

# BMJ Open

## Respiratory Syncytial Virus: The architecture of the global research output and the gender distribution

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-013615
Article Type:	Research
Date Submitted by the Author:	25-Jul-2016
Complete List of Authors:	Brueggmann, Doerthe; Keck School of Medicine of the University of Southern California, Ob/Gyn; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Köster , Corinna ; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Klingelhoef, Doris; Goethe University, Institute of Occupational Medicine Bauer, Jan; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Ohlendorf, Daniela; Institute of Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-University Frankfurt/Main, ; Bundschuh, Matthias; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Groneberg, David; Occupational, Social and Environmental Medicine, Medical Department of the Goethe-University Frankfurt am Main
<b>Primary Subject Heading</b>:	Infectious diseases
Secondary Subject Heading:	Global health, Paediatrics, Public health, Respiratory medicine
Keywords:	Respiratory Syncytial Virus, Scientometry, Publication, Gender, Economic benchmarks

SCHOLARONE™  
Manuscripts

1  
2  
3 **1 Respiratory Syncytial Virus:**

4  
5 **2 The architecture of the global research output and the gender distribution**

6  
7 3

8  
9  
10 4 Corresponding author: Dörthe Brüggmann – [occup-med@uni-frankfurt.de](mailto:occup-med@uni-frankfurt.de), Institute of  
11  
12 5 Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-  
13  
14 6 University, Theodor-Stern Kai 7, 60590 Frankfurt, Germany

15  
16 7 Telephone: +49 (0) 69 6301 6650, Fax +49 (0) 69 6301 7053

17  
18 8

19  
20  
21 9 Dörthe Brüggmann<sup>1,2,\*</sup>, Corinna Köster<sup>2,\*</sup>, Doris Klingelhöfer<sup>2</sup>, Jan Bauer<sup>2</sup>, Daniela  
22  
23 10 Ohlendorf<sup>2</sup>, Matthias Bundschuh<sup>2</sup>, David A Groneberg<sup>2</sup>

24  
25 11

26  
27 12 <sup>1</sup> Department of Obstetrics and Gynecology, Keck School of Medicine of USC, Los  
28  
29 13 Angeles, California, United States

30  
31 14

32  
33  
34 15 <sup>2</sup> Institute for Occupational Medicine, Social Medicine and Environmental Medicine,  
35  
36 16 Goethe University Frankfurt, Germany

37  
38 17

39  
40 18 \* equal contribution

41  
42 19

43  
44  
45 20 Word Count: 3882

46  
47 21

48  
49 22

1  
2  
3 **23 Abstract**  
4

5 24 Objective: Worldwide, the respiratory syncytial virus (RSV) represents the  
6  
7 25 predominant viral agent causing bronchiolitis and pneumonia in children. To conduct  
8  
9 26 research and tackle existing healthcare disparities, RSV-related research activities  
10  
11 27 around the globe need to be decoded. Hence, we aim to assess the associated  
12  
13 28 country-specific scientific architecture in relation to socio-economic and gender  
14  
15 29 parameters.  
16

17  
18 30 Design: retrospective, descriptive study  
19

20  
21 31 Setting: We employed the NewQIS platform to identify RSV-related articles published  
22  
23 32 in the Web of Science from 1900 to 2013. Items were analyzed regarding quantitative  
24  
25 33 and qualitative aspects; results were visualized by density equalizing mapping tools.  
26

27  
28 34 Results: We identified 4600 articles. The USA was leading in terms of overall  
29  
30 35 publication and citation numbers. When output was related to economic benchmarks,  
31  
32 36 Guinea-Bissau and The Gambia were leading the field. RSV research benefited from  
33  
34 37 collaborative networks, primarily established between high-income countries. The  
35  
36 38 gender analysis indicated that male scientists dominated in all countries except  
37  
38 39 Brazil.  
39

40  
41 40 Conclusions: The majority of RSV-related research output originated from high-  
42  
43 41 income countries. Developing nations were barely part of the research landscape or  
44  
45 42 collaborative networks. Hence, research efforts of these nations have to be  
46  
47 43 strengthened so apparent disparities can be minimized and the high mortality rates  
48  
49 44 related to RSV can be tackled successfully.  
50

51  
52 45  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 46 **Key words:** Respiratory Syncytial Virus, Publication, Citation, Scientometry, Gender,  
4  
5 47 Economic benchmarks  
6

7 48  
8  
9

10 49 **Strengths and Weaknesses**  
11

12  
13 50 • This is the first concise depiction of the international RSV research landscape.  
14

15 51 • The NewQIS platform combines scientometric methods and “density  
16  
17  
18 52 equalizing mapping projections” to evaluate the scientific output regarding  
19  
20 53 quantitative and qualitative aspects, geographical and chronological  
21  
22 54 developments, existing research networks and socio-economic benchmarks in  
23  
24 55 a reliable and standardized way.  
25

26  
27 56 • Since the WoS has a preference for English journals, we have to acknowledge  
28  
29 57 a language bias associated with our analysis.  
30

31 58 • Citation based parameters were assessed, which we defined as “semi-  
32  
33 59 qualitative” since these rather reflect the recognition of the research in the  
34  
35 60 scientific community than truly measure quality.  
36  
37

38  
39 61  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## 62 INTRODUCTION

63 The human respiratory syncytial virus (RSV) is the worldwide predominant viral agent  
64 affecting the respiratory tract <sup>1 2</sup>. It is associated with 64 million infections that occur  
65 primarily in children under 5 years <sup>3</sup>. RSV belongs to the Paramyxoviridae family. It is  
66 a negative-sense, non-segmented, single-stranded RNA virus <sup>4</sup>. Mostly transmitted  
67 by droplets, RSV causes bronchiolitis, pneumonia, bronchitis and croup and is linked  
68 to recurrent wheezing and pediatric asthma <sup>5 6</sup>. There is no definitive treatment for  
69 RSV-related conditions. The efforts to develop effective and safe vaccines have  
70 remained unsuccessful to date. One prophylactic agent is commercially available, the  
71 neutralizing anti-RSV antibody Palivizumab. Its use is limited to preterm babies,  
72 chronic lung disease of prematurity or infants with congenital heart disease <sup>7</sup>.

73

74 RSV-associated morbidity and mortality depends on many factors such as the  
75 geographic location, climate patterns, genetic susceptibility, socioeconomic factors  
76 and local virus strains <sup>3</sup>. The percentage of children having contracted RSV by their  
77 second year of life comes close to 100% <sup>8 9</sup>. In the United States of America (USA),  
78 over 2 million children aged 5 years and under need medical attention to treat their  
79 RSV infection every year <sup>10</sup>. On average, 0.3% of these children and 0.7% of infants  
80 younger than six months require hospitalization <sup>10</sup>. The general RSV mortality rate in  
81 this demographic varies between 0-33% <sup>9</sup>. Worldwide, up to 199 000 children die due  
82 to RSV infections, 99% of these deaths occur in in developing countries <sup>3</sup>. Hence,  
83 RSV represents a substantial burden for community health in these nations:  
84 According to WHO field studies in ten developing countries, RSV causes 70% of all  
85 acute respiratory-tract infections in children under 5 years of age <sup>11</sup>. Here, the virus is  
86 identified in about 15-40% of the hospitalized children with pneumonia or bronchiolitis

1  
2  
3 87 <sup>12</sup>. Further, the primary presentation of RSV infections and virus strains differ in  
4  
5 88 industrialized versus developing nations: In the USA and continental Europe, the  
6  
7 89 majority of children present with bronchiolitis linked to the viral subgroup A whereas  
8  
9  
10 90 in The Gambia, the same demographic suffers mainly from pneumonia associated  
11  
12 91 with the B strain <sup>13 14</sup>.

13  
14 92  
15  
16 93 Although care of RSV patients has been improved considerably and extensive  
17  
18 94 studies have been launched to estimate viral spread and disease burden in  
19  
20 95 developing countries, tremendous challenges still remain. Considering the high  
21  
22 96 prevalence, morbidity and mortality of RSV worldwide, we deduce that further  
23  
24 97 research and the implementation of related public health measures are crucial for  
25  
26 98 future successes. However, global research funds are limited and their allocation  
27  
28 99 becomes challenging. In this context, the assessment of the scientific performance is  
29  
30 100 a prerequisite for the reasonable distribution of monetary support and the planning of  
31  
32 101 future research endeavors by scientists interested in the field. Hence, we employed  
33  
34 102 scientometric tools with the goal to determine the RSV-related research output  
35  
36 103 among the extensive amount of biomedical publications and to evaluate the scientific  
37  
38 104 productivity of single countries in the framework of the global research landscape and  
39  
40 105 in relation to socioeconomic and gender aspects. To guide individual scholarship and  
41  
42 106 the publication of own research dedicated to the area, we also present the 15 most  
43  
44 107 cited articles and the most proliferative journals in the field of RSV research.  
45  
46  
47  
48  
49

50 108

## 51 109 **METHODS**

### 52 110 **Methodical Platform**

53  
54  
55  
56  
57 111 We used the New Quality and Quantity Indices in Science (NewQIS) platform to  
58  
59  
60

1  
2  
3 112 assess RSV research. This tool combines scientometric methods and “density  
4  
5 113 equalizing mapping projections” (DEMP) <sup>15-18</sup> to evaluate the scientific output  
6  
7 114 regarding quantitative and qualitative aspects, geographical and chronological  
8  
9 115 developments, existing research networks and socio-economic benchmarks in a  
10  
11 116 reliable and standardized way.  
12  
13

14 117

### 17 118 **Density-equalizing mapping**

19 119 DEMP is a state-of-the-art technique to visualize benchmarking processes by  
20  
21 120 anamorphic maps <sup>15 19</sup>. Based on the algorithm of Gastner and Newman, the size of  
22  
23 121 each country was modified analogously to country-specific data on RSV research  
24  
25 122 leading to a new geographic distribution of the global landscape <sup>15</sup>.  
26  
27  
28 123

### 31 124 **Data collection**

33 125 For data collection, the Web of Science (WoS) Core Collection database (Thomson  
34  
35 126 Reuters) was employed. We used the following search term: Title=(“RSV” OR  
36  
37 127 “Respiratory Syncytial Virus” OR “RS Virus\*”) NOT Topic=(Rous Sarcoma). The  
38  
39 128 Boolean operator NOT was used to exclude all publications concerning Rous  
40  
41 129 Sarcoma (Virus). We acknowledge that not all eligible RSV publications were  
42  
43 130 detected by the conducted “TITLE”-search. But this approach was preferred since a  
44  
45 131 “TOPIC” search would include a significant amount of off-topic publications  
46  
47 132 compromising the validity of our data collection. Further, our search was limited to  
48  
49 133 the document type "article" to only cover original research studies. No additional  
50  
51 134 platforms such as PubMed, Google Scholar or Scopus were employed to collect  
52  
53 135 bibliometric data because the management, organization and the scope of data is  
54  
55 136 slightly different among these databases, which affects triangulating, comparing and  
56  
57  
58  
59  
60

1  
2  
3 137 integrating data related to RSV research in a meaningful way. Following our protocol,  
4  
5 138 the time frame was restricted from 1900 to 2013; publications in 2014 were not  
6  
7 139 included due to incomplete data acquisition at the time the study was performed.  
8  
9

10 140

### 11 141 **Data analysis**

12  
13  
14 142 RSV-related articles were analyzed regarding quantitative aspects such as the total  
15  
16  
17 143 number of publications, citation numbers, countries of origin, institutions, languages,  
18  
19 144 document types, cited reference numbers, and publication date. As semi-qualitative  
20  
21 145 variables, h-Indices, and the average citation number per item (citation rate, CR)  
22  
23 146 were investigated. We defined them as “semi-qualitative”, because these  
24  
25  
26 147 performance indicators rather reflect the recognition of the research in the scientific  
27  
28 148 community than truly measure quality. Regression analysis was used to investigate  
29  
30 149 the chronological evolution of RSV research. We calculated the coefficient of  
31  
32 150 determination ( $r^2$ ) representing the slope of the growth in scientific output and  
33  
34  
35 151 citations.  
36

37 152

### 38 39 40 153 **Modified h-Index**

41  
42 154 The Hirsch-Index (h-Index) is a recognized semi-qualitative proxy measure to assess  
43  
44 155 the impact of one author’s research output on the scientific community<sup>20 21</sup>. An h-  
45  
46 156 index of 12 indicates that out of 12 published papers each has been cited at least 12  
47  
48 157 times. In this study, we applied this concept to the RSV-specific research productivity  
49  
50 158 of single countries and calculated a “modified country-specific” h-Index.  
51

52  
53 159  
54  
55  
56  
57  
58  
59  
60



1  
2  
3 160 **Gender analysis**  
4

5 161 The proportionality of male and female researchers publishing on RSV was analyzed.

6  
7 162 Online name databases were utilized to identify the authors' genders <sup>22</sup>. If first names  
8

9  
10 163 were not gender-specific or quoted as initials, a manual search (utilizing websites,  
11

12 164 corresponding addresses and social networks) was launched. We evaluated only  
13

14 165 countries, where more than 50% of authors were identified by gender and where a  
15

16 166 minimum of 60 gender-defined authors were working on RSV.  
17

18  
19 167

20  
21 168 **Cooperation analysis**  
22

23 169 We identified all RSV-associated publications that were issued based on international  
24

25 170 collaborative efforts. In brief, if at least two authors originating from different  
26

27 171 institutions or countries (as identified by the stated affiliations on the article)  
28

29 172 contributed to one article, this publication was defined as a collaborative work.  
30

31 173 Connecting vectors were used to visualize these co-operations; their width and  
32

33 174 shade of grey reflected the number of joint publications.  
34

35  
36  
37 175

38  
39 176 **Journal analysis**  
40

41 177 The journals publishing on RSV were analyzed regarding quantitative and qualitative  
42

43 178 aspects, e.g. number of published RSV articles as well as citations these items  
44

45 179 received (CR).  
46

47  
48 180

49  
50 181 **Analysis of economic key figures**  
51

52 182 Two quotients were calculated to assess the scientific output of a specific country, (1)  
53

54 183 in relation to the number of citizens (Q1), and (2) in relation to its economic power (as  
55  
56  
57  
58  
59  
60

1  
2  
3 184 measured by the gross domestic product, GDP, Q2). We computed these in the  
4  
5 185 following way:

6  
7 186 1. Articles/population-index (Q1) = number of articles/population in millions

8  
9 187 2. Articles/GDP-index (Q2) = number of articles/GDP in billions

10  
11 188 All countries were classified into high-, upper-middle-, lower-middle- and low-income  
12  
13 189 groups according to World Bank definitions <sup>23</sup>.

14  
15  
16  
17 190

## 18 19 20 191 **RESULTS**

### 21 22 192 **Number of published items**

23  
24  
25 193 We identified 4,600 articles on RSV published between 1900 and 2013; 57.5% of  
26  
27 194 these were issued after 2000. After 1960, the number of articles increased  
28  
29 195 significantly over time as indicated by  $r^2=0.9$  (Fig. 1). Also, the number of authors per  
30  
31 196 article grew from 3.8 in 1978 to 7.6 in 2013.

32  
33  
34  
35 197

### 36 37 38 198 **Analysis of research origin and citations**

39  
40 199 Although the publications originated from 92 countries, the majority of the articles  
41  
42 200 were written in English (96.6 %) followed by French (1.4 %) and German (0.7%).  
43  
44 201 More than 85% of the global research output was published by authors from high-  
45  
46 202 income economies. The USA was the most productive nation (2,139 articles, a)  
47  
48 203 followed by the United Kingdom (UK, a = 583), the Netherlands (a = 231), Canada (a  
49  
50 204 = 217) and Germany (a = 196). Hence, the USA and UK dominated the cartogram,  
51  
52 205 while major parts of Africa (with the exception of South Africa), Asia (with the  
53  
54 206 exception of Japan, China, South Korea, and India) and Central America occupied  
55  
56 207 only minor areas (Fig. 2A).

1  
2  
3 208

4  
5 209 The country-specific citation numbers and modified h-Indices showed a global  
6  
7 210 distribution similar to the number of publications: The US-American publications were  
8  
9 211 cited most (83,000 citations, c), followed by articles from the UK (c = 19,240), the  
10  
11 212 Netherlands (c = 5587), Canada (c = 5549) and Germany (c = 5319). Articles  
12  
13 213 published by African, Asian and Middle American authors received hardly any  
14  
15 214 citations.  
16  
17

18  
19 215

20  
21 216 The USA and the UK were the top ranked countries with a modified h-Index of 121  
22  
23 217 (USA) and 68 (UK) followed by the Netherlands (h-Index = 44), Germany (h-Index =  
24  
25 218 43) and Canada (h-Index = 40) (Fig. 2B).  
26

27  
28 219

29  
30 220 Regarding the country specific citation rate (average number of citations per total  
31  
32 221 number of publications for each country with more than 30 articles, CR), Sweden (CR  
33  
34 222 = 40) dominated and was followed by the USA (CR = 38.8), Finland (CR = 34.9), the  
35  
36 223 UK and Germany (CR = 27.13).  
37

38  
39 224

#### 40 41 225 **Analysis of citation performance**

42  
43 226 The absolute citation count of all identified RSV-related articles resembled the  
44  
45 227 growing volume of published papers in the investigated timeframe. We documented a  
46  
47 228 significant positive correlation between citation numbers and the time of publication  
48  
49 229 (with  $r^2=0.72$  for the timeframe from 1960 to 2008). The annual citation counts grew  
50  
51 230 modestly from 1960 to 1994; after 1995, a rapid increase followed until 2004 whereas  
52  
53 231 a steep decline was noticed after 2004. We identified visible peaks in citation activity  
54  
55 232 for 1969, 1987, 2000, and 2004 (Fig. 3). Additionally, we compiled the 15 most cited  
56  
57  
58  
59  
60

233 RSV articles, which constitute the publications that have sparked the most  
234 documented interest in the field to date (Table 1).

235

236 Table 1. The 15 most cited articles in the area of RSV-related research are displayed  
237 including their title, publication year, country of origin, citation count and journal.

Title	Publication Year	Country	Citations	Journal
Mortality associated with influenza and respiratory syncytial virus in the United States <b>Thompson WW et al.</b>	2003	United States	1520	JAMA
Pattern recognition receptors TLR4 and CD14 mediate response to respiratory syncytial virus <b>Kurt-Jones EA et al.</b>	2000	United States	856	Nat Immunol
Respiratory Syncytial Virus Disease In Infants Despite Prior Administration Of Antigenic Inactivated Vaccine <b>Kim HW et al.</b>	1969	United States	848	Am J Epidemiol
Respiratory syncytial virus in early life and risk of wheeze and allergy by age 13 years <b>Stein RT et al.</b>	1999	Brazil, United States	719	Lancet
Palivizumab, a humanized respiratory syncytial virus monoclonal antibody, reduces hospitalization from respiratory syncytial virus infection in high-risk infants <b>The Impact-RSV Study Group.</b>	1998	United States, Canada, UK	652	Pediatrics
An Epidemiologic Study Of Altered Clinical Reactivity To Respiratory Syncytial (Rs) Virus Infection In Children Previously Vaccinated With An Inactivated RS Virus Vaccine <b>Kapikian et al.</b>	1969	United States	552	Am J Epidemiol
Risk Of Primary Infection And Reinfection With Respiratory Syncytial Virus <b>Glezen et al.</b>	1986	United States	548	Am J Dis Child
Respiratory syncytial virus bronchiolitis in infancy is an important risk factor for asthma and allergy at age 7 <b>Sigurs N et al.</b>	2000	Sweden, Iceland	488	Am J Respir Crit Care Med
Wheezing, Asthma, And Pulmonary Dysfunction 10 Years After Infection With Respiratory Syncytial Virus In Infancy <b>Pullan CR and Hey EN</b>	1982	UK	449	Br Med J
Respiratory syncytial virus infection in elderly and high-risk adults <b>Falsey AR et al.</b>	2005	United States	430	NEJM
Prophylactic Administration Of Respiratory Syncytial Virus Immune Globulin To High-Risk Infants And Young-Children <b>Groothuis JR et al.</b>	1993	United States	427	NEJM
The Development Of Respiratory Syncytial Virus-Specific IgE And The Release Of Histamine In Nasopharyngeal Secretions After Infection <b>Welliver RC et al.</b>	1981	United States	425	NEJM

Respiratory-Syncytial-Virus Infections, Re-Infections And Immunity - Prospective, Longitudinal-Study In Young-Children <b>Henderson FW et al.</b>	1979	United States	418	NEJM
Generation of bovine respiratory syncytial virus (BRSV) from cDNA: BRSV NS2 is not essential for virus replication in tissue culture, and the human RSV leader region acts as a functional BRSV genome promoter <b>Buchholz UJ et al.</b>	1999	Germany	417	J Virol
Asthma and immunoglobulin-e antibodies after respiratory syncytial virus bronchiolitis - a prospective cohort study with matched controls <b>Sigurs N et al.</b>	1995	Sweden	416	Pediatrics

238

239 **Relation to economic parameters**

240 Relating the number of publications to the population of a country, high-income  
241 countries like Iceland (Q1 = 34.59), the Netherlands (Q1 = 13.90) and Denmark (Q1  
242 = 12.25), issued a higher number of publications per million citizens compared to low-  
243 or lower-middle-income countries, e.g. Nigeria (Q1 = 0.03) and Indonesia (Q1 = 0.02)  
244 (Fig. 4A). We identified two exceptions: The low-income countries Guinea Bissau (Q1  
245 = 6.30) and The Gambia (Q1 = 4.76) were represented among the 15 top ranked  
246 countries in this analysis.

