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# Data and Social Network Analysis on Malaria

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**Abstract** - In order to understand the existent and in formation relationships that might surface from scientific publications it is necessary to use methods for data and network analysis, besides the concepts of information flow and knowledge creation within organizations. The aim of this work was to show the application of tools and methods for data and network analysis and how those methods can bring forward proposals to improve the understanding of a specific disease, Malaria, within the scientific publications. The study of relational data retrieved from different databases might be elucidating in an environment, health system, which happens to be quite complex due to its many elements involved. How these elements interact within each other in order to fulfill the need to serve the population needs to be understood. The study of scientific publications is just one of the areas that might help decision makers have a better grasp on how to deal and focus on the needed areas.

**Keywords** - Scientific and technological vision, bibliometric, graphs, social networks, geo-strategy, visualization, interactivity, neglected diseases, malaria

## I. INTRODUCTION

The use of data and social analysis tools has become a very important technique in order to find and retrieve relevant information. With the use of massive storage spaces and great amounts of data new technologies for sorting, retrieving and visualizing this information is necessary. The use of data analysis on scientific publications facilitates and bring forward information that could not been found with ancient data analysis methods.

The research universe defined for this study is Malaria disease contained in the so-called neglected tropical diseases (NTD). The term NTD refers to a group of diseases that are especially endemic in low-income populations living in tropical and subtropical countries. However, up to this date, there are no clear or agreed definitions of what a neglected disease is constituted by. According to the 2010 report from the World Health Organization (WHO) “Working to Overcome the Global Impact of Neglected Tropical Diseases” the NTDs affect more than 1 billion people around the world.

The known diseases are defined by the WHO as types I, II and III where Malaria is considered a type III disease. The definition includes the wealth of a country between rich and poor, the state of its development between developed and developing and most importantly a measure of the burden of diseases by the incidence of the disease within the population (CEWG 2012). The definitions themselves are combined such that:

- Type I diseases: are incident in both rich and poor countries, with large numbers of vulnerable populations in each, example cancer.
- Type II diseases: are incident in both rich and poor countries, but with a substantial proportion of the cases in poor countries, example tuberculosis.
- Type III diseases: are those that are overwhelmingly or exclusively incident in developing countries, example malaria.

With regard to investments in the area, those diseases do not receive adequate attention for its treatment and eradication, which perpetuates the condition of people who are exposed to them [1].

It's imperative that new tools and approaches being developed focus on facilitating public policy planning and foster the management of innovation in countries' public health systems [2]. Recent studies on Leishmaniasis [3] and Chagas disease [4] used the Medline database and helped us with the understanding and alignment of our work. A comparison with results for co-authorship research [5] has also been made in regards to the same database analyzing the relationships within the scientific community.

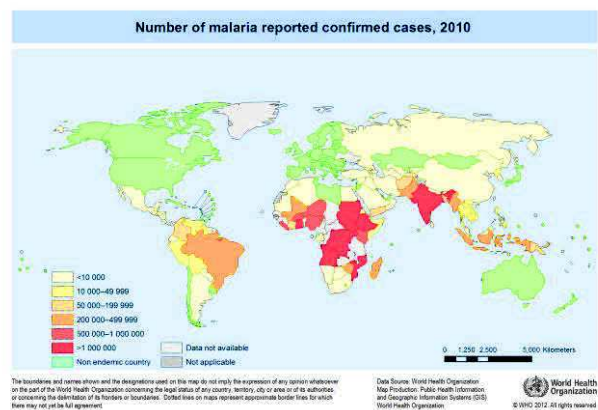


Figure 1 – World Map of Malaria Endemic countries. font (WHO.2012)

According to the World Malaria Report [6] in 2010 there were an estimated 219 million cases and 660.000 deaths. Malaria is present in over 100 countries and threatens half of the world's population. In sub-Saharan Africa malaria is the single largest cause of death for children under five. However there is an expectation of 75% reduce in malaria cases by 2015 compared to year 2000 due to investments and collaborative work. Investments in the area have grown significantly in the

past years from less than US\$ 100 million in 2000 to US\$ 1.71 billion in 2010. The increased investments have their consequences on the significant growth of research on the area. Figure 1 shows a world map of malaria endemic countries such that the countries in orange and red are the most affected ones.

## II. DATA ANALYSIS OF A NEGLECTED DISEASE

The use of data analysis for neglected diseases through bibliometric or social network on scientific publications is a way to help managers on different positions cope with the necessity to view and take decisions on those areas based on reliable information regarding research. The use of tools and technologies on those areas has helped to find and manage information on large sets of data.

