, Martin C, Mokrousov I, Narvskaia O, Ngeow YF, Naumann L, Niemann S, Parwati I, Rahim Z, Rasolofo-Razanamparany V, Rasolonavalona T, Rossetti ML, Rusch-Gerdes S, Sajduda A, Samper S, Shemyakin IG, Singh UB, Somoskovi A, Skuce RA, van Soolingen D, Streicher EM, Suffys PN, Tortoli E, Tracevska T, Vincent V, Victor TC, Warren RM, Yap SF, Zaman K, Portaels F, Rastogi N, Sola C. *Mycobacterium tuberculosis* complex genetic diversity: mining the fourth international spoligotyping database (SpolDB4) for classification, population genetics and epidemiology. BMC Microbiol 2006;6:23. http://dx.doi.org/10.1186/1471-2180-6-23.

[20] Bundschuh M, Groneberg DA, Klingelhoefer D, Gerber A. Yellow fever disease: density equalizing mapping and gender analysis of international research output. Parasit Vectors 2013;6:331. http://dx.doi.org/10.1186/1756-3305-6-331.

[21] Fricke R, Uibel S, Klingelhoefer D, Groneberg DA. Influenza: a scientometric and density-equalizing analysis. BMC Infect Dis 2013;13:454. http://dx.doi.org/10.1186/1471-2334-13-454.

[22] Schmidt S, Bundschuh M, Scutaru C, Klingelhoefer D, Groneberg DA, Gerber A, Hepatitis B. global scientific development from a critical point of view. J Viral Hepat 2013. http://dx.doi.org/10.1111/jvh.12205.

[23] Jentes ES, Poumerol G, Gershman MD, Hill DR, Lemarchand J, Lewis RF, Staples JE, Tomori O, Wilder-Smith A, Monath TP. The revised global yellow fever risk map and recommendations for vaccination, 2010: consensus of the Informal WHO Working Group on Geographic Risk for Yellow Fever. Lancet Infect Dis 2011;11:622–32. http://dx.doi.org/10.1016/s1473-3099(11)70147-5.

[24] Groneberg-Kloft B, Scutaru C, Kreiter C, Kolzow S, Fischer A, Quarcoo D. Institutional operating figures in basic and applied sciences: scientometric analysis of quantitative output benchmarking. Health Res Policy Syst 2008;6:6. http://dx.doi.org/10.1186/1478-4505-6-6.