247

248 When looking at the publication activity in relation to GDP, two low-income countries  
249 outperformed high-income nations (Fig. 4B): Guinea Bissau (Q2 = 11.776) and The  
250 Gambia (Q2 = 8.721) held leading positions, followed by Iceland (Q2 = 0.810), Kenya  
251 (Q2 = 0.516), and Croatia (Q2 = 0.319). Besides these two exceptions, other low- or  
252 lower-middle-income countries showed a weak performance (e.g. Philippines with Q2  
253 = 0.004 or Indonesia with Q2 = 0.007). Also, the USA did not remain under the top 10  
254 nations and was found at position 18 (Q2 = 0.132).

255

1  
2  
3 256 **Gender analyses**

4  
5 257 71.3 % of authors were identified regarding their gender. While the majority of the  
6  
7 258 senior authors were male (70.3 %), the relation between female (48.36 %) and male  
8  
9 259 first authors (51.64 %) was almost balanced.

10  
11 260

12  
13  
14 261 The country-specific gender analysis indicated that males represented the largest  
15  
16 262 proportion of scientists in almost all evaluated countries (Fig. 5). Brazil was an  
17  
18 263 exception. Here, males and females were almost equally represented, with a small  
19  
20 264 over-representation of female scientists. By calculating the proportion of male to  
21  
22 265 female scientists, we documented the lowest value (0.94) for Brazil, followed by  
23  
24 266 Germany (1.1). Japan reached the highest score with 2.8 showing a clear dominance  
25  
26 267 of male scientists.

27  
28  
29 268

30  
31  
32 269 **International cooperation analysis**

33  
34  
35 270 Since 1973, 614 joint articles were published on RSV accounting for 13.34% of all  
36  
37 271 articles. The USA was the preferred partner for international collaborations on RSV:  
38  
39 272 The most productive cooperation was established between the USA and the UK (67  
40  
41 273 joint works), followed by the USA and Canada (45 joint articles), and the USA and  
42  
43 274 Germany (34 joint articles). The most fruitful cooperation not involving the USA  
44  
45 275 existed between the UK and Spain (33 joint articles). The most productive  
46  
47 276 cooperation between high- and lower-middle- or low-income economies was set up  
48  
49 277 between Kenya and the UK (18 joint articles) followed by Guinea Bissau and  
50  
51 278 Denmark (10 joint articles). Overall, co-operations with low-income or lower-middle-  
52  
53 279 income countries were less popular (Fig. 6).

54  
55  
56 280

## 281 **Journal analysis**

282 We identified the most prolific journals in RSV research: The "Journal of Virology"  
283 was leading the field (334 articles, CR of 45.49), followed by "The Pediatric Infectious  
284 Disease Journal" (198 articles, CR = 24.66) and the "Journal of Infectious Diseases"  
285 (186 articles, CR 55.18) (Fig. 7). The highest citation rate was achieved by the  
286 "Proceedings of the National Academy of Sciences of the United States of America"  
287 (42 articles, CR = 81.43), followed by "Pediatrics" (66 articles, CR = 70.80), "Journal  
288 of Pediatrics" (65 articles, CR = 64.03), "American Journal of Respiratory Critical  
289 Care" (47 articles, CR = 62.55), and „Journal of Infectious Diseases“ (186 articles,  
290 CR = 55.18).

## 292 **DISCUSSION**

293 In the WoS, we documented only 4,600 RSV-related articles since 1900. The first  
294 item on the disease in humans was published in 1957<sup>24</sup>. This underscores that  
295 research on RSV is a relatively new field considering the virus was initially isolated in  
296 1956 from laboratory primates<sup>25</sup>. The predominance of English in the majority of  
297 identified articles aligns not only with the fact that this language is the recognized  
298 "scientific lingua franca" but also reflects the abundant research output of English  
299 speaking countries such as USA, Canada and the UK found in our study.

300  
301 The increasing number of RSV publications over time is typical for most biomedical  
302 research, e.g. on the John Cunningham Virus, influenza or breast cancer<sup>26 27</sup>.

303 Overall, the steady growth of article numbers can be explained by the rising interest  
304 in the field due to the increasing relevance of RSV in pneumonia and child mortality<sup>8</sup>.

305 In the first few years after the detection of the virus, basic research was conducted -



1  
2  
3 306 aiming to characterize the virus, identify immunologic responses and develop  
4  
5 307 vaccines <sup>28-31</sup> - and translated into a growing volume of articles on RSV. The  
6  
7 308 continuous increase since the beginning of the 1990s may be attributed to the launch  
8  
9 309 of modern communication systems based on new computer technologies like the  
10  
11 310 World Wide Web, which made it easier to communicate, exchange ideas with other  
12  
13 311 scientists and publicize articles in central databases.  
14  
15  
16 312

17  
18 313 The chronological development in publication quantity (Fig. 1) was resembled by the  
19  
20 314 steady increase of related citations (Fig.3). Four prominent citation peaks in 1969,  
21  
22 315 1987, 2000 and 2004 coincided with milestone papers the field: In 1969, adverse  
23  
24 316 effects of the formalin-inactivated RSV vaccine in children were reported <sup>32</sup>. Large  
25  
26 317 epidemiologic studies investigated the risks of reinfection and the mortality  
27  
28 318 associated with RSV in 1986 and 2003 <sup>33 34</sup>. The research on a prophylactic antibody  
29  
30 319 licensed in 1999 and novel insights into immunologic responses involving pattern  
31  
32 320 recognition receptors TLR4 and CD14 may be responsible for the peaking number of  
33  
34 321 publications and citations in 2000 <sup>35</sup>. The citation decline after 2004 can be attributed  
35  
36 322 to the short timespan articles had allotted to receive recognition within the scientific  
37  
38 323 community and obtain the appropriate citation number reflecting their true impact <sup>36</sup>.  
39  
40 324 Hence, we expect this trend to be reversed in the future.  
41  
42  
43 325

44  
45 326 The USA dominated RSV research in regards to overall publication quantity, citation  
46  
47 327 numbers and h-index. This corresponds with a previous biomedical benchmarking  
48  
49 328 study: Here, the USA was the most productive nation and authored 1,893,800 of  
50  
51 329 5,527,558 publications related to 22 organ systems from 1961 to 2007 <sup>37</sup>. The  
52  
53 330 leading role of the USA might be linked to major financial resources this nation  
54  
55 331 dedicates to research supporting manpower and an outstanding scientific  
56  
57  
58  
59  
60



1  
2  
3 332 infrastructure. This is also illustrated by the majority of institutions working on RSV  
4  
5 333 we identified in the USA, and the role of this nation as a preferred partner for national  
6  
7 334 and international co-operations.  
8

9 335

10  
11 336 The cluster of the USA, Western-European countries (e.g. UK or Germany) and  
12  
13 337 Japan dominated the overall publication output and analyses of semi-qualitative  
14  
15 338 benchmarks. This finding corresponds with other scientometric studies (e.g. on  
16  
17 339 Influenza, Ebola, or Hepatitis B <sup>26 38</sup>. Although Sweden and Finland published  
18  
19 340 relatively low numbers of articles, they are characterized by the highest citation rates  
20  
21 341 in our analysis indicating the outstanding quality and high recognition their articles  
22  
23 342 receive in the scientific community. Further, it is striking that most African, Asian and  
24  
25 343 Central American countries afflicted with a considerable RSV-related burden do not  
26  
27 344 play a visible role in the field. Methodologically, we included only countries in the  
28  
29 345 citation rate analysis that published more than 30 RSV articles aiming to generate a  
30  
31 346 better the validity of the investigation by avoiding overestimation of few but frequently  
32  
33 347 cited articles. Nevertheless, we want to stress that the absolute number of citations  
34  
35 348 as well as the citation rate should be viewed critically due to self-citation, inaccurate  
36  
37 349 citations or the Matthew effect <sup>39 40</sup>. Hence, we also evaluated the modified h-index  
38  
39 350 since it is less influenced by outstanding, frequently or rarely cited articles skewing  
40  
41 351 the citation rate value <sup>20 21</sup>.  
42

43 352

44  
45 353 Our analysis of RSV research outputs changed in relation to economic capabilities  
46  
47 354 (Fig. 4) and two developing, low-income nations, The Gambia and Guinea-Bissau,  
48  
49 355 occupied the leading positions. This finding points towards the fact that both prioritize  
50  
51 356 RSV research and might be connected to existing co-operations with a long standing  
52  
53 357 shared history between collaborating nations and their focused support of RSV  
54  
55  
56  
57  
58  
59  
60

20

1  
2  
3 358 scientific activities. For example, the United Kingdom's "Medical Research Council:  
4  
5 359 The Gambia Unit" and the Danish "Bandim Health Project" encourage medical  
6  
7 360 research in Guinea-Bissau and The Gambia <sup>41</sup> <sup>42</sup>. Also, research in the field is  
8  
9 361 promoted by single researchers with a strong dedication to conduct research in  
10  
11 362 African sites: Here, Sir Brian Greenwood has spearheaded RSV-related research  
12  
13 363 very successfully for decades while being faculty at the London School of Hygiene  
14  
15 364 and Tropical Medicine as well as the Director of the Medical Research Council in The  
16  
17 365 Gambia.  
18  
19  
20  
21 366  
22  
23 367 Collaborations are becoming increasingly important in the field of RSV research as  
24  
25 368 indicated by existing tight-knit networks and the growing numbers of authors per  
26  
27 369 article over time. We link this development to the globalization process, which  
28  
29 370 connects scientists worldwide to exchange ideas, resources and knowledge  
30  
31 371 facilitated by the growing availability of information technology. Further, it is  
32  
33 372 noticeable that countries such as the USA or European nations play a more  
34  
35 373 prominent role in international collaborations compared to low- and lower-middle-  
36  
37 374 income countries. As exceptions, we could identify proliferative co-operations  
38  
39 375 between the UK and Kenya as well as Denmark and Guinea-Bissau. The relation  
40  
41 376 between Kenya and the UK might be based on their shared history and facilitated by  
42  
43 377 implemented programs such as the "*KEMRI Welcome Trust Research Program*"  
44  
45 378 between the Kenya Medical Research Institute and the University of Oxford <sup>43</sup>.  
46  
47 379 Research activity on RSV in Guinea-Bissau is supported by the aforementioned  
48  
49 380 Danish "Bandim Health Project", which was founded by the anthropologist Sir Peter  
50  
51 381 Aaby in the 1970s. It gathers local epidemiological data on more than 200,000  
52  
53 382 individuals. Since its foundation, this group published more than 600 items on  
54  
55 383 vaccines, maternal mortality and childhood infections such as RSV <sup>41</sup>.  
56  
57  
58  
59  
60

1  
2  
3 384

4  
5 385 The evaluation of publication performance by gender is meaningful but should be  
6  
7 386 evaluated critically: Although more than 70% of authors could be identified by  
8  
9 387 gender, not all first names were included in our analysis since some were gender-  
10  
11 388 neutral, not listed in name databases or displayed as initials. Therefore, the threshold  
12  
13 389 of at least 60 publishing scientists and 50% gender definability was implemented to  
14  
15 390 include only countries providing meaningful and valid data. We identified an  
16  
17 391 overrepresentation of male authors in the majority of evaluated nations besides Brazil  
18  
19 392 (Fig. 5). This result correlates with previous investigations on Yellow fever and  
20  
21 393 Rotavirus infections <sup>44</sup> as well as with gender benchmarking studies (e. g. conducted  
22  
23 394 by the “Konrad-Adenauer Foundation” or the “Organization for Women in Science for  
24  
25 395 the Developing World” (OWSD)), which prove that Brazil pioneers in the support and  
26  
27 396 participation of females in science <sup>45 46</sup>.

28  
29  
30  
31  
32 397

33  
34 398 Using the WoS to conduct this study is associated with an important strength but also  
35  
36 399 with one weakness of the study: The WoS enabled us to assess not only quantitative  
37  
38 400 but also semi-qualitative aspects of the scientific output related to RSV research.  
39  
40 401 This is a unique feature allowing a multifaceted evaluation of the research  
41  
42 402 productivity. On the other hand, the WoS displays a strong preference for English  
43  
44 403 journals. Therefore, not all articles ever published on RSV could be analyzed here.  
45  
46 404 However, we regard this bias as limited as the majority of high quality data is  
47  
48 405 commonly published in international journals indexed by the WoS and therefore  
49  
50 406 definitely included in our search.

51  
52  
53  
54 407

55  
56 408 Timing, intensity and clinical impact of RSV infections vary worldwide <sup>3</sup>. Hence,  
57  
58 409 research is still needed to alleviate the burden related to RSV in high-risk

22

1  
2  
3 410 populations. Interventions should focus on data collection via established  
4  
5 411 surveillance systems aiming to define local morbidity and mortality, assist disease  
6  
7 412 modeling, and guide prophylactic measures and vaccine development <sup>47</sup>. In this  
8  
9 413 context, our study revealed a striking discrepancy in scientific productivity and  
10  
11 414 collaborative involvement between high- and low-income countries. Also, attention  
12  
13 415 should be drawn to a further problem concerning low-income nations or countries  
14  
15 416 whose researchers have a limited financial budget to pay for publication in renowned  
16  
17 417 open access journals. This issue increases the apparent discrepancies regarding  
18  
19 418 publication activities even further. To minimize this problem, a number of waiver  
20  
21 419 programs already exists, i.e. for journals like PLOS, Biomed Central or BMJ OPEN <sup>48</sup>-  
22  
23 420 <sup>50</sup>, but these should be expanded more broadly. However, we can deduce from our  
24  
25 421 findings, that developing nations - although experiencing the most significant  
26  
27 422 consequences of RSV epidemics - cannot compete equally in the field of RSV  
28  
29 423 research due to the lack of funding and infrastructure. Therefore, we want to  
30  
31 424 underline the need – and almost ethical responsibility - to involve these nations in  
32  
33 425 funding programs and successful international collaborations as seen for Guinea-  
34  
35 426 Bissau, Kenya and The Gambia. We acknowledge that the establishment of these  
36  
37 427 collaboration is challenging due to the lack of resources, manpower and funding  
38  
39 428 opportunities, the political climate, cultural differences between the potential partners  
40  
41 429 and a unrealistic assessment of the local research capacity and resources <sup>51</sup>.  
42  
43 430 Nevertheless, tight-knit networks would be the key for developing countries to  
44  
45 431 participate in the international exchange of data, resources and knowledge, and to  
46  
47 432 facilitate their involvement in high quality research efforts despite an unequal starting  
48  
49 433 point.  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 434 **Conclusion**

4  
5 435 We evaluated the worldwide RSV-related research output and demonstrated large  
6  
7 436 differences between industrialized and developing nations regarding most  
8  
9 437 scientometric variables. These discrepancies partly diminished when country-specific  
10  
11 438 scientific activities were related to economic key measures; here, the leading position  
12  
13 439 of the USA in science was challenged by other nations. Hence, calculating these  
14  
15 440 quotients is beneficial for the comparison of countries with unequal conditions and  
16  
17 441 different scientific infrastructures. However, we can deduce from our study that  
18  
19 442 research efforts of middle-income or low-income nations have to be strengthened,  
20  
21 443 e.g. by the reduction of journal fees and inclusion in international collaborations, so  
22  
23 444 apparent disparities can be minimized and higher mortality rates related to RSV in  
24  
25 445 developing nations can be tackled successfully.  
26  
27  
28

29 446

30  
31  
32 447 **Acknowledgements:**

33  
34 448 We thank Cristian Scutaru for the development and provision of the NewQIS  
35  
36 449 analyzing tools. We also thank Mario Schwarzer, MD for supporting the study and  
37  
38 450 helpful discussions.  
39

40  
41  
42 451 **Source of Funding:**

43  
44 452 This research received no specific grant from any funding agency in the public,  
45  
46 453 commercial or not-for-profit sectors  
47  
48

49 454

50  
51  
52 455 **Conflicts of Interest:**

53  
54 456 All authors state that they have no conflicts of interest to declare.  
55

56  
57 457  
58  
59  
60

1  
2  
3 458 **Data Sharing Statement:**  
4

5  
6 459 Datasets of this study are available from the corresponding author upon request.  
7

8  
9 460

10  
11  
12 461 **Authors' contributions:**  
13

14  
15 462 DB, CK, DK, DAG, DO, JB and MB have made substantial contributions to the  
16  
17 463 conception and design of the study, acquisition of the study data and have been  
18  
19 464 involved in drafting and revising the manuscript. All authors have read and approved  
20  
21 465 the final manuscript.  
22  
23

24  
25 466  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 467 **Figure Legends**

4  
5 468 Figure 1: Chronological development of the number of articles.

6  
7 469 Figure 2: Density equalizing mapping projections (DEMP).

8  
9 470 A) Number of publications B) Modified h-Index

10  
11 471 Figure 3: Chronological development of annual citation numbers.

12  
13 472 Figure 4: Density equalizing mapping projections (DEMP).

14  
15 473 A) Articles/population-index (Q1)

16  
17 474 B) Articles/GDP-index (Q2)

18  
19 475 (Threshold  $\geq 15$  articles)

20  
21 476 Figure 5: Country specific gender analysis of the authors publishing articles referring  
22  
23 to RSV of countries.

24  
25 477 (Threshold:  $> 50\%$  definable genders,  $> 60$  authors per country)

26  
27 478 Figure 6: International cooperation (threshold  $\geq 2$  cooperations).

28  
29 479 Numbers in brackets (number of publications/number of publications in  
30  
31 cooperation

32  
33 480 Figure 7: Most prolific journals in the field of RSV research in regards to overall  
34  
35 publication numbers and the average citation rate.

36  
37 481  
38  
39 482  
40  
41 484 **Referenes**

- 42  
43  
44 485 1. Murphy BR, Prince GA, Collins PL, et al. Current approaches to the development of  
45 486 vaccines effective against parainfluenza and respiratory syncytial viruses. *Virus*  
46 487 *research* 1988;**11**(1):1-15.
- 47 488 2. Collins PL, Graham BS. Viral and host factors in human respiratory syncytial virus  
48 489 pathogenesis. *Journal of virology* 2008;**82**(5):2040-55.
- 49 490 3. Nair H, Nokes DJ, Gessner BD, et al. Global burden of acute lower respiratory  
50 491 infections due to respiratory syncytial virus in young children: a systematic  
51 492 review and meta-analysis. *Lancet (London, England)* 2010;**375**(9725):1545-55.
- 52 493 4. Borchers AT, Chang C, Gershwin ME, et al. Respiratory syncytial virus--a  
53 494 comprehensive review. *Clinical reviews in allergy & immunology*  
54 495 2013;**45**(3):331-79.
- 55 496 5. Blanken MO, Rovers MM, Molenaar JM, et al. Respiratory syncytial virus and recurrent  
56 497 wheeze in healthy preterm infants. *The New England journal of medicine*  
57 498 2013;**368**(19):1791-9.