### A. METHOD FOR DATA TREATMENT

For the data treatment and analyses we used the platform software Tetralogie. The software allows several and remote users to conduct strategic analysis from heterogeneous textual data through analysis of conventional and innovative methods. With statistical methods and exploratory data analysis methods, it shows strategic information such as actors identity, mobility, emergence and evolution of topics, concepts and terminology. Another feature of the software is that it allows graphical visualization for understanding human activities and their interactions as well as their evolution in a decision-making perspective. It combines static and dynamic visualization where the static aspect is based on a representation space, in which the precepts of graph theory are applied. The dynamic visualization applies features and capabilities to further understand evolution of the data and facts in respect to time. Tetralogie allowed us to identify the role of data within the structure, analyzing their neighborhood, filtering, k-core, transitivity, back to the source documents, to partition the graph or to focus on its structural features [7].

### B. DATA RETRIEVED

For this study we have used the PubMed database, which accesses the Medline database. PubMed is a free database accessing references and abstracts on life sciences and biomedical topics. The access to the database occurred during the months of May and June, 2013. We have decided to take into consideration only the publications and patents from 2000 to 2012 included.

The research has been made taking into consideration authors of articles, countries where those authors were from, journals used for the scientific publications besides MeSH (Medical Subject Headings). Data files were retrieved from PubMed with the term/descriptor "Malaria" for title and abstract.

In regards to the number of publications for the years studied we have retrieved 27.880 articles containing a total of 51.720 authors from 121 different countries. The number of journals added up to 2.330, however only 412 of those had 10 or more articles in the area. The number of MeSH words filed on those articles were 8.890 from which the top 09 MeSH words were mentioned more than 10.000 times.

## III. NETWORK ANALYSIS

The pattern of relationships of a system can be represented as a network where system components are the vertices and the connections between them ties. The structure of these networks and the specific pattern that might arise from its analyses has a major impact on the behavior of the system and its informational structures. Understand patterns in existing socio-technical networks and to intervene in these networks is one of the possibilities raised by this study.

The Network Analysis or Social Network Analysis (SNA) includes an extensive set of methods for assessing the structure of social groups [8], [9]. The use of SNA enables differentiated perception of a social environment. With this tools a new phenomena can be investigated and new hypotheses can be established. The SNA is derived from both the social sciences and the exact sciences, and their applications are enhanced by the ability to compute mathematical calculations and modeling as well as the expansion of communication networks and the use of digital environments.

The SNA brought interest from researchers in different fields of knowledge. In attempt to understand the impact of the relationship structure on networked environments, SNA gave rise to several analysis methods, which were based on the relationships between individuals or other type of elements, in a structured shaped network.

A social network consists of one or more finite sets of actors (vertices) and the defined relationships between them. The actors in a social network can be either individuals or companies, analyzed as individual units, as well as collective social units, for example, departments within an organization, public service agencies, nation-states of a continent or the world. The concept of actor is flexible, allowing different levels of aggregation, which allows its adaptation to different research problems [9].

A network is a simplified representation of a system that is reduced to an abstract structure consisting largely of patterns of relationships among the vertices. The vertices and lines can have extra information like names or size so that more details about the system can be captured. However, even with this extra information still much information is lost in the process of reducing an entire system on a network representation [5].

Besides these scholars, work done in the area of biotechnology and in the area of neglected diseases in NTDs endemic countries has been a reference to this scientific work. Dr. Carlos Morel Medici has published a series of articles using the methods of SNA to relate co-authorship in scientific research [1]. In France Dr. Brigitte Gay has conducted research on partnerships in the biotechnological industry and how these partnerships can define the success or failure of their companies [11], [12].

## IV. RESULTS

The first step on our study was to understand the growth in regards to the numbers of publications and authors per year as seen in figure 2.

As can be seen on the figure, more publications have a direct relation to increased number of authors. With more and

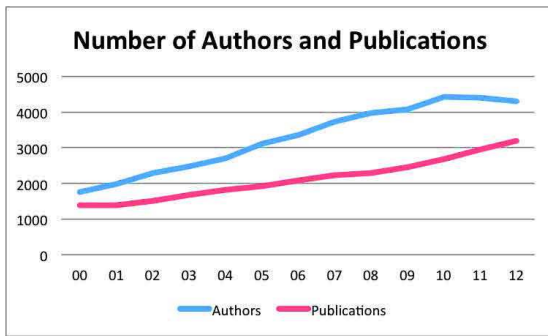


Figure 2 – Authors and Publications per year

new researchers involved the area tend to be more dynamic and new finds could help solve issues related to the disease. The total number of publications and authors has increased steadily the past 13 years which might collaborate with the investments in the area and the reduce expectation of malaria cases. The total number of publications has almost double on those years while the number of authors in the area has increased almost 2,5 times.