- 1  
2  
3 499 6. Wu P, Dupont WD, Griffin MR, et al. Evidence of a causal role of winter virus infection  
4 500 during infancy in early childhood asthma. *American journal of respiratory and*  
5 501 *critical care medicine* 2008;**178**(11):1123-9.
- 6 502 7. Polack FP. The changing landscape of respiratory syncytial virus. *Vaccine*  
7 503 2015;**33**(47):6473-8.
- 8 504 8. CentersforDiseaseControlandPrevention. Respiratory Syncytial Virus Infection (RSV).  
9 505 Secondary Respiratory Syncytial Virus Infection (RSV). 2016.  
10 506 <http://www.cdc.gov/rsv/about/index.html>.
- 11 507 9. Welliver RC, Sr., Checchia PA, Bauman JH, et al. Fatality rates in published reports of  
12 508 RSV hospitalizations among high-risk and otherwise healthy children. *Current*  
13 509 *medical research and opinion* 2010;**26**(9):2175-81.
- 14 510 10. Hall CB, Weinberg GA, Iwane MK, et al. The burden of respiratory syncytial virus  
15 511 infection in young children. *The New England journal of medicine*  
16 512 2009;**360**(6):588-98.
- 17 513 11. Selwyn BJ. The epidemiology of acute respiratory tract infection in young children:  
18 514 comparison of findings from several developing countries. *Coordinated Data*  
19 515 *Group of BOSTID Researchers. Reviews of infectious diseases* 1990;**12 Suppl**  
20 516 **8**:S870-88.
- 21 517 12. Weber MW, Mulholland EK, Greenwood BM. Respiratory syncytial virus infection in  
22 518 tropical and developing countries. *Tropical medicine & international health : TM*  
23 519 *& IH* 1998;**3**(4):268-80.
- 24 520 13. Walsh EE, McConnochie KM, Long CE, et al. Severity of respiratory syncytial virus  
25 521 infection is related to virus strain. *The Journal of infectious diseases*  
26 522 1997;**175**(4):814-20.
- 27 523 14. Weber MW, Dackour R, Usen S, et al. The clinical spectrum of respiratory syncytial  
28 524 virus disease in The Gambia. *The Pediatric infectious disease journal*  
29 525 1998;**17**(3):224-30.
- 30 526 15. Gastner MT, Newman ME. Diffusion-based method for producing density-equalizing  
31 527 maps. *Proceedings of the National Academy of Sciences of the United States of*  
32 528 *America* 2004;**101**(20):7499-504.
- 33 529 16. Scutaru C, Quarcoo D, Sakr M, et al. Density-equalizing mapping and scientometric  
34 530 benchmarking of European allergy research. *Journal of occupational medicine*  
35 531 *and toxicology (London, England)* 2010;**5**:2.
- 36 532 17. Groneberg-Kloft B, Fischer TC, Quarcoo D, et al. New quality and quantity indices in  
37 533 science (NewQIS): the study protocol of an international project. *Journal of*  
38 534 *occupational medicine and toxicology (London, England)* 2009;**4**:16.
- 39 535 18. Groneberg-Kloft B, Quarcoo D, Scutaru C. Quality and quantity indices in science: use  
40 536 of visualization tools. *EMBO reports* 2009;**10**(8):800-3.
- 41 537 19. Gerber A, Klingelhoef D, Groneberg D, et al. Antineutrophil cytoplasmic antibody-  
42 538 associated vasculitides: a scientometric approach visualizing worldwide research  
43 539 activity. *International journal of rheumatic diseases* 2014;**17**(7):796-804.
- 44 540 20. Hirsch JE. An index to quantify an individual's scientific research output. *Proceedings*  
45 541 *of the National Academy of Sciences of the United States of America*  
46 542 2005;**102**(46):16569-72.
- 47 543 21. Hirsch JE. Does the H index have predictive power? *Proceedings of the National*  
48 544 *Academy of Sciences of the United States of America* 2007;**104**(49):19193-8.
- 49 545 22. Namepedia. Namepedia. Secondary Namepedia 2016. <http://www.namepedia.org/>.
- 50 546 23. WorldBank. Country and Lending Groups. Secondary Country and Lending Groups  
51 547 2015. <http://data.worldbank.org/about/country-and-lending-groups>.



- 1  
2  
3 548 24. Chanock R, Roizman B, Myers R. Recovery from infants with respiratory illness of a  
4 549 virus related to chimpanzee coryza agent (CCA). I. Isolation, properties and  
5 550 characterization. *Am J Hyg* 1957;**66**(3):281-90.  
6 551 25. Blount RE, Jr., Morris JA, Savage RE. Recovery of cytopathogenic agent from  
7 552 chimpanzees with coryza. *Proceedings of the Society for Experimental Biology  
8 553 and Medicine Society for Experimental Biology and Medicine (New York, NY)*  
9 554 1956;**92**(3):544-9.  
10 555 26. Fricke R, Uibel S, Klingelhofer D, et al. Influenza: a scientometric and density-  
11 556 equalizing analysis. *BMC infectious diseases* 2013;**13**:454.  
12 557 27. Zheng HC, Yan L, Cui L, et al. Mapping the history and current situation of research  
13 558 on John Cunningham virus - a bibliometric analysis. *BMC infectious diseases*  
14 559 2009;**9**:28.  
15 560 28. Simoes EA. Respiratory syncytial virus infection. *Lancet (London, England)*  
16 561 1999;**354**(9181):847-52.  
17 562 29. Collins PL, Hill MG, Camargo E, et al. Production of infectious human respiratory  
18 563 syncytial virus from cloned cDNA confirms an essential role for the transcription  
19 564 elongation factor from the 5' proximal open reading frame of the M2 mRNA in  
20 565 gene expression and provides a capability for vaccine development. *Proceedings  
21 566 of the National Academy of Sciences of the United States of America*  
22 567 1995;**92**(25):11563-7.  
23 568 30. Cranage MP, Gardner PS. Systemic cell-mediated and antibody responses in infants  
24 569 with respiratory syncytial virus infections. *Journal of medical virology*  
25 570 1980;**5**(2):161-70.  
26 571 31. Fulginiti VA, Eller JJ, Sieber OF, et al. Respiratory virus immunization. I. A field trial of  
27 572 two inactivated respiratory virus vaccines; an aqueous trivalent parainfluenza  
28 573 virus vaccine and an alum-precipitated respiratory syncytial virus vaccine.  
29 574 *American journal of epidemiology* 1969;**89**(4):435-48.  
30 575 32. Kim HW, Canchola JG, Brandt CD, et al. Respiratory syncytial virus disease in infants  
31 576 despite prior administration of antigenic inactivated vaccine. *American journal of  
32 577 epidemiology* 1969;**89**(4):422-34.  
33 578 33. Glezen WP, Taber LH, Frank AL, et al. Risk of primary infection and reinfection with  
34 579 respiratory syncytial virus. *American journal of diseases of children (1960)*  
35 580 1986;**140**(6):543-6.  
36 581 34. Thompson WW, Shay DK, Weintraub E, et al. Mortality associated with influenza and  
37 582 respiratory syncytial virus in the United States. *Jama* 2003;**289**(2):179-86.  
38 583 35. Kurt-Jones EA, Popova L, Kwinn L, et al. Pattern recognition receptors TLR4 and  
39 584 CD14 mediate response to respiratory syncytial virus. *Nature immunology*  
40 585 2000;**1**(5):398-401.  
41 586 36. Testa J. The Thomson Scientific journal selection process. *International microbiology  
42 587 : the official journal of the Spanish Society for Microbiology* 2006;**9**(2):135-8.  
43 588 37. Groneberg-Kloft B, Scutaru C, Kreiter C, et al. Institutional operating figures in basic  
44 589 and applied sciences: scientometric analysis of quantitative output  
45 590 benchmarking. *Health research policy and systems / BioMed Central* 2008;**6**:6.  
46 591 38. Schmidt S, Bundschuh M, Scutaru C, et al. Hepatitis B: global scientific development  
47 592 from a critical point of view. *Journal of viral hepatitis* 2013.  
48 593 39. Fassoulaki A, Paraskeva A, Papilas K, et al. Self-citations in six anaesthesia journals  
49 594 and their significance in determining the impact factor. *British journal of  
50 595 anaesthesia* 2000;**84**(2):266-9.  
51 596 40. Merton RK. The Matthew effect in science. The reward and communication systems  
52 597 of science are considered. *Science (New York, NY)* 1968;**159**(810):56-63.

- 1  
2  
3 598 41. BandimHealthProject. About BHP. Secondary About BHP.  
4 599 <http://www.bandim.org/about-bhp.aspx>.  
5 600 42. Council. MR. Medical Research Council: The Gambia Unit. Secondary Medical  
6 601 Research Council: The Gambia Unit. <http://www.mrc.gm/our-research/themes>.  
7 602 43. KEMRIWellcomeTrustResearchProgramm. KEMRI Wellcome Trust Research  
8 603 Programm. Secondary KEMRI Wellcome Trust Research Programm.  
9 604 <http://www.kemri-wellcome.org>.  
10 605 44. Koster C, Klingelhofer D, Groneberg DA, et al. Rotavirus - Global research density  
11 606 equalizing mapping and gender analysis. Vaccine 2016;**34**(1):90-100.  
12 607 45. Konrad-Adenauer-Stiftung. Frauen in Brasilien. Secondary Frauen in Brasilien 2014.  
13 608 [http://www.kas.de/wf/doc/kas\\_17800-1522-1-30.pdf?091024002708](http://www.kas.de/wf/doc/kas_17800-1522-1-30.pdf?091024002708).  
14 609 46. Huyer S, Hafkin N. Scorecard on Gender Equality in the Knowledge Society.  
15 610 Secondary Scorecard on Gender Equality in the Knowledge Society 2014.  
16 611 [http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows)  
17 612 [and-innovation-study-shows](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows).  
18 613 47. Haynes AK, Manangan AP, Iwane MK, et al. Respiratory syncytial virus circulation in  
19 614 seven countries with Global Disease Detection Regional Centers. The Journal of  
20 615 infectious diseases 2013;**208** Suppl 3:S246-54.  
21 616 48. PLOS. Publication fees. Secondary Publication fees.  
22 617 <http://www.plos.org/publications/publication-fees>.  
23 618 49. BioMedCentral. Can charges be waived if the author cannot pay? Secondary Can  
24 619 charges be waived if the author cannot pay?  
25 620 <http://www.biomedcentral.com/about/apcfaq/waivers>.  
26 621 50. BMJOpen. Instructions for authors. Secondary Instructions for authors.  
27 622 <http://bmjopen.bmj.com/site/about/guidelines.xhtml>.  
28 623 51. Akinremi TO. Research collaboration with low resource countries: overcoming the  
29 624 challenges. Infect Agent Cancer 2011;**6** Suppl 2:S3.

625

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

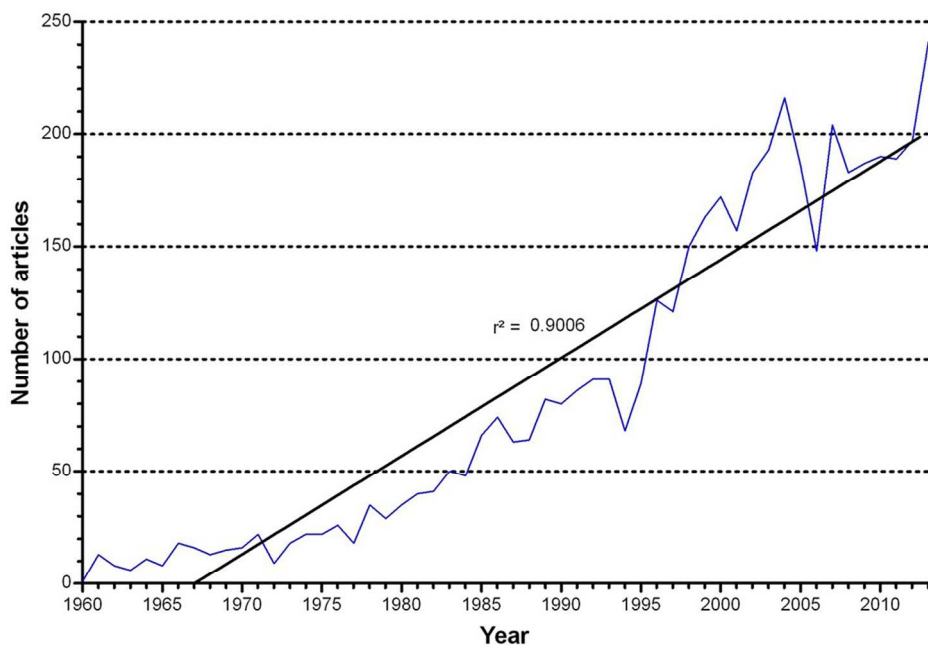


Figure 1: Chronological development of the number of articles.

109x75mm (300 x 300 DPI)

view only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

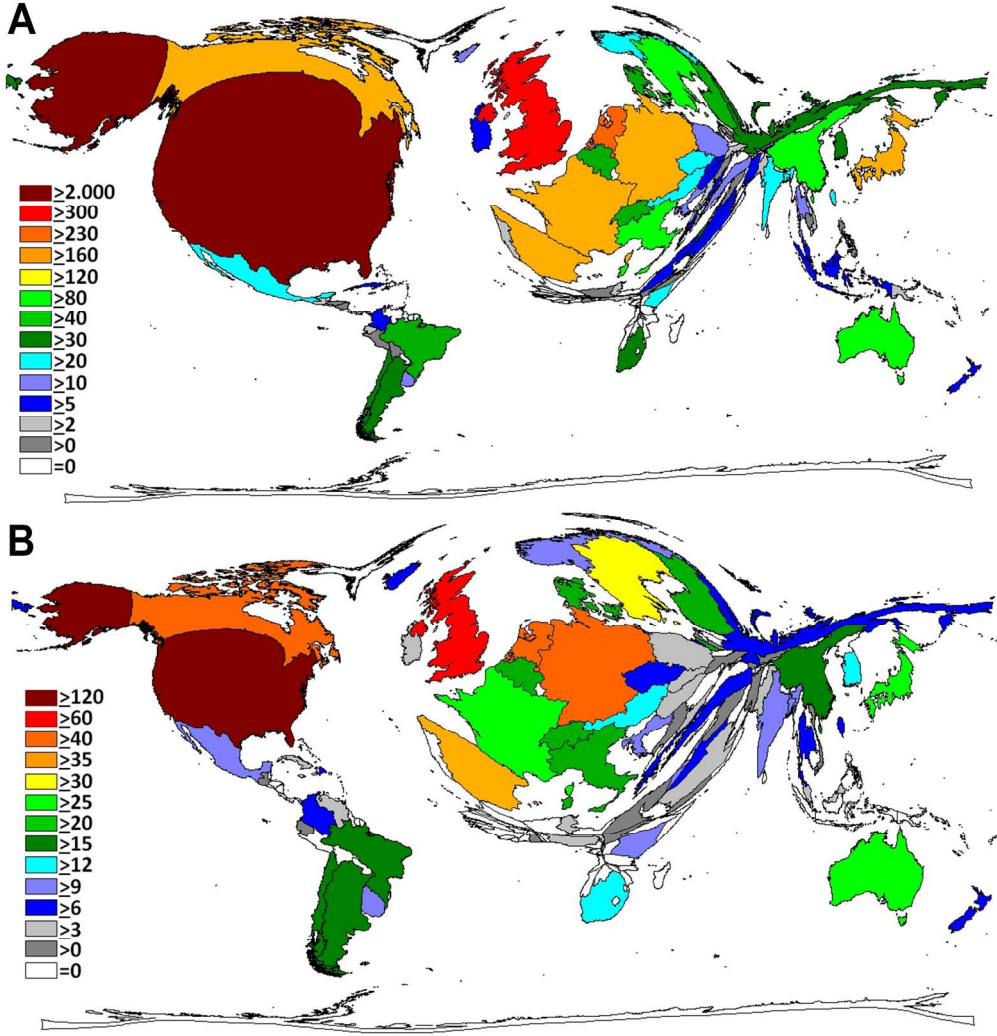


Figure 2: Density equalizing mapping projections (DEMP).  
A) Number of publications  
B) Modified h-Index

203x212mm (300 x 300 DPI)

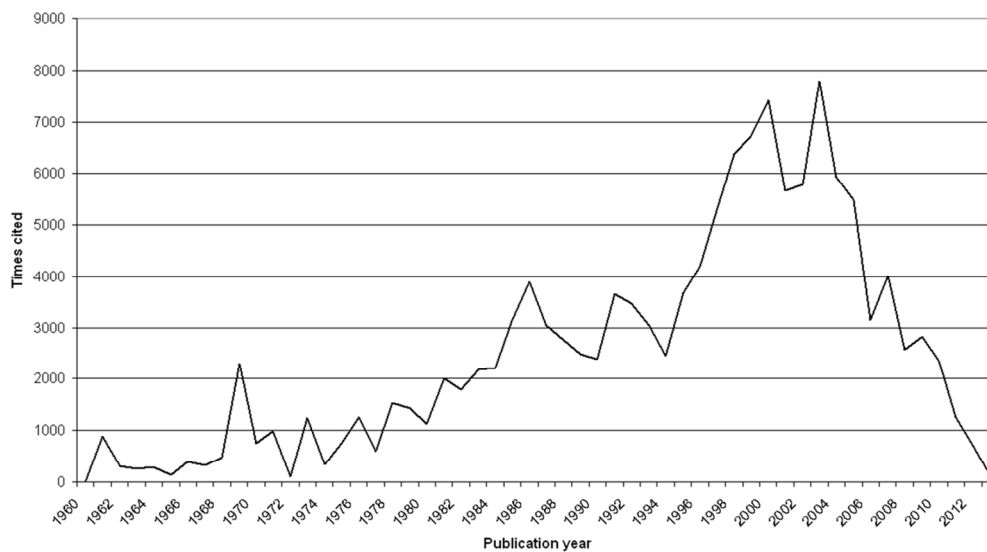


Figure 3: Chronological development of annual citation numbers.

109x61mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

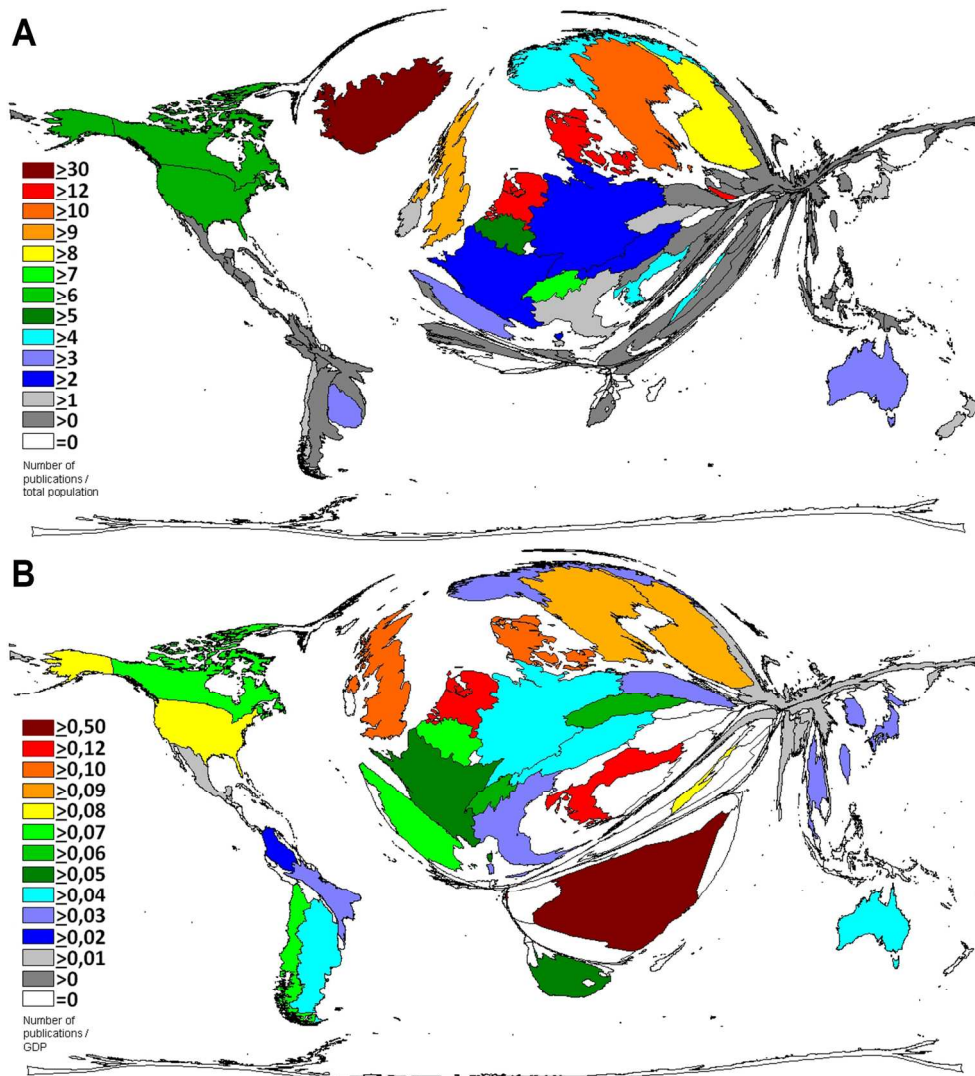


Figure 4: Density equalizing mapping projections (DEMP).  
 A) Articles/population-index (Q1)  
 B) Articles/GDP-index (Q2)  
 (Threshold > 15 articles)

203x220mm (300 x 300 DPI)

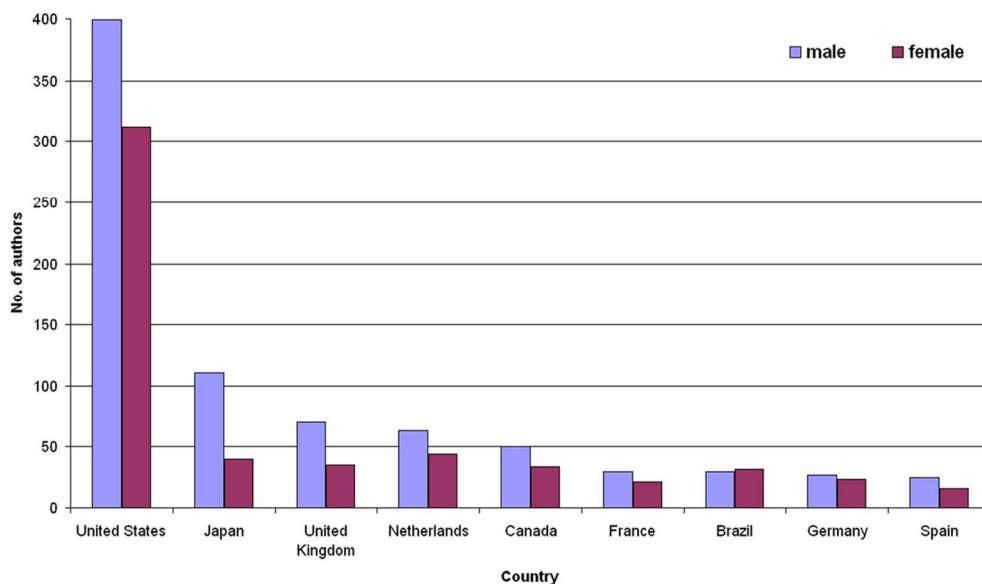


Figure 6: Country specific gender analysis of the authors publishing articles referring to RSV of countries.  
 !! † (Threshold: > 50% definable genders, > 60 authors per country)!! †

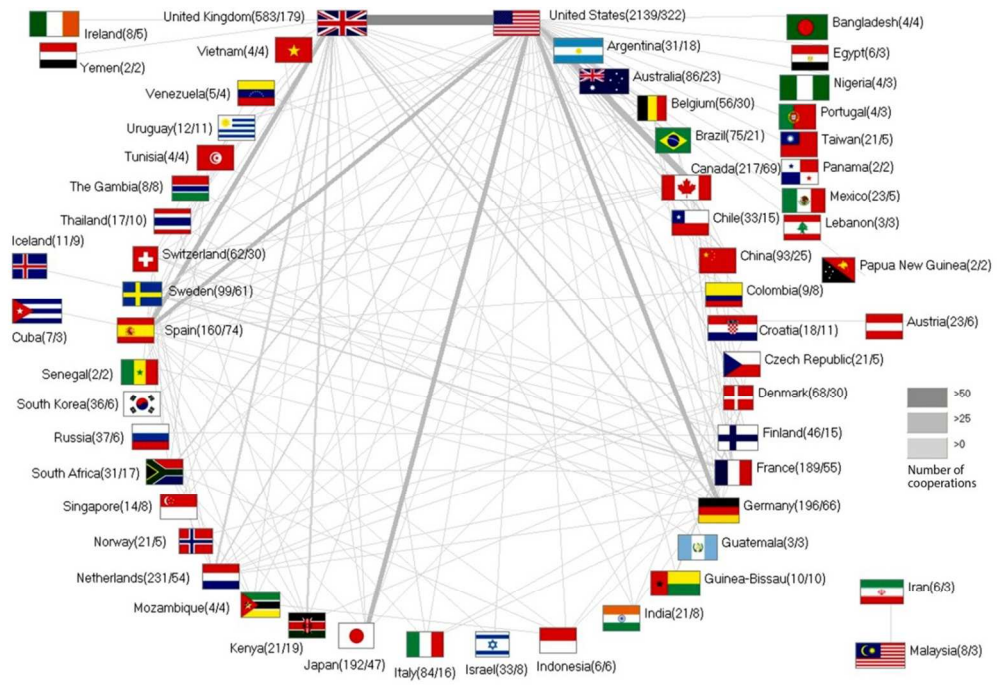
109x65mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60





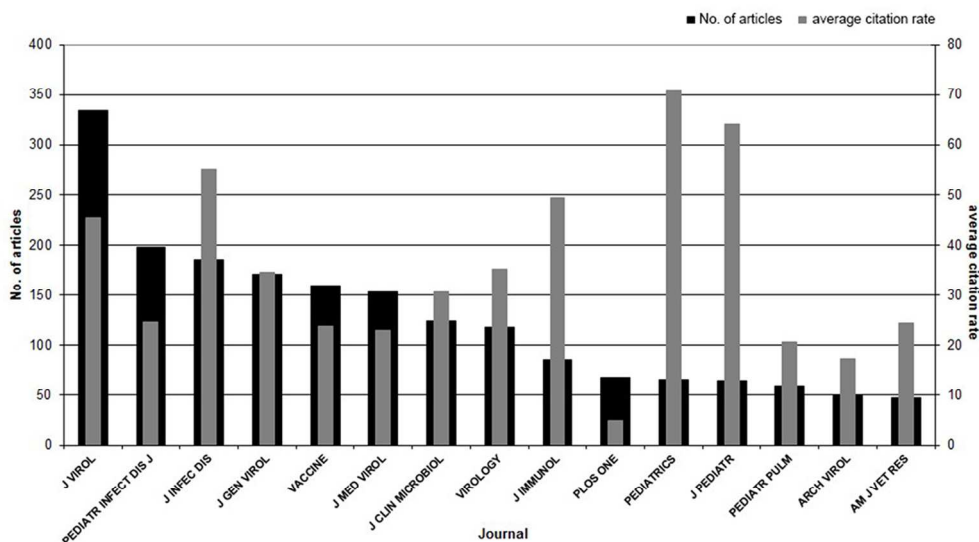


Figure 8: Most prolific journals in the field of RSV research in regards to overall publication numbers and the average citation rate.

109x65mm (300 x 300 DPI)

Review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

# BMJ Open

## Respiratory Syncytial Virus: A systematic scientometric analysis of the global publication output and the gender distribution of publishing authors

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-013615.R1
Article Type:	Research
Date Submitted by the Author:	18-Nov-2016
Complete List of Authors:	Brueggmann, Doerthe; Keck School of Medicine of the University of Southern California, Ob/Gyn; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Köster , Corinna ; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Klingelhoef, Doris; Goethe University, Institute of Occupational Medicine Bauer, Jan; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Ohlendorf, Daniela; Institute of Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-University Frankfurt/Main, ; Bundschuh, Matthias; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Groneberg, David; Occupational, Social and Environmental Medicine, Medical Department of the Goethe-University Frankfurt am Main
<b>Primary Subject Heading</b>:	Infectious diseases
Secondary Subject Heading:	Global health, Paediatrics, Public health, Respiratory medicine
Keywords:	Respiratory Syncytial Virus, Scientometry, Publication, Gender, Economic benchmarks

SCHOLARONE™  
Manuscripts

1  
2  
3 1 **Respiratory Syncytial Virus: A systematic scientometric analysis of the global**  
4  
5 2 **publication output and the gender distribution of publishing authors**  
6  
7 3

8  
9 4 Corresponding author: Dörthe Brüggmann – [occup-med@uni-frankfurt.de](mailto:occup-med@uni-frankfurt.de), Institute of  
10  
11 5 Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-  
12  
13 6 University, Theodor-Stern Kai 7, 60590 Frankfurt, Germany  
14  
15 7 Telephone: +49 (0) 69 6301 6650, Fax +49 (0) 69 6301 7053  
16  
17 8

18  
19  
20 9 Dörthe Brüggmann<sup>1,2,\*</sup>, Corinna Köster<sup>2,\*</sup>, Doris Klingelhöfer<sup>2</sup>, Jan Bauer<sup>2</sup>, Daniela  
21  
22 10 Ohlendorf<sup>2</sup>, Matthias Bundschuh<sup>2</sup>, David A Groneberg<sup>2</sup>  
23  
24 11

25  
26  
27 12 <sup>1</sup> Department of Obstetrics and Gynecology, Keck School of Medicine of USC, Los  
28  
29 13 Angeles, California, United States  
30  
31 14

32  
33  
34 15 <sup>2</sup> Institute for Occupational Medicine, Social Medicine and Environmental Medicine,  
35  
36 16 Goethe University Frankfurt, Germany  
37  
38 17

39  
40 18 \* equal contribution  
41  
42 19

43  
44  
45 20 Word Count: 6,212  
46  
47 21

48  
49 22  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 **23 Abstract**  
4

5 24 Objective: Worldwide, the respiratory syncytial virus (RSV) represents the  
6  
7 25 predominant viral agent causing bronchiolitis and pneumonia in children. To conduct  
8  
9 26 research and tackle existing healthcare disparities, RSV-related research activities  
10  
11 27 around the globe need to be described. Hence, we assessed the associated scientific  
12  
13 28 output (represented by research articles) by geographical, chronological and socio-  
14  
15 29 economic criteria and analyzed the authors publishing in the field by gender. Also,  
16  
17 30 the 15 most cited articles and the most prolific journals were identified for RSV  
18  
19 31 research.  
20

21  
22  
23 32 Design: retrospective, descriptive study  
24

25 33 Setting: The NewQIS platform was employed to identify RSV-related articles  
26  
27 34 published in the Web of Science until 2013. We performed a numerical analysis of all  
28  
29 35 articles, and examined citation-based aspects (e.g. citation rates); results were  
30  
31 36 visualized by density equalizing mapping tools.  
32  
33

34 37 Results: We identified 4600 RSV-related articles. The USA led the field; US-  
35  
36 38 American authors published 2,139 articles (46.5% % of all identified articles), which  
37  
38 39 have been cited 83,000 times. When output was related to socio-economic  
39  
40 40 benchmarks such as GDP or R&D expenditures, Guinea-Bissau, The Gambia and  
41  
42 41 Chile were ranked in leading positions. 614 articles on RSV (13.34% of all articles)  
43  
44 42 were attributed to scientific collaborations. These were primarily established between  
45  
46 43 high-income countries. The gender analysis indicated that male scientists dominated  
47  
48 44 in all countries except Brazil.  
49

50  
51 45 Conclusions: The majority of RSV-related research articles originated from high-  
52  
53 46 income countries whereas developing nations showed only minimal publication  
54  
55 47 productivity and were barely part of any collaborative networks. Hence, research  
56  
57  
58  
59  
60

1  
2  
3 48 capacity in these nations should be increased in order to assist in addressing  
4  
5 49 inequities in resource allocation and the clinical burden of RSV in these countries.  
6  
7  
8  
9

10  
11  
12  
13  
14  
15 50  
16  
17

18  
19  
20  
21 51 **Key words:** Respiratory Syncytial Virus, Publication, Citation, Scientometry, Gender,  
22  
23 52 Economic benchmarks  
24  
25  
26  
27

28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

### 54 **Strengths and Weaknesses**

55 • This is the first concise depiction of the worldwide scientific productivity related  
56 to RSV, which was assessed by geographical, chronological and socio-  
57 economic criteria.

58 • The NewQIS platform combines scientometric methods and “density  
59 equalizing mapping projections” to evaluate the scientific output regarding  
60 quantitative and qualitative aspects, geographical and chronological  
61 developments, existing research networks and socio-economic benchmarks in  
62 a reliable and standardized way.

63 • Since the WoS has a preference for English journals, we have to acknowledge  
64 a language bias associated with our analysis.

65 • Citation based parameters were assessed, which have limitations since these  
66 rather reflect the recognition of the research in the scientific community than  
67 truly measure quality.

50  
51 68  
52  
53  
54  
55  
56  
57  
58  
59  
60

## 69 INTRODUCTION

70 The human respiratory syncytial virus (RSV) is the predominant viral agent affecting  
71 the respiratory tract worldwide <sup>1,2</sup>. It is associated with 64 million infections that occur  
72 primarily in children under 5 years <sup>3</sup>. RSV belongs to the Paramyxoviridae family and  
73 is a negative-sense, non-segmented, single-stranded RNA virus, which is mostly  
74 transmitted by droplets <sup>4</sup>. RSV causes bronchiolitis, pneumonia, bronchitis and croup.  
75 It is linked to recurrent wheezing and pediatric asthma <sup>5, 6</sup>. There is no definitive  
76 treatment for RSV-related conditions. Although the development of effective and safe  
77 vaccines has remained unsuccessful to date, the variety of candidate vaccines is  
78 constantly growing in the last years <sup>7</sup>. One prophylactic agent is commercially  
79 available, the neutralizing anti-RSV antibody Palivizumab. Its use is limited to  
80 preterm babies, chronic lung disease of prematurity and infants with congenital heart  
81 disease <sup>8</sup>.

82

83 RSV-associated morbidity and mortality depends on many factors such as the  
84 geographic location, climate patterns, genetic susceptibility, socioeconomic factors  
85 and local virus strains <sup>3</sup>. The percentage of children having contracted RSV by their  
86 second year of life approaches 100% <sup>9, 10</sup>. In the United States of America (USA),  
87 over 2 million children aged 5 years and under need medical attention to treat their  
88 RSV infection every year <sup>11</sup>. On average, 0.3% of these children and 0.7% of infants  
89 younger than six months require hospitalization <sup>11</sup>. The general RSV mortality rate in  
90 this demographic varies between 0-33% <sup>10</sup>. Worldwide, up to 199 000 children die  
91 due to RSV infections. 99% of these deaths occur in in developing countries <sup>3</sup> hence,  
92 RSV represents a substantial burden for community health in these nations.  
93 According to WHO field studies in ten developing countries, RSV causes 70% of all

1  
2  
3 94 acute respiratory-tract infections in children under 5 years of age<sup>12</sup>. Here, the virus is  
4  
5 95 identified in about 15-40% of the hospitalized children with pneumonia or bronchiolitis  
6  
7 96<sup>13</sup>. RSV epidemics occur during rainy seasons in tropical climates and during the  
8  
9 97 winter months in temperate zones<sup>4</sup>. Both virus strains, RSV-A and -B, co-circulate  
10  
11 98 during outbreaks in any given year. The A subtype is typically associated with more  
12  
13 99 severe disease<sup>14</sup>. Distinct genotypes of both strains (identified by the genetic  
14  
15  
16 100 classification of their G protein) are predominant in any given year. This pattern is  
17  
18 101 highly flexible, varies by region and may shift to other prominent genotypes the  
19  
20 102 following year<sup>15</sup>. Epidemiological studies are dedicated to characterize the  
21  
22 103 distribution of RSV strains and genotypes worldwide, often leading to the  
23  
24 104 identification of new variants such as the RSV B genotype THB in Thailand<sup>16</sup>.  
25  
26  
27  
28

29 106 Although care of RSV patients has been improved considerably and extensive  
30  
31 107 studies have been launched to estimate viral spread and disease burden in  
32  
33 108 developing countries, tremendous challenges still remain. In regards to the high  
34  
35 109 prevalence, morbidity and mortality of RSV worldwide, we consider that further  
36  
37 110 research and the implementation of related public health measures are crucial for  
38  
39 111 future successes. However, global research funds are limited and their allocation  
40  
41 112 becomes challenging. In this context, the assessment of the scientific performance is  
42  
43 113 a prerequisite for the reasonable distribution of monetary support and the planning of  
44  
45 114 future research endeavors by scientists interested in the field. Hence, we employed  
46  
47 115 scientometric tools with the goals (1) to determine the RSV-related publication output  
48  
49 116 among the extensive amount of biomedical publications and (2) to evaluate the  
50  
51 117 scientific productivity of single countries in the framework of the global research  
52  
53 118 landscape and in relation to socioeconomic and gender aspects. We also identified  
54  
55 119 the 15 most cited landmark articles and the most prolific journals in the field of RSV  
56  
57  
58  
59  
60



1  
2  
3 120 research.  
4  
5  
6  
7  
8  
9

10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

121

## 122 **METHODS**

### 123 **Methodical Platform**

124 We used the New Quality and Quantity Indices in Science (NewQIS) platform to  
125 assess the worldwide RSV publication activity in a reliable and standardized way.  
126 This tool combines scientometric methods and “density equalizing mapping  
127 projections“ (DEMP) <sup>17-19</sup> to evaluate the publication output regarding quantitative and  
128 qualitative aspects, geographical and chronological developments, existing research  
129 networks and socio-economic benchmarks.

130

### 131 **Density-equalizing mapping**

132 DEMP is a state-of-the-art technique to visualize benchmarking processes by  
133 anamorphic maps <sup>17, 20</sup>. Based on the algorithm of Gastner and Newman, the size of  
134 each country was modified analogously to country-specific data on RSV research  
135 leading to a new geographic distribution of the global landscape <sup>17</sup>.

136

### 137 **Data collection**

138 For data collection, the Web of Science (WoS) Core Collection database (Thomson  
139 Reuters) was employed. The following search term was created: Title=(“RSV” OR  
140 “Respiratory Syncytial Virus” OR “RS Virus\*”) NOT Topic=(Rous Sarcoma). The  
141 Boolean operator NOT was used to exclude all publications concerning the Rous  
142 Sarcoma (Virus). We limited our search to original research articles. Following our  
143 protocol, the time frame was restricted from 1900 to 2013; publications in 2014 were  
144 not regarded due to incomplete data acquisition at the time the study was performed.

10

## 145 **Data analysis**

146 RSV-related articles were analyzed regarding quantitative aspects such as the total  
147 number of publications, citation numbers, countries of article origin (defined as the  
148 'country where the institution is located each author, who worked on publishing the  
149 article, is affiliated'), institutions, languages, cited reference numbers, and publication  
150 date. The number of authors publishing on RSV was only quantified for the years  
151 with 30 or more annual publications. Also, h-Indices, and the average citation number  
152 per item (citation rate, CR) were investigated. Regression analysis was used to  
153 investigate the chronological evolution of RSV research. We calculated the  
154 coefficient of determination ( $r^2$ ) representing the slope of the growth in scientific  
155 output and citations.

## 157 **Modified h-Index**

158 The Hirsch-Index (h-Index) is a recognized semi-qualitative proxy measure to assess  
159 the impact of one author's research output on the scientific community<sup>21, 22</sup>. An h-  
160 index of 12 indicates that out of 12 published papers each has been cited at least 12  
161 times. In this study, we applied this concept to the RSV-specific research productivity  
162 of single countries and calculated a "modified country-specific" h-Index.

## 164 **Country-specific gender analysis**

165 The proportionality of male and female researchers among authors publishing on  
166 RSV was analyzed. Online name databases were utilized to identify the authors'  
167 genders<sup>23</sup>. If first names were not gender-specific or quoted as initials, a manual  
168 search (utilizing websites, corresponding addresses and social networks) was  
169 launched. We only evaluated countries where a minimum of 60 authors were

170 affiliated and a minimum of 50% of authors were identified by gender to ensure a  
171 valid analysis. These thresholds were chosen arbitrarily based on previous studies.

172

### 173 **Cooperation analysis**

174 We identified all RSV-associated publications that were issued due to international  
175 collaborative efforts. The total count of collaborative items was related to the overall  
176 number of publications for each investigated country. In brief, if at least two authors  
177 originating from different institutions or countries (as identified by the affiliations in the  
178 article) contributed to one article, this publication was defined as a collaborative item.  
179 Publications with two or more authors affiliated to the same country were counted  
180 one time only towards the complete count of joint publications of this particular  
181 country. If an author had two affiliations, these were counted for every country  
182 mentioned in the affiliations. Connecting vectors visualized these co-operations; their  
183 width and shade of grey reflected the number of joint publications.

184

### 185 **Journal analysis**

186 The journals publishing on RSV were analyzed regarding quantitative and qualitative  
187 aspects, e.g. number of published RSV articles as well as citations these items  
188 received (CR).