#### A. COUNTRIES, JOURNALS AND AUTHORS PUBLICATIONS

In regards to country publications we can see a growth in interest, which has more than doubled the number of publications since 2000 in most countries but more so on countries with endemic problems such as India, Thailand, Nigeria, Kenya and Brazil. Those countries are becoming more involved in research, and due to its close relation to the disease there is an urge to find solutions. However, countries such as USA, UK, France and Australia still play an important role on research and publications. The financial support received by those countries on research and technologies has helped millions of people. Figure 3 shows an overview of the world map in terms of publications on PubMed. The countries with a lighter green have more publications than countries with darker green. In the past few years countries such as India, Brazil and China, which are part of the “BRICS”, have had an important role over those researches.

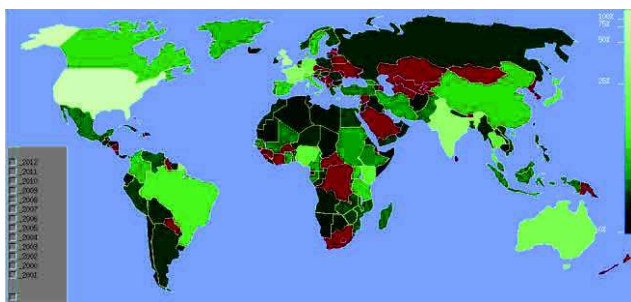


Figure 3 – Country Publication

Another area for our study was the Journal’ publications which is also an important feature to be analysed in scientific research. More journals interested in the area directly result in more publications and more research. Table 1 shows the journals with the highest number of publications over the past 13 years. The journals with higher degree of interest in the area, in regards to the number of publications are Malaria Journal in the top of the list with 2.110 publications over the

period followed by The American Journal of Tropical Medicine and Hygiene with 1.209 publications.

Table 1 – Top Journals by the number of publications per year

Journals	Number of Publications per Year (2012 – 2001)													
	Sum	'12	'11	'10	'09	'08	'07	'06	'05	'04	'03	'02	'01	'00
Malaria Journal	2110	409	361	350	308	250	161	112	59	43	41	16	0	0
American Journal of Tropical Medicine	1209	82	82	95	87	65	152	135	100	110	102	71	82	46
Plos One	841	278	219	136	91	78	37	2	0	0	0	0	0	0
Tropical Medicine International Health	550	25	32	24	31	33	48	61	54	66	56	49	34	37
Trans of the Royal Society of Tropical Medicine and Hygiene	510	17	12	38	49	37	43	48	43	32	49	50	45	47
Journal of Infected Diseases	429	37	34	30	40	34	38	40	48	31	29	25	23	20
Infection and Immunity	433	21	22	30	24	28	32	42	50	47	34	33	26	44
Acta Tropical	413	58	25	44	44	30	20	39	43	47	23	18	11	11
Trends in Parasitology	387	22	29	31	27	49	32	26	34	29	37	32	39	0
Lancet	358	22	24	37	29	17	21	27	23	45	22	30	30	31

As for the authors we can notice on table 2 that some of them have a higher number of publications, much greater than the average researcher on the area. The top 10 authors for example have more than 150 publications (11 are shown in the table) over the period while the mean number of publications per author is 2,3. This demonstrates a high concentration or centrality in a network. One problem that we might encounter in researching over authors publications is their alias or different formats for ones own names such as smith t or smith .t .a which might characterize the same person. To partially resolve the problem, Tetralogie creates a synonymous table for authors and other elements as needed. For the data analysed there were a table with 7.036 author synonymous, so for those authors all their publications were added up to one name.

Table 2 – Author Publication

Journals	Number of Publications per Year (2012 – 2001)													
	Sum	'12	'11	'10	'09	'08	'07	'06	'05	'04	'03	'02	'01	'00
White, N	310	37	29	25	20	27	21	22	22	26	21	21	18	21
Looareesuw	221	0	1	4	3	13	16	19	18	29	30	25	37	26
Kremsner, P	208	9	15	13	19	12	18	16	22	18	20	17	14	15
Marsh, K	193	12	16	14	19	16	20	16	22	15	8	17	10	8
Snor, R	182	14	14	25	16	18	10	17	15	14	9	15	5	10
Dumbo, O	175	20	23	18	19	15	17	14	19	9	6	7	4	4
Nosten, F	172	29	20	16	9	17	14	11	10	13	8	6	11	8
Rosenthal, P	168	18	18	19	19	17	15	16	7	13	10	7	5	4
Greenwood	159	6	6	21	17	18	16	12	5	5	8	8	6	10
Alonso, P	151	26	25	10	23	16	10	8	3	7	5	7	5	6
Smith, T	138	17	10	5	9	9	14	27	8	10	8	9	7	5

The understanding of the participation of those authors during the period is also important. Figure 4 shows an analysis on individual authors called “Histogram of the Individual” over the period from 2000 to 2012, where the red bar demonstrate the number of publications for that particular year. As an example we have chosen authors with different characteristics such as author that has just come into the field in regards to publications (top graph) and only has published on the past 5 years (2008 to 2012). Authors that have not published during a period of time (middle graph) (dud not publish on 2006, 2007



and 2008); Or authors which have been consistent and present during the entire period (published all years from 2000 to 2012).