189

### 190 **Analysis of economic key figures**

191 Two quotients were calculated to assess the scientific output of a specific country, (1)  
192 in relation to the number of inhabitants (Q1), and (2) in relation to its economic power  
193 (as measured by the gross domestic product, GDP, Q2). Data regarding the

1  
2  
3 194 population and GDP of investigated countries were obtained from 2012 from the CIA  
4  
5 195 *World Factbook*<sup>24</sup>. We computed the quotients in the following way:  
6

7 196 1. Articles/population-index (Q1) = number of articles/population in millions  
8

9 197 2. Articles/GDP-index (Q2) = number of articles/GDP in billions  
10

11 198 All countries were classified into high-, upper-middle-, lower-middle- and low-income  
12  
13 199 groups according to World Bank definitions<sup>25</sup>.  
14  
15

16 200

17  
18 201 We compared the total number of RSV articles to the gross domestic expenditure on  
19  
20 202 Research and Development (in % of GDP) as well as to the number of researchers  
21  
22 203 (per billion inhabitants) affiliated to the investigated countries<sup>26</sup>. The analysis was  
23  
24 204 limited to countries that published a minimum of 30 articles in the field of RSV.  
25  
26

27  
28 205  
29  
30

## 31 206 **RESULTS**

### 32 207 **Number of published items**

33  
34 208 We identified 4,600 articles on RSV published between 1900 and 2013; 2,645  
35  
36 209 (57.5%) of these were issued after 2000. 1960 and onwards, the number of articles  
37  
38 210 increased significantly over time as indicated by  $r^2=0.9$  (Fig. 1). 10,791 authors  
39  
40 211 published in the field of RSV. The number of authors per article increased by 100% in  
41  
42 212 the investigated timeframe. We identified a mean of 3.8 and a median of 3 authors in  
43  
44 213 1978, which was the first year with more than 30 annual publications. 10 years later,  
45  
46 214 a mean of 4.59 and a median of 4 authors were found, followed by a mean of 5.05  
47  
48 215 and a median of 5 authors in 2000, a mean of 5.95 and a median of 5 authors in  
49  
50 216 2006 and a mean of 7.6 and a median of 6 authors in 2013  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 217  
4  
5

6 218 **Analysis of research origin and citations**  
7

8 219 Although the publications originated from 92 of the 251 investigated countries and  
9  
10 220 autonomous regions the majority of the articles were written in English (4444 articles,  
11  
12 221 96.6 % of all published RSV articles) followed by French (64 articles, 1.4 % of all  
13  
14 222 articles) and German (32 articles, 0.7% of all articles). More than 85% of the global  
15  
16 223 publication output was issued by authors from high-income economies. The USA  
17  
18 224 was the most productive nation (2,139 articles, 46.5% of all published RSV articles)  
19  
20 225 followed by the United Kingdom (UK, 583 articles, 12.7%), the Netherlands (231  
21  
22 226 articles, 5.0%), Canada (217 articles, 4.7%) and Germany (196 articles, 4.3%).  
23  
24 227 Hence, the USA and UK dominated the cartogram, while major parts of Africa (with  
25  
26 228 the exception of South Africa), Asia (with the exception of Japan, China, South  
27  
28 229 Korea, and India) and Central America occupied only minor areas (Fig. 2A).  
29  
30  
31

32 230  
33

34 231 The country-specific citation numbers and modified h-Indices showed a global  
35  
36 232 distribution similar to the number of publications. Articles with US-American affiliation  
37  
38 233 of the authors were cited most (83,000 citations, c), followed by articles from the UK  
39  
40 234 (c = 19,240), the Netherlands (c = 5587), Canada (c = 5549) and Germany (c =  
41  
42 235 5319). Articles published by African, Asian and Middle American authors received  
43  
44 236 hardly any citations.  
45  
46  
47

48 237  
49

50 238 The USA and the UK were the top ranked countries with a modified h-Index of 121  
51  
52 239 (USA) and 68 (UK), followed by the Netherlands (h-Index = 44), Germany (h-Index =  
53  
54 240 43) and Canada (h-Index = 40) (Fig. 2B).  
55

56 241  
57  
58  
59  
60

242 Regarding the country-specific citation rate (average number of citations per total  
 243 number of publications for each country with more than 30 articles, CR), Sweden (CR  
 244 = 40) dominated and was followed by the USA (CR = 38.8), Finland (CR = 34.9), the  
 245 UK and Germany (CR = 27.13).

246

### 247 **Analysis of citation performance**

248 The absolute citation count of all identified RSV-related articles resembled the  
 249 growing volume of published papers in the investigated timeframe. We documented a  
 250 significant positive correlation between citation numbers and the time of publication  
 251 (with  $r^2=0.72$  for the timeframe from 1960 to 2008). The annual citation counts grew  
 252 from 1960 to 1994 (e.g. from 19 annual citations in 1960 to 2448 annual citations in  
 253 1994); after 1995, a rapid increase followed until 2003 (e.g. 5274 annual citations in  
 254 1997 and 7790 annual citations in 2003) whereas a steep decline was noticed after  
 255 2006 (e.g. 3147 annual citations in 2006). We identified visible peaks in citation  
 256 activity for 1969 (2294 annual citations), 1986 (3898 annual citations), 2000 (7411  
 257 annual citations), and 2003 (7790 annual citations) (Fig. 3). Additionally, we compiled  
 258 the 15 most cited RSV articles, which constitute the publications that have sparked  
 259 the most documented interest in the field to date (Table 1).

260

261 Table 1. The 15 most cited articles in the area of RSV-related research are displayed  
 262 including their title, publication year, countries of article origin (defined as the  
 263 countries where first, senior- and co-authors are affiliated), citation count and journal.

Title	Publication Year	Country of Article Origin	Citations	Journal
Mortality associated with influenza and respiratory syncytial virus in the United States Thompson WW et al.	2003	United States	1520	JAMA

1 2 3 4 5 6	Pattern recognition receptors TLR4 and CD14 mediate response to respiratory syncytial virus <b>Kurt-Jones EA et al.</b>	2000	United States	856	Nat Immunol
7 8 9 10 11	Respiratory Syncytial Virus Disease In Infants Despite Prior Administration Of Antigenic Inactivated Vaccine <b>Kim HW et al.</b>	1969	United States	848	Am J Epidemiol
12 13 14	Respiratory syncytial virus in early life and risk of wheeze and allergy by age 13 years <b>Stein RT et al.</b>	1999	Brazil, United States	719	Lancet
15 16 17 18 19	Palivizumab, a humanized respiratory syncytial virus monoclonal antibody, reduces hospitalization from respiratory syncytial virus infection in high-risk infants <b>The Impact-RSV Study Group.</b>	1998	United States, Canada, UK	652	Pediatrics
20 21 22 23 24 25	An Epidemiologic Study Of Altered Clinical Reactivity To Respiratory Syncytial (Rs) Virus Infection In Children Previously Vaccinated With An Inactivated RS Virus Vaccine <b>Kapikian et al.</b>	1969	United States	552	Am J Epidemiol
26 27 28	Risk Of Primary Infection And Reinfection With Respiratory Syncytial Virus <b>Glezen et al.</b>	1986	United States	548	Am J Dis Child
29 30 31 32	Respiratory syncytial virus bronchiolitis in infancy is an important risk factor for asthma and allergy at age 7 <b>Sigurs N et al.</b>	2000	Sweden, Iceland	488	Am J Respir Crit Care Med
33 34 35 36 37	Wheezing, Asthma, And Pulmonary Dysfunction 10 Years After Infection With Respiratory Syncytial Virus In Infancy <b>Pullan CR and Hey EN</b>	1982	UK	449	Br Med J
38 39 40	Respiratory syncytial virus infection in elderly and high-risk adults <b>Falsey AR et al.</b>	2005	United States	430	NEJM
41 42 43 44	Prophylactic Administration Of Respiratory Syncytial Virus Immune Globulin To High-Risk Infants And Young-Children <b>Groothuis JR et al.</b>	1993	United States	427	NEJM
45 46 47 48 49	The Development Of Respiratory Syncytial Virus-Specific IgE And The Release Of Histamine In Nasopharyngeal Secretions After Infection <b>Welliver RC et al.</b>	1981	United States	425	NEJM
50 51 52 53	Respiratory-Syncytial-Virus Infections, Re-Infections And Immunity - Prospective, Longitudinal-Study In Young-Children <b>Henderson FW et al.</b>	1979	United States	418	NEJM
54 55 56 57 58 59	Generation of bovine respiratory syncytial virus (BRSV) from cDNA: BRSV NS2 is not essential for virus replication in tissue culture, and the human RSV leader region acts as a functional BRSV genome promoter	1999	Germany	417	J Virol

<b>Buchholz UJ et al.</b>				
Asthma and immunoglobulin-e antibodies after respiratory syncytial virus bronchiolitis - a prospective cohort study with matched controls				
<b>Sigurs N et al.</b>	1995	Sweden	416	Pediatrics

264

265 **Relation to economic parameters**

266 Relating the number of publications to the population of a country, high-income  
 267 countries like Iceland (Q1 = 34.59), the Netherlands (Q1 = 13.90) and Denmark (Q1  
 268 = 12.25), issued a higher number of publications per million inhabitants compared to  
 269 low-or lower-middle-income countries, e.g. Nigeria (Q1 = 0.03) and Indonesia (Q1 =  
 270 0.02) (Fig. 4A). We identified two exceptions, which included the low-income  
 271 countries Guinea Bissau (Q1 = 6.30) and The Gambia (Q1 = 4.76). Both were  
 272 represented among the 15 top ranked countries in this analysis.

273

274 When looking at the publication activity in relation to GDP, two low-income countries  
 275 outperformed high-income nations (Fig. 4B). Guinea Bissau (Q2 = 11.776) and The  
 276 Gambia (Q2 = 8.721) again held leading positions, followed by Iceland (Q2 = 0.810),  
 277 Kenya (Q2 = 0.516), and Croatia (Q2 = 0.319). Besides these two exceptions, other  
 278 low- or lower-middle-income countries showed a weak performance (e.g. Philippines  
 279 with Q2 = 0.004 or Indonesia with Q2 = 0.007). Also, the USA did not remain under  
 280 the top 10 nations and was found at position 18 (Q2 = 0.132).

281

282 Chile, the Netherlands, South Africa, UK and Argentina were leading the analysis  
 283 when the total article count was related to the country-specific Research and  
 284 Development (R&D) expenditures (33.72, 13.32, 12.14, 11.46 and 9.56 articles per  
 285 billion GDP spent on R&D, respectively). The USA dropped to position 11 with 4.52  
 286 articles per billion GDP spent on R&D (Fig. 5A, Table 2A).



1  
2  
3 287

4  
5 288 When we related the article count to the number of researchers (per billion  
6  
7 289 inhabitants) as a proxy measure for the active research community working on RSV  
8  
9 290 and the productivity of these researchers, the USA was leading the field (532.27  
10  
11 291 articles per researcher per billion inhabitants), followed by the UK, China, Chile and  
12  
13 292 South Africa (137.10, 83.55, 77.10, and 76.60 articles per number of researchers per  
14  
15 293 billion inhabitants) (Fig. 5B, Table 2B).

16  
17  
18 294

19  
20 295 Table 2A. Total number of publications related to gross domestic expenditures on  
21  
22 296 Research and Development in Billion USD of countries that have published more  
23  
24 297 than 30 items on RSV.

25  
26  
27 298

Rank	Country	No. of articles	R&D expenditure in % GDP	GDP in billion USD	R&D Expenditure in billion USD	Articles/ billion USD of R&D Expenditure
1	Chile	33	0.38	258	0.98	33.72
2	Netherlands	231	1.97	879	17.34	13.32
3	South Africa	31	0.73	349	2.55	12.14
4	UK	583	1.70	2990	50.85	11.46
5	Argentina	31	0.61	529	3.24	9.56
6	Spain	160	1.23	1381	17.01	9.41
7	Canada	217	1.61	1783	28.73	7.55
8	Denmark	68	3.08	346	10.67	6.37
9	Sweden	99	3.16	571	18.05	5.49
10	Finland	46	3,17	272	8.63	5.33
11	USA	2139	2.73	17348	472.78	4.52

12	Belgium	56	2.46	531	13.09	4.28
13	Italy	84	1.29	2138	27.52	3.05
14	Switzerland	62	2.97	701	20.80	2.98
15	France	189	2.26	2829	63.82	2.96
16	Australia	86	2.20	1454	31.93	2.69
17	Israel	33	4.11	305	12.53	2.63
18	Brazil	75	1.24	2417	29.87	2.51
19	Germany	196	2.87	3868	110.96	1.77
20	Russia	37	1.19	2030	24.09	1.54
21	Japan	192	3.58	4596	164.73	1.17
22	South Korea	36	4.29	1411	60.55	0.59
23	China*	93	2.05	10351	211.79	0.44

299

300 Table 2B. Total number of publications related to articles per researcher (per billion  
 301 inhabitants) of countries that have published more than 30 items on RSV.

302

Rank	Country	Number of RSV articles	Number researchers of per billion inhabitants	Articles/researcher (per billion inhabitants)
1	USA	2139	4.02	532.27
2	UK	583	4.25	137.10
3	China*	93	1.11	83.55
4	Chile	33	0.42	77.11
5	South Africa	31	0.40	76.60
6	Spain	160	2.64	60.55
7	Netherlands	231	4.48	51.58

8	Canada	217	4.52	48.02
9	France	189	4.20	44.99
10	Germany	196	4.38	44.74
11	Italy	84	2.01	41.86
12	Japan	192	5.39	35.65
13	Argentina	31	1.20	25.79
14	Sweden	99	6.87	14.41
15	Switzerland	62	4.48	13.83
16	Belgium	56	4.18	13.41
17	Russia	37	3.10	11.93
18	Denmark	68	7.20	9.45
19	Finland	46	7.00	6.58
20	South Korea	36	6.90	5.22
21	Israel	33	8.26	4.00

303

304

### 305 **Country-specific gender analysis**

306 We identified the gender distribution among authors working on RSV in institutions  
 307 affiliated to 92 countries. Our analysis indicated a larger proportion of male scientists  
 308 in almost all evaluated countries (Fig. 6). Brazil was an exception. 95 authors with  
 309 affiliation to Brazilian institutions were identified as working on RSV. 62 of those were  
 310 identifiable by name and gender. Here, males and females were almost equally  
 311 represented (32 female authors, 51.6% of identifiable authors, 30 male authors,  
 312 48.4% of identifiable authors). By calculating the proportion of male to female

1  
2  
3 313 scientists, we documented the lowest ratio (0.94) for Brazil, followed by Germany  
4  
5 314 (1.1). Japan had the highest score with 2.8.

6  
7 315

8  
9  
10 316 **International cooperation analysis**

11  
12 317 The first collaborative article on RSV was identified in 1973. It was published by  
13  
14 318 researchers working in institutions located in Switzerland and the USA <sup>27</sup>. Since  
15  
16  
17 319 1973, 614 joint articles were published on RSV accounting for 13.34% of all articles.

18  
19 320 The USA was the preferred partner for international collaborations on RSV. The most  
20  
21 321 productive cooperation was established between the USA and the UK (67 joint  
22  
23 322 works, 10.9% of collaborative articles), followed by the USA and Canada (45 joint  
24  
25 323 articles, 7.3% of collaborative articles), and the USA and Germany (34 joint articles,  
26  
27 324 5.5% of collaborative articles).

28  
29  
30 325

31  
32 326 The most fruitful cooperation not involving the USA existed between the UK and  
33  
34 327 Spain (33 joint articles, 5.4% of collaborative articles). The most productive  
35  
36 328 cooperation between high- and lower-middle- or low-income economies was set up  
37  
38 329 between Kenya and the UK (18 joint articles, 2.9% of collaborative articles) followed  
39  
40 330 by Guinea Bissau and Denmark (10 joint articles, 1.6% of collaborative articles).

41  
42 331 Overall, co-operations with low-income or lower-middle-income countries were less  
43  
44 332 popular (Fig. 7).

45  
46  
47 333

48  
49  
50 334 **Journal analysis**

51  
52 335 When we identified the most prolific journals in RSV research, the "Journal of  
53  
54 336 Virology" led the field (334 articles, CR of 45.49), followed by "The Pediatric  
55  
56 337 Infectious Disease Journal" (198 articles, CR = 24.66) and the "Journal of Infectious  
57  
58  
59  
60

1  
2  
3 338 Diseases" (186 articles, CR 55.18) (Fig. 8). The highest citation rate was achieved by  
4  
5 339 the "Proceedings of the National Academy of Sciences of the United States of  
6  
7 340 America" (42 articles, CR = 81.43), followed by "Pediatrics" (66 articles, CR = 70.80),  
8  
9 341 "Journal of Pediatrics" (65 articles, CR = 64.03), "American Journal of Respiratory  
10  
11 342 Critical Care" (47 articles, CR = 62.55), and „Journal of Infectious Diseases“ (186  
12  
13 343 articles, CR = 55.18).  
14  
15  
16  
17  
18  
19

344

## 345 **DISCUSSION**

20  
21 346 In the WoS, we documented only 4,600 RSV-related articles since 1900. The first  
22  
23 347 item on the disease in humans was published in 1957<sup>28</sup>. This emphasizes that  
24  
25 348 research on RSV is a relatively new field considering the virus was initially isolated in  
26  
27 349 1956 from laboratory primates<sup>29</sup>. The predominance of English in the majority of  
28  
29 350 identified articles aligns not only with the fact that this language is the recognized  
30  
31 351 "scientific lingua franca" but also reflects the abundant research output of English  
32  
33 352 speaking countries such as USA, Canada and the UK found in our study.  
34  
35  
36

353

354 The increasing number of RSV publications over time is typical for most biomedical  
35  
36 355 research, e.g. on the John Cunningham Virus, influenza or breast cancer<sup>30, 31</sup>.  
37  
38

39 356 Overall, the steady growth of article numbers can be explained by the rising interest  
40  
41 357 in the field due to the increasing relevance of RSV in pneumonia and child mortality<sup>9</sup>.  
42  
43

44 358 In the first few years after the detection of the virus, basic research was conducted.  
45  
46

47 359 These endeavors, which aimed to characterize the virus, identify immunologic  
48  
49 360 responses and develop vaccines, translated into a growing volume of articles on RSV  
50  
51 361<sup>32-35</sup>. The continuous increase since the beginning of the 1990s may be attributed to  
52  
53  
54

55 362 the launch of a growing number of scientific journals providing a platform for  
56  
57  
58  
59  
60

1  
2  
3 363 publishing. The development of modern communication systems based on new  
4  
5 364 computer technologies like the World Wide Web made it easier to communicate,  
6  
7 365 exchange ideas, and publicize articles in central databases. Also, it is noticeable that  
8  
9 366 the increasing publication output since the 1960s was paralleled by a globally  
10  
11 367 growing funding volume allocated to the R&D sector. In the USA alone, a total of  
12  
13 368 13,711 million US-Dollars (UDS) was allocated to R&D in 1960 as documented by  
14  
15 369 the National Science Foundation. This amount increased to 26,271 million UDS in  
16  
17  
18 370 1970 and 452,556 million USD in 2012  
19  
20 371 (<https://www.nsf.gov/statistics/2015/nsf15315/>).

21  
22 372

23  
24 373 The chronological development in publication quantity (Fig. 1) was resembled by the  
25  
26 374 steady increase of related citations (Fig.3). Four prominent citation peaks in 1969,  
27  
28 375 1986, 2000 and 2003 coincided with milestone papers the field. In 1969, adverse  
29  
30 376 effects of the formalin-inactivated RSV vaccine in children were reported <sup>36</sup>. Large  
31  
32 377 epidemiologic studies investigated the risks of reinfection and the mortality  
33  
34 378 associated with RSV in 1986 and 2003 <sup>37, 38</sup>. The research on a prophylactic antibody  
35  
36 379 licensed in 1999 and novel insights into immunologic responses involving pattern  
37  
38 380 recognition receptors TLR4 and CD14 may be responsible for the peaking number of  
39  
40 381 publications and citations in 2000 <sup>39</sup>. The citation decline after 2006 can be attributed  
41  
42 382 to the short timespan articles had allotted to receive recognition within the scientific  
43  
44 383 community and obtain the appropriate citation number reflecting their true impact <sup>40</sup>.  
45  
46 384 Hence, we expect this trend to be reversed in the future.

47  
48 385

49  
50 386 The USA dominated RSV research with regards to overall publication quantity,  
51  
52 387 citation numbers and h-index. This corresponds with a previous biomedical  
53  
54 388 benchmarking study. Here, the USA was the most productive nation and authored

1  
2  
3 389 1,893,800 of 5,527,558 publications related to 22 organ systems from 1961 to 2007  
4  
5 390 <sup>41</sup>. The leading role of the USA might be linked to major financial resources this  
6  
7 391 nation dedicates to research. The US-American National Institutes of Health (NIH)  
8  
9 392 are by far the biggest biomedical funder in the world (e.g. with a funding volume of  
10  
11 393 26.08 billion USD in 2013 compared to the biggest funding source in the EU, the  
12  
13 394 European Commission, with a funding volume of 3.71 billion USD in 2013). Also, the  
14  
15 395 Department of Defense constitutes another large US-American funding organization  
16  
17 396 with a volume of 1.017 billion USD (2013), followed by private philanthropic  
18  
19 397 institutions such as the Howard Hughes Medical Institute or the Bill & Melinda Gates  
20  
21 398 Foundation with impressive funding volumes of 752.0 (2013) and 462.6 million USD  
22  
23 399 (2011), respectively <sup>42</sup>. These funds can support manpower and an outstanding  
24  
25 400 scientific infrastructure illustrated by the fact, that the majority of institutions working  
26  
27 401 on RSV were identified in the USA, and that this nation is a preferred partner for  
28  
29 402 national and international co-operations.  
30  
31  
32  
33

34 403

35  
36 404 The cluster of the USA, Western-European countries (e.g. UK or Germany) and  
37  
38 405 Japan dominated the overall publication output and analyses of citation-based  
39  
40 406 benchmarks. This finding corresponds with other scientometric studies (e.g. on  
41  
42 407 Influenza, Ebola, or Hepatitis B <sup>30, 43</sup>. Although Sweden and Finland published  
43  
44 408 relatively low numbers of articles, they are characterized by the highest citation rates  
45  
46 409 in our analysis indicating the outstanding quality and high recognition their articles  
47  
48 410 received in the scientific community. Furthermore, it was striking that most African,  
49  
50 411 Asian and Central American countries afflicted with a considerable RSV-related  
51  
52 412 burden did not play a visible role in the field. Methodologically, we included only  
53  
54 413 countries in the citation rate analysis that published more than 30 RSV articles  
55  
56 414 aiming to generate a better the validity of the investigation by avoiding overestimation  
57  
58  
59  
60

24

1  
2  
3 415 of few but frequently cited articles. Nevertheless, we want to stress that the absolute  
4  
5 416 number of citations as well as the citation rate should be viewed critically. These  
6  
7 417 parameters can be affected by self-citation and inaccurate citations. Also, the  
8  
9 418 Matthew effect might influence citation-based variables. Here, scientists prefer to cite  
10  
11 419 articles issued by well-known researchers to papers by junior scientists leading to a  
12  
13 420 disproportional increase of the related citation counts <sup>44, 45</sup>. Hence, we also evaluated  
14  
15 421 the modified h-index since it is less influenced by outstanding, frequently or rarely  
16  
17 422 cited articles skewing the citation rate value <sup>21, 22</sup>. Furthermore, all citation-based  
18  
19 423 variables have limitations in assessing the quality of the identified articles because  
20  
21 424 they rather reflect the recognition of the research in the scientific community than  
22  
23 425 measure quality.  
24  
25  
26  
27  
28

29 426  
30 427 We identified an overrepresentation of male authors in the majority of evaluated  
31  
32 428 nations. This corresponds to the study of Head et al. who documented the  
33  
34 429 preferential funding of male researchers by UK institutions in the area of global  
35  
36 430 infectious disease research. Between 1997-2010, funding agencies supported fewer  
37  
38 431 studies of female PIs and awarded less monetary support to research supervised by  
39  
40 432 women. Particularly for RSV, male researchers received 5-times more funding than  
41  
42 433 female scientists, who spearheaded only half the funded studies compared to their  
43  
44 434 male counterparts in the field <sup>46</sup>. In our gender analysis, Brazil was an exception with  
45  
46 435 a majority of women authoring RSV research (Fig. 6). This result correlates with  
47  
48 436 previous investigations on Yellow fever and Rotavirus infections <sup>47</sup> as well as with  
49  
50 437 gender benchmarking studies (e. g. conducted by the “Konrad-Adenauer Foundation”  
51  
52 438 or the “Organization for Women in Science for the Developing World” (OWSD)),  
53  
54 439 which suggests that Brazil pioneers in the support and participation of females in  
55  
56 440 science <sup>48, 49</sup>.  
57  
58  
59  
60



1  
2  
3 441

4  
5 442 Our analysis of RSV publication outputs changed in relation to economic capabilities  
6  
7 443 (Fig. 4). Two developing, low-income nations, The Gambia and Guinea-Bissau,  
8  
9 444 occupied the leading positions. This finding points towards the fact that both prioritize  
10  
11 445 RSV research and might be connected to existing co-operations with a long standing  
12  
13 446 shared history between collaborating nations and their focused support of RSV  
14  
15 447 scientific activities. For example, the United Kingdom's "Medical Research Council  
16  
17 448 The Gambia Unit" and the Danish "Bandim Health Project" encourage medical  
18  
19 449 research in Guinea-Bissau and The Gambia <sup>50, 51</sup>. Also, research in the field is  
20  
21 450 promoted by single researchers with a strong dedication to conduct research in  
22  
23 451 African sites. Here, Sir Brian Greenwood has spearheaded RSV-related research  
24  
25 452 very successfully for decades while being faculty at the London School of Hygiene  
26  
27 453 and Tropical Medicine as well as the Director of the Medical Research Council in The  
28  
29 454 Gambia <sup>52, 53541355, 565758</sup>.

30  
31  
32  
33  
34 455

35  
36 456 If the RSV article counts were related to R&D expenditures and number of  
37  
38 457 researchers in specific countries, a different, more refined picture emerged compared  
39  
40 458 to the assessments based on absolute publications numbers or related to socio-  
41  
42 459 economic variables. Here, two Latin American countries gained importance, Chile  
43  
44 460 and Argentina. It appears that these nations invest funding very efficiently in RSV  
45  
46 461 research, with Chile ranked first position with 33.72 RSV articles per billion USD in  
47  
48 462 R&D expenditures followed by Argentina in fifth position (9.56 articles per billion USD  
49  
50 463 in R&D). Both nations' interest to fund RSV research might be linked to the fact that  
51  
52 464 respiratory infections and RSV in particular impose a heavy burden on the local  
53  
54 465 pediatric population. Respiratory infections constitute the second leading cause of  
55  
56 466 death in Latin American children aged 5 years or under with RSV as the causative

57  
58  
59  
60 26

1  
2  
3 467 agent in 70.0% of these infections.<sup>3,459, 60</sup>. In the temperate climate of Chile and  
4  
5 468 Argentina, RSV causes predictable outbreaks during the summer months. A  
6  
7 469 particular high RSV burden of up to 70% was reported in Chilean children aged 0-11  
8  
9 470 months with lower respiratory tract infection. This was substantially higher than in  
10  
11 471 other Latin American countries (e.g.18.2 % Argentina and 44% in Brazil)<sup>61</sup>. Hence,  
12  
13 472 RSV is constantly in the focus of the local health authorities, which routinely monitor  
14  
15 473 and report the trends in RSV infections to better allocate resources for pediatric  
16  
17 474 patients and limit related morbidity and mortality<sup>61,62</sup>.  
18  
19  
20  
21 475

22  
23 476 Collaborations are becoming increasingly important in the field of RSV research as  
24  
25 477 indicated by existing tight-knit networks and the growing numbers of authors per  
26  
27 478 article over time. We link this development to the globalization process, which  
28  
29 479 connects scientists worldwide to exchange ideas, resources and knowledge  
30  
31 480 facilitated by the growing availability of information technology. Further, it is  
32  
33 481 noticeable that countries such as the USA or European nations play a more  
34  
35 482 prominent role in international collaborations compared to low- and lower-middle-  
36  
37 483 income countries. As exceptions, we could identify productive co-operations between  
38  
39 484 the UK and Kenya as well as Denmark and Guinea-Bissau. The relation between  
40  
41 485 Kenya and the UK might be based on their shared history and facilitated by  
42  
43 486 implemented programs such as the “*KEMRI Wellcome Trust Research Program*”  
44  
45 487 between the Kenya Medical Research Institute and the University of Oxford<sup>63</sup>. As  
46  
47 488 revealed by Fitchett et al.<sup>64</sup>, a substantial funding volume goes to infectious disease  
48  
49 489 research in countries with colonial ties to the UK such as Kenya and The Gambia.  
50  
51 490 From 1997 – 2010, these countries received 13.13 million £ (The Gambia) and 12.92  
52  
53 491 million £ (Kenya) of biomedical funding by UK based institutions. Research activity on  
54  
55 492 RSV in Guinea-Bissau is also supported by the aforementioned Danish “Bandim  
56  
57  
58  
59  
60

1  
2  
3 493 Health Project", which was founded by the anthropologist Sir Peter Aaby in the  
4  
5 494 1970s. It gathers local epidemiological data on more than 200,000 individuals. Since  
6  
7 495 its foundation, this group has published more than 600 items on vaccines, maternal  
8  
9 496 mortality and childhood infections such as RSV <sup>50</sup>.

10  
11 497

12  
13  
14 498 Timing, intensity and clinical impact of RSV infections vary worldwide <sup>3</sup>. Hence,  
15  
16 499 research is still needed to alleviate the burden related to RSV in high-risk  
17  
18 500 populations. Interventions should focus on data collection via established  
19  
20 501 surveillance systems (e.g. aiming to define local morbidity and mortality, assist  
21  
22 502 disease modeling, and guide prophylactic measures and vaccine development) <sup>65</sup>. In  
23  
24 503 this context, our study revealed a striking discrepancy in scientific productivity and  
25  
26 504 collaborative involvement between high- and low-income countries. Also, attention  
27  
28 505 should be drawn to a further problem concerning low-income nations or countries  
29  
30 506 whose researchers have a limited financial budget to pay for publication in renowned  
31  
32 507 open access journals. This issue increases the apparent discrepancies regarding  
33  
34 508 publication activities even further. To minimize this problem, a number of waiver  
35  
36 509 programs currently exist, i.e. for journals like PLOS, Biomed Central or BMJ OPEN <sup>66-</sup>  
37  
38 510 <sup>68</sup>, but these should be expanded more broadly. However, we can deduce from our  
39  
40 511 findings, that developing nations - although experiencing the most significant  
41  
42 512 consequences of RSV epidemics - cannot compete equally in the field of RSV  
43  
44 513 research due to the lack of funding and infrastructure. Therefore, we want to  
45  
46 514 emphasize the need – an almost ethical responsibility - to involve these nations in  
47  
48 515 funding programs and successful international collaborations as seen for Guinea-  
49  
50 516 Bissau, Kenya and The Gambia. We acknowledge that the establishment of  
51  
52 517 collaborations between high- and low-income nations is challenging due to the lack of  
53  
54 518 resources, manpower and funding opportunities, the political climate, cultural  
55  
56  
57  
58  
59  
60

28

1  
2  
3 519 differences between the potential partners and a unrealistic assessment of the local  
4  
5 520 research capacity and resources <sup>69</sup>. Also, existing collaborations and funding streams  
6  
7 521 need to be viewed critically since they should rather reflect local disease burden,  
8  
9 522 apparent healthcare disparities and scientific capability than being allocated based  
10  
11 523 on a shared language or history between countries (e.g. guided by former colonial  
12  
13 524 ties). Therefore, funding institutions should revise their policies appropriately <sup>64</sup>. Also,  
14  
15 525 global investment surveillance systems need to be established such as the  
16  
17 526 “Research Fairness Initiative” led by Cohred to guide and monitor sustainable,  
18  
19 527 transparent and effective partnerships in research ([http://rfi.cohred.org/origin-of-the-](http://rfi.cohred.org/origin-of-the-rfi/)  
20  
21 528 [rfi/](http://rfi.cohred.org/origin-of-the-rfi/)). Nevertheless, tight-knit networks would be key for developing countries to  
22  
23 529 participate in the international exchange of data, resources and knowledge, and to  
24  
25 530 facilitate their involvement in high quality research efforts despite an unequal starting  
26  
27  
28  
29 531 point.

30  
31  
32 532

### 33 533 **Study Limitations**

34  
35  
36 534 Our study has several limitations. Using the WoS to conduct this analysis is  
37  
38 535 associated with an important strength but also with a weakness of the study. The  
39  
40 536 WoS enabled us to assess not only quantitative but also qualitative aspects of the  
41  
42 537 publication output related to RSV research. This is a unique feature allowing a  
43  
44 538 multifaceted evaluation of the publication productivity. On the other hand, the WoS  
45  
46 539 displays a strong preference for English journals. Therefore, not all articles ever  
47  
48 540 published on RSV could be analyzed here. However, we regard this bias as limited  
49  
50 541 as the majority of high quality data is commonly published in international journals  
51  
52 542 indexed by the WoS and therefore definitely included in our search. Also, we  
53  
54 543 acknowledge that not all eligible RSV publications were detected by the conducted  
55  
56 544 “TITLE”-search. This approach was preferred to a “TOPIC” search, which identifies

57  
58  
59  
60 29

1  
2  
3 545 the search term in the abstract and the keywords leading to a significant amount of  
4  
5 546 off-topic publications compromising the validity of our data collection. We  
6  
7 547 concentrated our study on original articles to focus on published “cutting edge  
8  
9 548 research” in the field of RSV. We acknowledge that this strategy narrowed down the  
10  
11 549 focus on the topic since other publication types such as commentaries, reviews, case  
12  
13 550 reports, or meeting reports were not included. Further, we did not employ any  
14  
15 551 additional platforms such as PubMed, Google Scholar or Scopus to collect  
16  
17 552 bibliometric data because the management, organization and the scope of data is  
18  
19 553 slightly different among these databases. This would affect triangulating, comparing  
20  
21 554 and integrating data related to RSV research in a meaningful way.  
22  
23  
24  
25

26 555

27 556 We identified the first collaborative article on RSV in 1973, which would indicate that  
28  
29 557 researchers from different countries did not work together on RSV before this point in  
30  
31 558 time. This assumption is not necessarily true. In 1972, the WoS indexed author  
32  
33 559 affiliations for the first time, which indicates that articles published in a joint effort  
34  
35 560 before 1972 would not have been detected by our methodological approach. The  
36  
37 561 evaluation of country-specific publication performance by gender is meaningful but  
38  
39 562 should be evaluated critically. Not all first names were included in our analysis since  
40  
41 563 some were gender-neutral, not listed in name databases or displayed as initials.  
42  
43 564 Therefore, the threshold of at least 60 publishing scientists and 50% gender  
44  
45 565 definability was implemented to include only countries providing meaningful and valid  
46  
47 566 data. Further, we identified “Mortality associated with influenza and respiratory  
48  
49 567 syncytial virus in the United States” by Thompson et al. as the most cited journal  
50  
51 568 article in the field of RSV. It received 1520 citations representing its outstanding  
52  
53 569 recognition in the scientific community. The publication covers the topics RSV as well  
54  
55 570 as Influenza, so the limitation has to be mentioned that our computed approach did  
56  
57  
58  
59  
60

30

1  
2  
3 571 not differentiate if the article was cited in “influenza” or “RSV” papers. Employing a  
4  
5 572 manual analysis, we found that 70,3% of citing articles can be attributed to influenza,  
6  
7 573 only 15,8% to RSV, and 2.2% were covering both topics. Hence, the impact of this  
8  
9 574 particular paper on the field of RSV must be considered as less than it initially  
10  
11 575 appeared based on the citation count alone.  
12  
13  
14 576

## 17 577 **Conclusion**

18  
19 578 We evaluated the worldwide RSV-related research output and demonstrated large  
20  
21 579 differences between high-, middle-income or low-income nations regarding most  
22  
23 580 scientometric variables. These discrepancies partly diminished when country-specific  
24  
25 581 scientific activities were related to economic key measures; here, the leading position  
26  
27 582 of the USA in science was challenged by other nations. Hence, calculating these  
28  
29 583 quotients is beneficial for the comparison of countries with unequal conditions and  
30  
31 584 different scientific infrastructures. However, we can deduce from our study that  
32  
33 585 research efforts of middle-income or low-income nations have to be strengthened,  
34  
35 586 e.g. by the reduction of journal fees and inclusion in international collaborations, so  
36  
37 587 apparent disparities can be minimized and higher mortality rates related to RSV in  
38  
39 588 developing nations can be tackled successfully.  
40  
41  
42  
43  
44 589

## 47 590 **Acknowledgements:**

48  
49 591 We thank Cristian Scutaru for the development and provision of the NewQIS  
50  
51 592 analyzing tools. We also thank Mario Schwarzer, MD for supporting the study and  
52  
53 593 helpful discussions as well as Jenny M. Jaque, MD for thoroughly editing our  
54  
55 594 manuscript.  
56  
57  
58  
59  
60

1  
2  
3 595 **Source of Funding:**  
4  
5

6 596 This research received no specific grant from any funding agency in the public,  
7  
8 597 commercial or not-for-profit sectors  
9

10 598

11  
12 599 **Conflicts of Interest:**  
13

14 600 All authors state that they have no conflicts of interest to declare.  
15  
16

17 601

18  
19  
20 602 **Data Sharing Statement:**  
21

22  
23 603 Datasets of this study are available from the corresponding author upon request.  
24  
25

26 604

27  
28  
29 605 **Authors' contributions:**  
30

31  
32 606 DB, CK, DK, DAG, DO, JB and MB have made substantial contributions to the  
33  
34 607 conception and design of the study, acquisition of the study data and have been  
35  
36 608 involved in drafting and revising the manuscript. All authors have read and approved  
37  
38 609 the final manuscript.  
39

40  
41  
42 610  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 611 **Figure Legends**  
4

5 612 Figure 1: Chronological development of the number of articles.  
6

7 613 Figure 2: Density equalizing mapping projections (DEMP).  
8

9 614 A) Number of publications B) Modified h-Index  
10

11 615 Figure 3: Chronological development of annual citation numbers.  
12

13 616 Figure 4: Density equalizing mapping projections (DEMP).  
14

15 617 A) Articles/population-index (Q1)  
16

17 618 B) Articles/GDP-index (Q2)  
18

19 619 (Threshold  $\geq 15$  articles)  
20

21 620 Figure 5: Density equalizing mapping projections (DEMP)  
22

23 621 A) Articles/ R&D Expenditure in billion USD -index  
24

25 622 B) Articles/ researcher (per billion inhabitants)-index  
26

27 623 (Threshold  $\geq 30$  articles)  
28

29 624 Figure 6: Country specific gender analysis of the authors publishing articles referring  
30

31 625 to RSV of countries.  
32

33 626 (Threshold:  $> 50\%$  definable genders,  $> 60$  authors per country)  
34

35 627 Figure 7: International cooperation (threshold  $\geq 2$  cooperations).  
36

37 628 Numbers in brackets (number of publications/number of publications in  
38

39 629 cooperation  
40

41 630 Figure 8: Most prolific journals in the field of RSV research in regards to overall  
42

43 631 publication numbers and the average citation rate.  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



## 632 References

633

634

- 635 1. Murphy BR, Prince GA, Collins PL, *et al.* Current approaches to the development of  
636 vaccines effective against parainfluenza and respiratory syncytial viruses. *Virus*  
637 *Res* 1988;**11**:1-15 Online First: 1988/08/01].
- 638 2. Collins PL, Graham BS. Viral and host factors in human respiratory syncytial virus  
639 pathogenesis. *J Virol* 2008;**82**:2040-55 doi: 10.1128/jvi.01625-07published  
640 Online First: 2007/10/12].
- 641 3. Nair H, Nokes DJ, Gessner BD, *et al.* Global burden of acute lower respiratory  
642 infections due to respiratory syncytial virus in young children: a systematic  
643 review and meta-analysis. *Lancet* 2010;**375**:1545-55 doi: 10.1016/s0140-  
644 6736(10)60206-1published Online First: 2010/04/20].
- 645 4. Borchers AT, Chang C, Gershwin ME, *et al.* Respiratory syncytial virus--a  
646 comprehensive review. *Clin Rev Allergy Immunol* 2013;**45**:331-79 doi:  
647 10.1007/s12016-013-8368-9published Online First: 2013/04/12].
- 648 5. Blanken MO, Rovers MM, Molenaar JM, *et al.* Respiratory syncytial virus and recurrent  
649 wheeze in healthy preterm infants. *N Engl J Med* 2013;**368**:1791-9 doi:  
650 10.1056/NEJMoa1211917published Online First: 2013/05/10].
- 651 6. Wu P, Dupont WD, Griffin MR, *et al.* Evidence of a causal role of winter virus infection  
652 during infancy in early childhood asthma. *Am J Respir Crit Care Med*  
653 2008;**178**:1123-9 doi: 10.1164/rccm.200804-5790Cpublished Online First:  
654 2008/09/09].
- 655 7. Graham BS. Vaccines against respiratory syncytial virus: The time has finally come.  
656 *Vaccine* 2016;**34**:3535-41 doi: 10.1016/j.vaccine.2016.04.083published Online  
657 First: 2016/05/18].
- 658 8. Polack FP. The changing landscape of respiratory syncytial virus. *Vaccine*  
659 2015;**33**:6473-8 doi: 10.1016/j.vaccine.2015.06.119published Online First:  
660 2015/08/08].
- 661 9. CentersforDiseaseControlandPrevention. Respiratory Syncytial Virus Infection (RSV).  
662 Secondary Respiratory Syncytial Virus Infection (RSV). 2016.  
663 <http://www.cdc.gov/rsv/about/index.html>.
- 664 10. Welliver RC, Sr., Checchia PA, Bauman JH, *et al.* Fatality rates in published reports of  
665 RSV hospitalizations among high-risk and otherwise healthy children. *Curr Med*  
666 *Res Opin* 2010;**26**:2175-81 doi: 10.1185/03007995.2010.505126published  
667 Online First: 2010/07/30].