This type of analysis can be used to verify individual behaviours on specific authors, such patterns on publications.

*B. SOCIAL AND MORPHOLOGICAL NETWORKS ANALYSIS*

As we have mentioned on this study new forms of analysis must take place in order to better understand the information that is available. One of those forms is the network analysis,

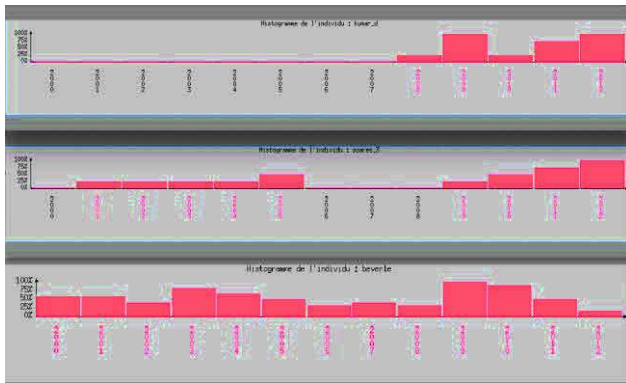


Figure 4 – Author Individual Publication per Year

which consists of an analysis over the relationship amongst people or words over those publications. The most common and already in use over scientific publications is the social network analysis where authors, which have co-author a paper, demonstrate a relationship and so can be analyzed as such. One important issue related to visual analysis is the ability to understand what has been presented, which might become a problem when we are dealing with large sets of data such as the case of scientific publications. Before we can make any sense of what might appear on a network graph it is necessary to sort the data that is most important or relevant at the moment.

Figure 5 shows 3 tables for an author relationship with a lower density for the ones in the right compared to the previous one in the left. The left most table on figure 5 shows the authors with 5 or more publications, over the period study, and its relationships. An author defined on the x axis, that have co-author a paper with another author, on y axis, will have a red dot over its column and on the respective line for its companion. Once we were dealing with more than 50.000 authors, the size of the table, without the correct filters might become an issue. Noticed that on that figure there is a great density where most of the authors have relationships with several of its peers. The red line crossing the center is where the author relates to itself on the x and y axis and is not considered. Because the table is a symmetric matrix all the dots

on the left of the center line will appear on the right side of that line.

One of the analyses for that graph is the clustering coefficient, which were 0,496 for the Malaria co-authorship. The clustering coefficient measures network “clustering” or “transitivity,” which is the probability that two of a scientist’s coauthors have themselves coauthored a paper. In science a high clustering coefficient would suggest that people are working together quite often, while a very detached network, as in patents for example, might suggest that people very rarely contribute with people outside its group. This demonstrates that on the malaria research environment people tend to collaborate quite often with each other. This is also true for other areas of research [5].

The middle table shows the relations amongst authors that have worked together on at least two occasions (publications) and the right most table authors that have worked together on at least three occasions. From the rightmost table we focus our analysis on the area where there is a greater concentration (top left) of relationships and from there we draw figure 6.

The social network analysis consists of understanding the connections (relations) existent over the network. Each red dot on figure 6 denotes a researcher and each line a relationship with another researcher. People with more connections have worked with more people and in consequence they have a higher centrality. Some interesting connections happen also amongst clusters. On Figure 6 we have 3 clusters that are connected with each other by few people. Those researchers might not have a higher centrality degree (absolute number of connections) but are key to keep the network together and help the flux of information. For this network we are showing authors that have at least 5 publications over the period and that have worked together on publications on three different occasions. The graph is only a partial view of the third table on figure 5.

A number of conclusions could be made with a simple visualization analysis over the graph. The authors, for example, with higher centrality might have the ability to influence a greater number of people. On the other hand, those same authors are exposed to a great number of ideas. As for the researchers that make the connections between clusters we can say that they might work as gate keepers and are the ones responsible to share new ideas to their own group or close related friends. A closer study over each individual author and its own work is necessary to further understand the possibilities and implications of such a graph but for the purpose of this work we have only raised the issue without a deeper analysis. The graph helps us to pinpoint the most important players and the ones we should pursue a further study.

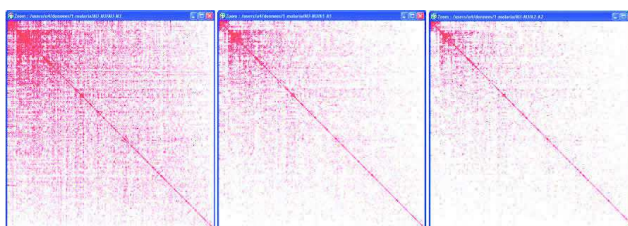


Figure 5 – Author relationship tables