- 1  
2  
3 668 11. Hall CB, Weinberg GA, Iwane MK, *et al.* The burden of respiratory syncytial virus  
4 669 infection in young children. *N Engl J Med* 2009;**360**:588-98 doi:  
5 670 10.1056/NEJMoa0804877published Online First.
- 6  
7 671 12. Selwyn BJ. The epidemiology of acute respiratory tract infection in young children:  
8 672 comparison of findings from several developing countries. Coordinated Data  
9 673 Group of BOSTID Researchers. *Rev Infect Dis* 1990;**12 Suppl 8**:S870-88 Online  
10 674 First: 1990/11/01].
- 11  
12  
13 675 13. Weber MW, Mulholland EK, Greenwood BM. Respiratory syncytial virus infection in  
14 676 tropical and developing countries. *Trop Med Int Health* 1998;**3**:268-80 Online  
15 677 First: 1998/06/12].
- 16  
17 678 14. Walsh EE, McConnochie KM, Long CE, *et al.* Severity of respiratory syncytial virus  
18 679 infection is related to virus strain. *J Infect Dis* 1997;**175**:814-20 Online First:  
19 680 1997/04/01].
- 20  
21 681 15. Peret TC, Hall CB, Schnabel KC, *et al.* Circulation patterns of genetically distinct group  
22 682 A and B strains of human respiratory syncytial virus in a community. *J Gen Virol*  
23 683 1998;**79 ( Pt 9)**:2221-9 doi: 10.1099/0022-1317-79-9-2221published Online  
24 684 First: 1998/09/25].
- 25  
26  
27 685 16. Auksornkitti V, Kamprasert N, Thongkomplew S, *et al.* Molecular characterization of  
28 686 human respiratory syncytial virus, 2010-2011: identification of genotype ON1  
29 687 and a new subgroup B genotype in Thailand. *Arch Virol* 2014;**159**:499-507 doi:  
30 688 10.1007/s00705-013-1773-9published Online First: 2013/09/27].
- 31  
32 689 17. Gastner MT, Newman ME. Diffusion-based method for producing density-equalizing  
33 690 maps. *Proc Natl Acad Sci U S A* 2004;**101**:7499-504 doi:  
34 691 10.1073/pnas.0400280101published Online First: 2004/05/12].
- 35  
36  
37 692 18. Scutaru C, Quarcoo D, Sakr M, *et al.* Density-equalizing mapping and scientometric  
38 693 benchmarking of European allergy research. *J Occup Med Toxicol* 2010;**5**:2 doi:  
39 694 10.1186/1745-6673-5-2published Online First: 2010/10/12].
- 40  
41 695 19. Groneberg-Kloft B, Quarcoo D, Scutaru C. Quality and quantity indices in science: use  
42 696 of visualization tools. *EMBO Rep* 2009;**10**:800-3 doi:  
43 697 10.1038/embor.2009.162published Online First: 2009/08/04].
- 44  
45  
46 698 20. Gerber A, Klingelhofer D, Groneberg D, *et al.* Antineutrophil cytoplasmic antibody-  
47 699 associated vasculitides: a scientometric approach visualizing worldwide research  
48 700 activity. *Int J Rheum Dis* 2014;**17**:796-804 doi: 10.1111/1756-  
49 701 185x.12376published Online First: 2014/04/08].
- 50  
51 702 21. Hirsch JE. An index to quantify an individual's scientific research output. *Proc Natl*  
52 703 *Acad Sci U S A* 2005;**102**:16569-72 doi: 10.1073/pnas.0507655102published  
53 704 Online First: 2005/11/09].
- 54  
55  
56 705 22. Hirsch JE. Does the H index have predictive power? *Proc Natl Acad Sci U S A*  
57 706 2007;**104**:19193-8 doi: 10.1073/pnas.0707962104published Online First:  
58 707 2007/11/28].
- 59  
60

- 1  
2  
3 708 23. Namepedia. Namepedia. Secondary Namepedia 2016. <http://www.namepedia.org/>.
- 4  
5 709 24. Anonymus. World Economic Outlook Database. Secondary World Economic Outlook  
6 710 Database 2013 2013.  
7 711 <http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?pr.x=75&pr.y=10&sy=2012&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=193%2C223%2C924%2C132%2C134%2C146%2C136%2C158%2C112%2C111&s=NGDPD&grp=0&a=>.
- 8 712  
9 713  
10 714  
11  
12 715 25. WorldBank. Country and Lending Groups. Secondary Country and Lending Groups  
13 716 2015. <http://data.worldbank.org/about/country-and-lending-groups>.
- 14  
15  
16 717 26. OECD. Main Science and Technology Indicators. Secondary Main Science and  
17 718 Technology Indicators 2013.  
18 719 [http://www.oecd.org/sti/2013\\_1\\_documentation\\_e.pdf](http://www.oecd.org/sti/2013_1_documentation_e.pdf).
- 19  
20 720 27. Bachi T, Howe C. Morphogenesis and ultrastructure of respiratory syncytial virus. *J*  
21 721 *Virology* 1973;**12**:1173-80 Online First: 1973/11/01].
- 22  
23 722 28. Chanock R, Roizman B, Myers R. Recovery from infants with respiratory illness of a  
24 723 virus related to chimpanzee coryza agent (CCA). I. Isolation, properties and  
25 724 characterization. *Am J Hyg* 1957;**66**:281-90 Online First.
- 26  
27  
28 725 29. Blount RE, Jr., Morris JA, Savage RE. Recovery of cytopathogenic agent from  
29 726 chimpanzees with coryza. *Proc Soc Exp Biol Med* 1956;**92**:544-9 Online First:  
30 727 1956/07/01].
- 31  
32 728 30. Fricke R, Uibel S, Klingelhofer D, *et al*. Influenza: a scientometric and density-  
33 729 equalizing analysis. *BMC Infect Dis* 2013;**13**:454 doi: 10.1186/1471-2334-13-  
34 730 454published Online First: 2013/10/02].
- 35  
36 731 31. Zheng HC, Yan L, Cui L, *et al*. Mapping the history and current situation of research  
37 732 on John Cunningham virus - a bibliometric analysis. *BMC Infect Dis* 2009;**9**:28 doi:  
38 733 10.1186/1471-2334-9-28published Online First: 2009/03/17].
- 39  
40 734 32. Simoes EA. Respiratory syncytial virus infection. *Lancet* 1999;**354**:847-52 doi:  
41 735 10.1016/s0140-6736(99)80040-3published Online First: 1999/09/15].
- 42  
43 736 33. Collins PL, Hill MG, Camargo E, *et al*. Production of infectious human respiratory  
44 737 syncytial virus from cloned cDNA confirms an essential role for the transcription  
45 738 elongation factor from the 5' proximal open reading frame of the M2 mRNA in  
46 739 gene expression and provides a capability for vaccine development. *Proc Natl*  
47 740 *Acad Sci U S A* 1995;**92**:11563-7 Online First: 1995/12/05].
- 48  
49  
50 741 34. Cranage MP, Gardner PS. Systemic cell-mediated and antibody responses in infants  
51 742 with respiratory syncytial virus infections. *J Med Virology* 1980;**5**:161-70 Online  
52 743 First: 1980/01/01].
- 53  
54  
55 744 35. Fulginiti VA, Eller JJ, Sieber OF, *et al*. Respiratory virus immunization. I. A field trial of  
56 745 two inactivated respiratory virus vaccines; an aqueous trivalent parainfluenza  
57 746 virus vaccine and an alum-precipitated respiratory syncytial virus vaccine. *Am J*  
58 747 *Epidemiol* 1969;**89**:435-48 Online First: 1969/04/01].
- 59  
60

- 1  
2  
3 748 36. Kim HW, Canchola JG, Brandt CD, *et al.* Respiratory syncytial virus disease in infants  
4 749 despite prior administration of antigenic inactivated vaccine. *Am J Epidemiol*  
5 750 1969;**89**:422-34 Online First: 1969/04/01].  
6  
7 751 37. Glezen WP, Taber LH, Frank AL, *et al.* Risk of primary infection and reinfection with  
8 752 respiratory syncytial virus. *Am J Dis Child* 1986;**140**:543-6 Online First:  
9 753 1986/06/01].  
10  
11 754 38. Thompson WW, Shay DK, Weintraub E, *et al.* Mortality associated with influenza and  
12 755 respiratory syncytial virus in the United States. *JAMA* 2003;**289**:179-86 Online  
13 756 First: 2003/01/09].  
14  
15 757 39. Kurt-Jones EA, Popova L, Kwinn L, *et al.* Pattern recognition receptors TLR4 and  
16 758 CD14 mediate response to respiratory syncytial virus. *Nat Immunol* 2000;**1**:398-  
17 759 401 doi: 10.1038/80833published Online First: 2001/03/23].  
18  
19 760 40. Testa J. The Thomson Scientific journal selection process. *Int Microbiol* 2006;**9**:135-8  
20 761 Online First: 2006/07/13].  
21  
22 762 41. Groneberg-Kloft B, Scutaru C, Kreiter C, *et al.* Institutional operating figures in basic  
23 763 and applied sciences: scientometric analysis of quantitative output  
24 764 benchmarking. *Health Res Policy Syst* 2008;**6**:6 doi: 10.1186/1478-4505-6-  
25 765 6published Online First: 2008/06/17].  
26  
27 766 42. Viergever RF, Hendriks TC. The 10 largest public and philanthropic funders of health  
28 767 research in the world: what they fund and how they distribute their funds. *Health*  
29 768 *Res Policy Syst* 2016;**14**:12 doi: 10.1186/s12961-015-0074-zpublished Online  
30 769 First: 2016/02/20].  
31  
32 770 43. Schmidt S, Bundschuh M, Scutaru C, *et al.* Hepatitis B: global scientific development  
33 771 from a critical point of view. *J Viral Hepat* 2013 doi: 10.1111/jvh.12205published  
34 772 Online First: 2013/11/12].  
35  
36 773 44. Fassoulaki A, Paraskeva A, Papilas K, *et al.* Self-citations in six anaesthesia journals  
37 774 and their significance in determining the impact factor. *Br J Anaesth*  
38 775 2000;**84**:266-9 Online First: 2000/04/01].  
39  
40 776 45. Merton RK. The Matthew effect in science. The reward and communication systems  
41 777 of science are considered. *Science* 1968;**159**:56-63 Online First.  
42  
43 778 46. Head MG, Fitchett JR, Cooke MK, *et al.* Differences in research funding for women  
44 779 scientists: a systematic comparison of UK investments in global infectious disease  
45 780 research during 1997-2010. *BMJ Open* 2013;**3**:e003362 doi: 10.1136/bmjopen-  
46 781 2013-003362published Online First: 2013/12/12].  
47  
48 782 47. Koster C, Klingelhofer D, Groneberg DA, *et al.* Rotavirus - Global research density  
49 783 equalizing mapping and gender analysis. *Vaccine* 2016;**34**:90-100 doi:  
50 784 10.1016/j.vaccine.2015.11.002published Online First: 2015/11/28].  
51  
52 785 48. Konrad-Adenauer-Stiftung. Frauen in Brasilien. Secondary Frauen in Brasilien 2014.  
53 786 [http://www.kas.de/wf/doc/kas\\_17800-1522-1-30.pdf?091024002708](http://www.kas.de/wf/doc/kas_17800-1522-1-30.pdf?091024002708).

- 1  
2  
3 787 49. Huyer S, Hafkin N. Scorecard on Gender Equality in the Knowledge Society.  
4 788 Secondary Scorecard on Gender Equality in the Knowledge Society 2014.  
5 789 [http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows)  
6 790 [and-innovation-study-shows](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows).  
7  
8 791 50. BandimHealthProject. About BHP. Secondary About BHP.  
9 792 <http://www.bandim.org/about-bhp.aspx>.  
10  
11 793 51. Council. MR. Medical Research Council: The Gambia Unit. Secondary Medical  
12 794 Research Council: The Gambia Unit. <http://www.mrc.gm/our-research/themes>.  
13  
14 795 52. Adegbola RA, Falade AG, Sam BE, *et al*. The etiology of pneumonia in malnourished  
15 796 and well-nourished Gambian children. *Pediatr Infect Dis J* 1994;**13**:975-82 Online  
16 797 First: 1994/11/01].  
17  
18 798 53. Suara RO, Piedra PA, Glezen WP, *et al*. Prevalence of neutralizing antibody to  
19 799 respiratory syncytial virus in sera from mothers and newborns residing in the  
20 800 Gambia and in The United States. *Clin Diagn Lab Immunol* 1996;**3**:477-9 Online  
21 801 First: 1996/07/01].  
22  
23 802 54. Weber MW, Dackour R, Usen S, *et al*. The clinical spectrum of respiratory syncytial  
24 803 virus disease in The Gambia. *Pediatr Infect Dis J* 1998;**17**:224-30 Online First:  
25 804 1998/04/16].  
26  
27 805 55. Weber MW, Milligan P, Hilton S, *et al*. Risk factors for severe respiratory syncytial  
28 806 virus infection leading to hospital admission in children in the Western Region of  
29 807 The Gambia. *Int J Epidemiol* 1999;**28**:157-62 Online First: 1999/04/09].  
30  
31 808 56. Weber MW, Milligan P, Sanneh M, *et al*. An epidemiological study of RSV infection in  
32 809 the Gambia. *Bull World Health Organ* 2002;**80**:562-8 Online First: 2002/08/07].  
33  
34 810 57. Weber MW, Milligan P, Giadom B, *et al*. Respiratory illness after severe respiratory  
35 811 syncytial virus disease in infancy in The Gambia. *J Pediatr* 1999;**135**:683-8 Online  
36 812 First: 1999/12/10].  
37  
38 813 58. Loscertales MP, Roca A, Ventura PJ, *et al*. Epidemiology and clinical presentation of  
39 814 respiratory syncytial virus infection in a rural area of southern Mozambique.  
40 815 *Pediatr Infect Dis J* 2002;**21**:148-55 Online First: 2002/02/13].  
41  
42 816 59. Salomao Junior JB, Gardinassi LG, Simas PV, *et al*. Human respiratory syncytial virus  
43 817 in children hospitalized for acute lower respiratory infection. *J Pediatr (Rio J)*  
44 818 2011;**87**:219-24 doi: doi:10.2223/JPED.2085published Online First:  
45 819 2011/04/05].  
46  
47 820 60. Pineros JG, Baquero H, Bastidas J, *et al*. Respiratory syncytial virus infection as a  
48 821 cause of hospitalization in population under 1 year in Colombia. *J Pediatr (Rio J)*  
49 822 2013;**89**:544-8 doi: 10.1016/j.jpmed.2013.04.002published Online First:  
50 823 2013/09/14].  
51  
52 824 61. Bardach A, Rey-Ares L, Cafferata ML, *et al*. Systematic review and meta-analysis of  
53 825 respiratory syncytial virus infection epidemiology in Latin America. *Rev Med Virol*  
54 826 2014;**24**:76-89 Online First: 2014/04/24].  
55  
56  
57  
58  
59  
60



- 1  
2  
3 827 62. Avendano LF, Palomino MA, Larranaga C. Surveillance for respiratory syncytial virus  
4 828 in infants hospitalized for acute lower respiratory infection in Chile (1989 to  
5 829 2000). *J Clin Microbiol* 2003;**41**:4879-82 Online First: 2003/10/09].
- 6  
7 830 63. KEMRIWellcomeTrustResearchProgramm. KEMRI Wellcome Trust Research  
8 831 Programm. Secondary KEMRI Wellcome Trust Research Programm.  
9 832 <http://www.kemri-wellcome.org>.
- 10  
11 833 64. Fitchett JR, Head MG, Atun R. Infectious disease research investments follow colonial  
12 834 ties: questionable ethics. *Int Health* 2014;**6**:74-6 doi:  
13 835 10.1093/inthealth/ih036published Online First: 2014/01/28].
- 14  
15  
16 836 65. Haynes AK, Manangan AP, Iwane MK, *et al*. Respiratory syncytial virus circulation in  
17 837 seven countries with Global Disease Detection Regional Centers. *J Infect Dis*  
18 838 2013;**208 Suppl 3**:S246-54 doi: 10.1093/infdis/jit515published Online First:  
19 839 2013/12/07].
- 20  
21 840 66. PLOS. Publication fees. Secondary Publication fees.  
22 841 <http://www.plos.org/publications/publication-fees>.
- 23  
24  
25 842 67. BioMedCentral. Can charges be waived if the author cannot pay? Secondary Can  
26 843 charges be waived if the author cannot pay?  
27 844 <http://www.biomedcentral.com/about/apcfaq/waivers>.
- 28  
29 845 68. BMJOpen. Instructions for authors. Secondary Instructions for authors.  
30 846 <http://bmjopen.bmj.com/site/about/guidelines.xhtml>.
- 31  
32 847 69. Akinremi TO. Research collaboration with low resource countries: overcoming the  
33 848 challenges. *Infect Agent Cancer* 2011;**6 Suppl 2**:S3 doi: 10.1186/1750-9378-6-S2-  
34 849 S3published Online First.

850

851

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

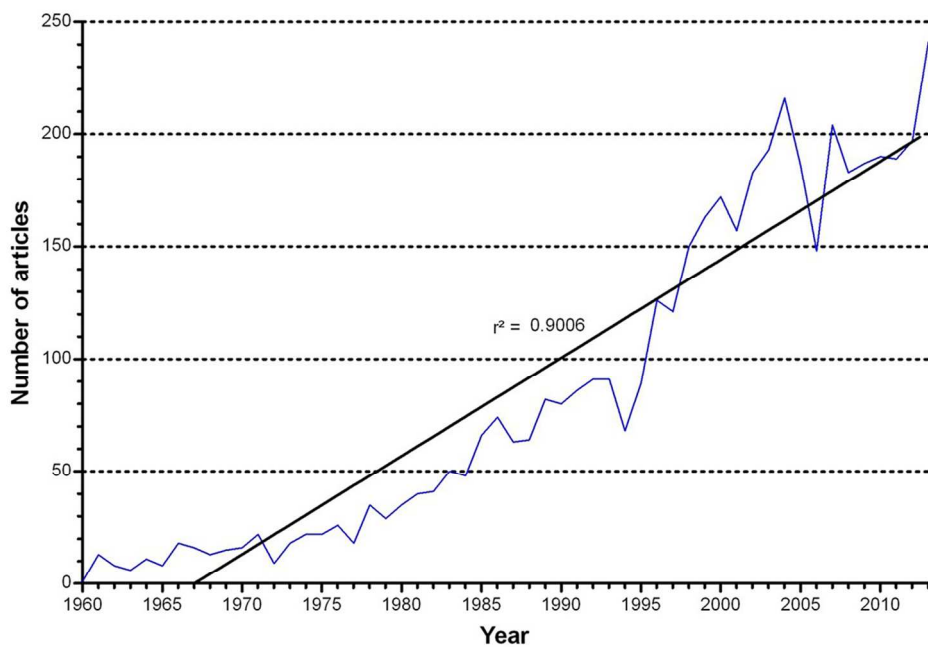


Figure 1: Chronological development of the number of articles.

109x75mm (300 x 300 DPI)

view only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

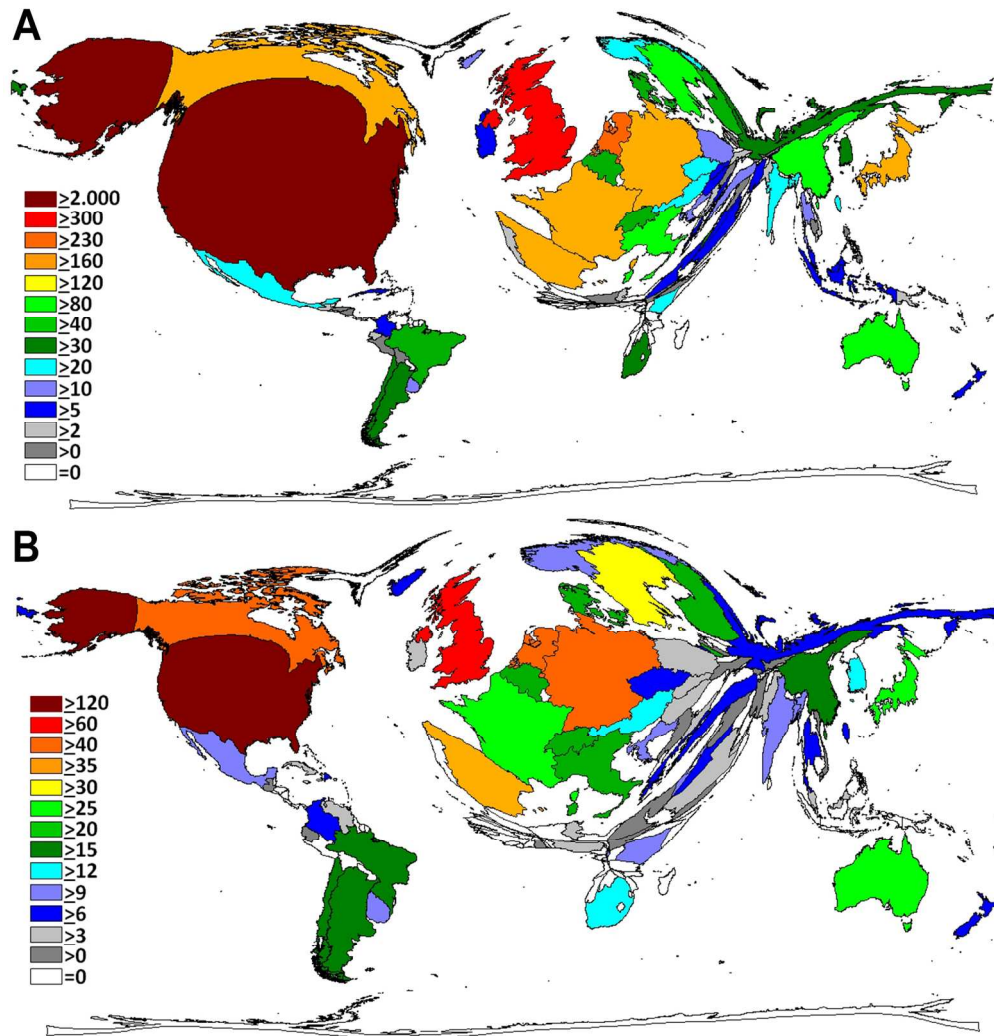


Figure 2: Density equalizing mapping projections (DEMP).  
A) Number of publications  
B) Modified h-Index

203x212mm (300 x 300 DPI)



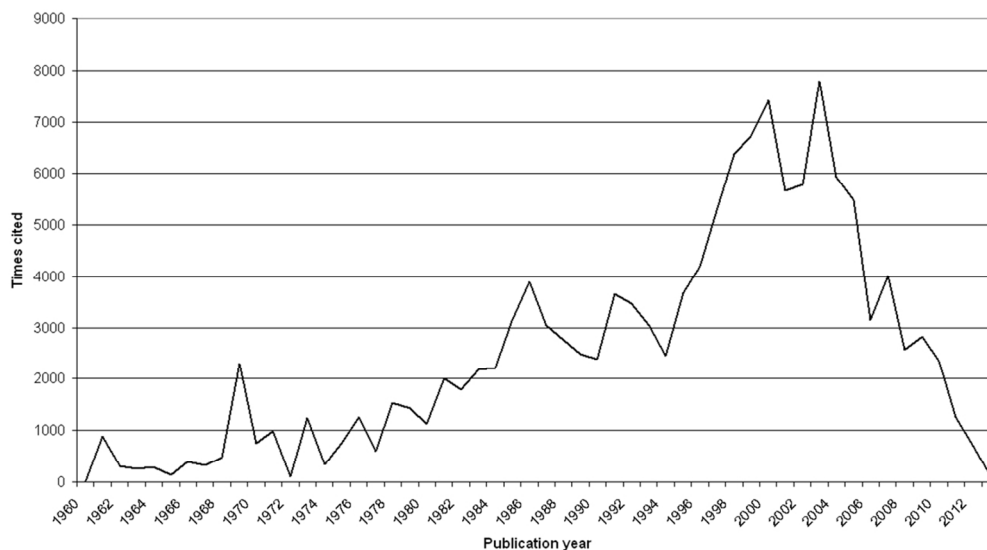


Figure 3: Chronological development of annual citation numbers.

109x61mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

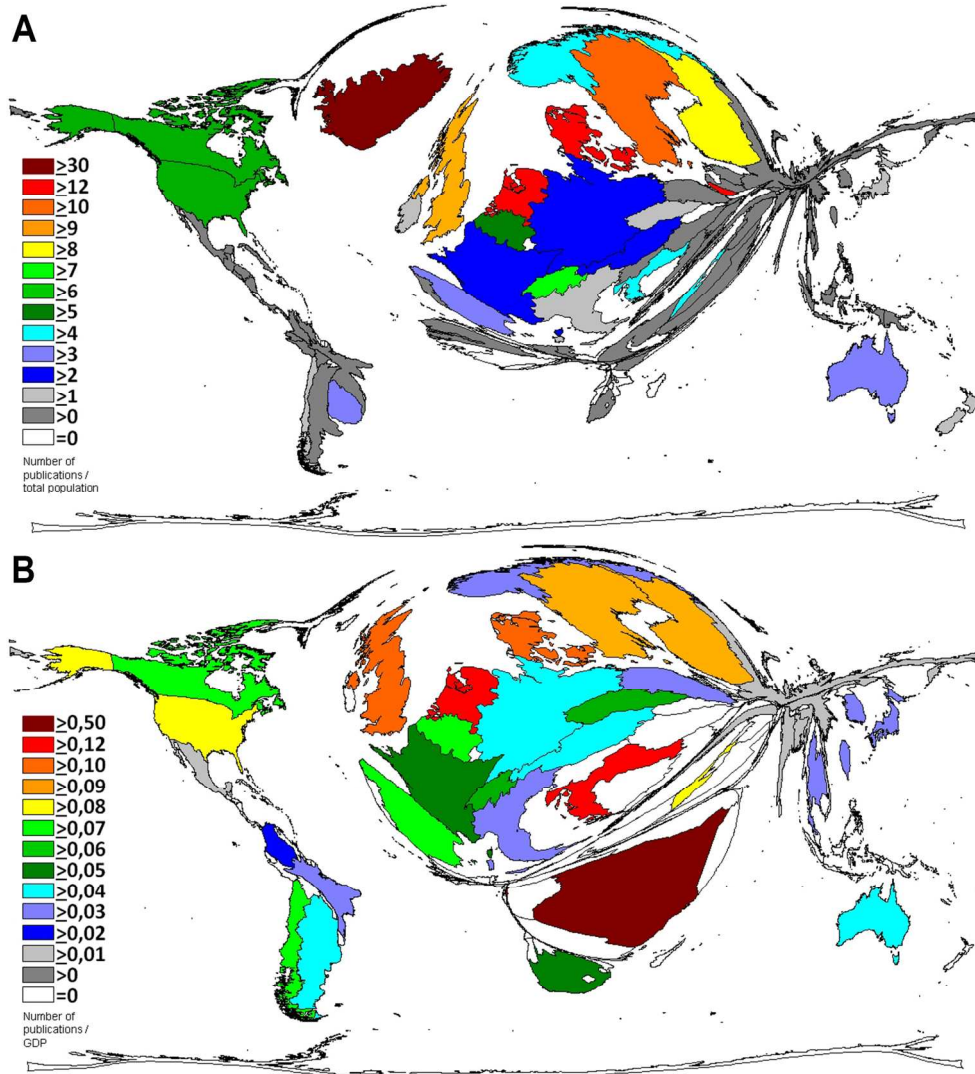


Figure 4: Density equalizing mapping projections (DEMP).  
 A) Articles/population-index (Q1)  
 B) Articles/GDP-index (Q2)  
 (Threshold > 15 articles)

203x220mm (300 x 300 DPI)

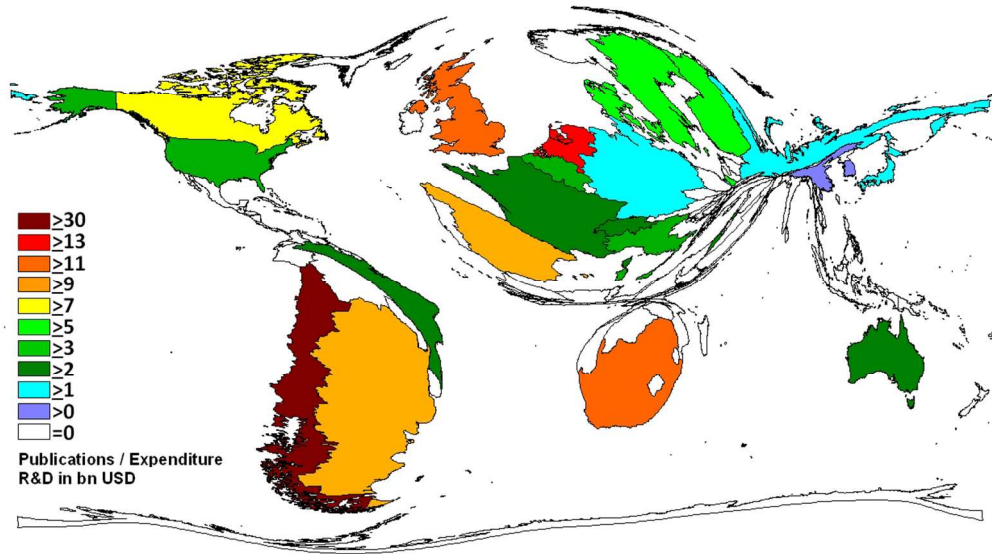


Figure 5A: Density equalizing mapping projections (DEMP). Articles/ R&D Expenditures in billion USD –index. (Threshold > 30 articles)

300x167mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

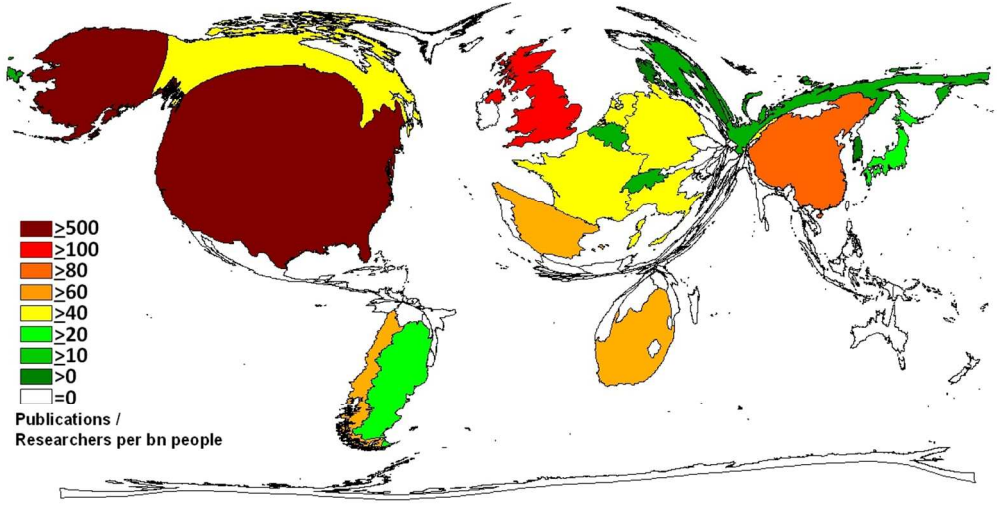


Figure 5B: Density equalizing mapping projections (DEMP). Articles/ researcher (per billion inhabitants)-index. (Threshold > 30 articles)

439x223mm (72 x 72 DPI)

review only

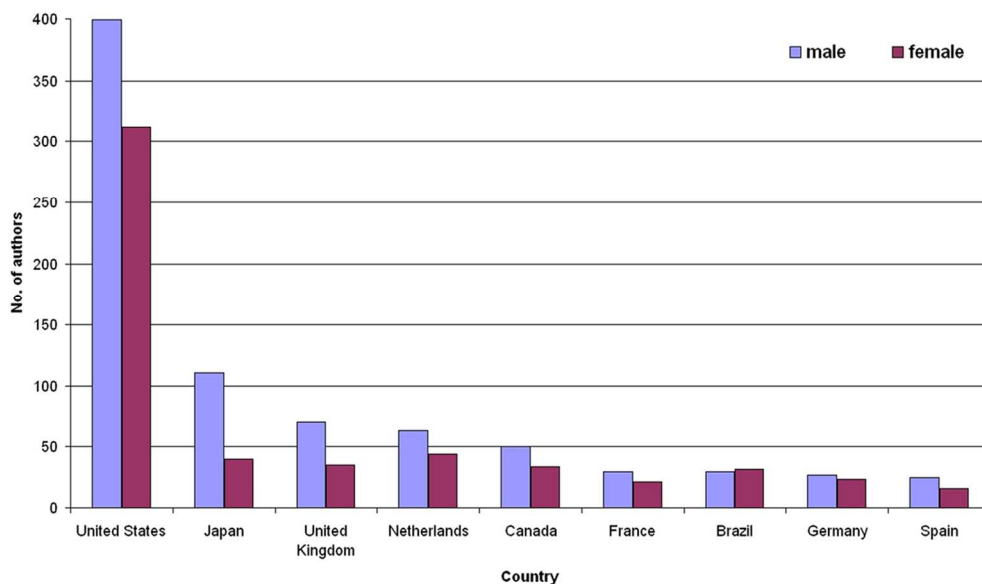


Figure 6: Country specific gender analysis of the authors publishing articles referring to RSV of countries.  
 !! † (Threshold: > 50% definable genders, > 60 authors per country)!! †

109x65mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



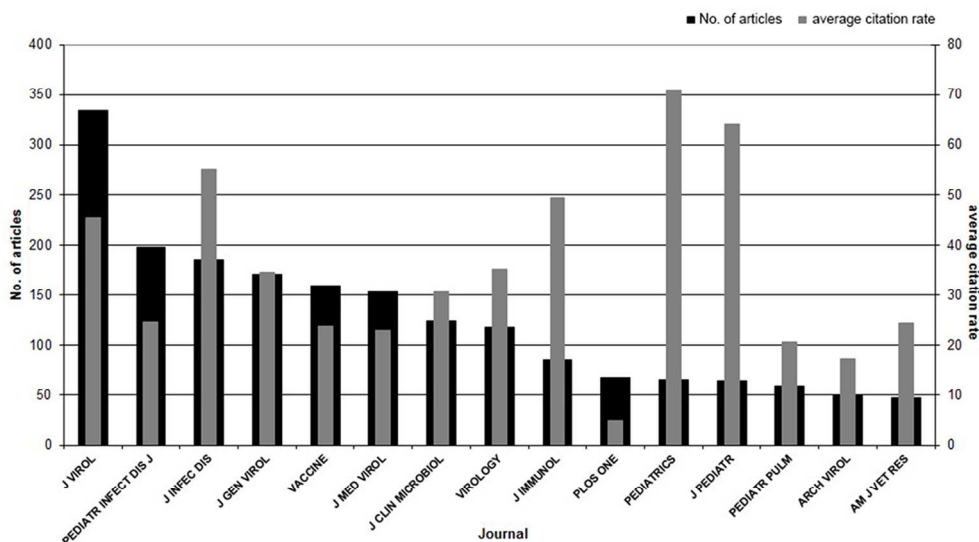


Figure 8: Most prolific journals in the field of RSV research in regards to overall publication numbers and the average citation rate.

109x65mm (300 x 300 DPI)

Review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



# BMJ Open

## Respiratory Syncytial Virus: A systematic scientometric analysis of the global publication output and the gender distribution of publishing authors

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-013615.R2
Article Type:	Research
Date Submitted by the Author:	01-Mar-2017
Complete List of Authors:	Brueggmann, Doerthe; Keck School of Medicine of the University of Southern California, Ob/Gyn; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Köster , Corinna ; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Klingelhoef, Doris; Goethe University, Institute of Occupational Medicine Bauer, Jan; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Ohlendorf, Daniela; Institute of Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-University Frankfurt/Main, ; Bundschuh, Matthias; Goethe-Universitat Frankfurt am Main, Institute of Occupational Medicine, Social Medicine and Environmental Medicine Groneberg, David; Occupational, Social and Environmental Medicine, Medical Department of the Goethe-University Frankfurt am Main
<b>Primary Subject Heading</b>:	Infectious diseases
Secondary Subject Heading:	Global health, Paediatrics, Public health, Respiratory medicine
Keywords:	Respiratory Syncytial Virus, Scientometry, Publication, Gender, Economic benchmarks

SCHOLARONE™  
Manuscripts

1  
2  
3 1 **Respiratory Syncytial Virus: A systematic scientometric analysis of the global**  
4  
5 2 **publication output and the gender distribution of publishing authors**  
6  
7 3

8  
9 4 Corresponding author: Dörthe Brüggmann – occup-med@uni-frankfurt.de, Institute of  
10  
11 5 Occupational Medicine, Social Medicine and Environmental Medicine, Goethe-  
12  
13 6 University, Theodor-Stern Kai 7, 60590 Frankfurt, Germany

14  
15  
16 7 Telephone: +49 (0) 69 6301 6650, Fax +49 (0) 69 6301 7053  
17  
18 8

19  
20  
21 9 Dörthe Brüggmann<sup>1,2,\*</sup>, Corinna Köster<sup>2,\*</sup>, Doris Klingelhöfer<sup>2</sup>, Jan Bauer<sup>2</sup>, Daniela  
22  
23 10 Ohlendorf<sup>2</sup>, Matthias Bundschuh<sup>2</sup>, David A Groneberg<sup>2</sup>  
24  
25 11

26  
27 12 <sup>1</sup> Department of Obstetrics and Gynecology, Keck School of Medicine of USC, Los  
28  
29 13 Angeles, California, United States  
30  
31 14

32  
33  
34 15 <sup>2</sup> Institute for Occupational Medicine, Social Medicine and Environmental Medicine,  
35  
36 16 Goethe University Frankfurt, Germany  
37  
38 17

39  
40 18 \* equal contribution  
41  
42 19

43  
44  
45 20 Word Count: 6,212  
46  
47 21

48  
49 22  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 **Abstract**  
4

5 Objective: Worldwide, the respiratory syncytial virus (RSV) represents the  
6  
7 predominant viral agent causing bronchiolitis and pneumonia in children. To conduct  
8  
9 research and tackle existing healthcare disparities, RSV-related research activities  
10  
11 around the globe need to be described. Hence, we assessed the associated scientific  
12  
13 output (represented by research articles) by geographical, chronological and socio-  
14  
15 economic criteria and analyzed the authors publishing in the field by gender. Also,  
16  
17 the 15 most cited articles and the most prolific journals were identified for RSV  
18  
19 research.  
20  
21

22 Design: retrospective, descriptive study

23 Setting: The NewQIS platform was employed to identify RSV-related articles  
24  
25 published in the Web of Science until 2013. We performed a numerical analysis of all  
26  
27 articles, and examined citation-based aspects (e.g. citation rates); results were  
28  
29 visualized by density equalizing mapping tools.  
30  
31

32 Results: We identified 4600 RSV-related articles. The USA led the field; US-  
33  
34 American authors published 2,139 articles (46.5% % of all identified articles), which  
35  
36 have been cited 83,000 times. When output was related to socio-economic  
37  
38 benchmarks such as GDP or R&D expenditures, Guinea-Bissau, The Gambia and  
39  
40 Chile were ranked in leading positions. 614 articles on RSV (13.34% of all articles)  
41  
42 were attributed to scientific collaborations. These were primarily established between  
43  
44 high-income countries. The gender analysis indicated that male scientists dominated  
45  
46 in all countries except Brazil.

47 Conclusions: The majority of RSV-related research articles originated from high-  
48  
49 income countries whereas developing nations showed only minimal publication  
50  
51 productivity and were barely part of any collaborative networks. Hence, research  
52  
53  
54  
55  
56  
57  
58  
59  
60



## 68 INTRODUCTION

69 The human respiratory syncytial virus (RSV) is the predominant viral agent affecting  
70 the respiratory tract worldwide <sup>1,2</sup>. It is associated with 64 million infections that occur  
71 primarily in children under 5 years <sup>3</sup>. RSV belongs to the Paramyxoviridae family and  
72 is a negative-sense, non-segmented, single-stranded RNA virus, which is mostly  
73 transmitted by droplets <sup>4</sup>. RSV causes bronchiolitis, pneumonia, bronchitis and croup.  
74 It is linked to recurrent wheezing and pediatric asthma <sup>5, 6</sup>. There is no definitive  
75 treatment for RSV-related conditions. Although the development of effective and safe  
76 vaccines has remained unsuccessful to date, the variety of candidate vaccines is  
77 constantly growing in the last years <sup>7</sup>. One prophylactic agent is commercially  
78 available, the neutralizing anti-RSV antibody Palivizumab. Its use is limited to  
79 preterm babies, chronic lung disease of prematurity and infants with congenital heart  
80 disease <sup>8</sup>.

81

82 RSV-associated morbidity and mortality depends on many factors such as the  
83 geographic location, climate patterns, genetic susceptibility, socioeconomic factors  
84 and local virus strains <sup>3</sup>. The percentage of children having contracted RSV by their  
85 second year of life approaches 100 % <sup>9, 10</sup>. In the United States of America (USA),  
86 over 2 million children aged 5 years and under need medical attention to treat their  
87 RSV infection every year <sup>11</sup>. On average, 0.3% of these children and 0.7 % of infants  
88 younger than six months require hospitalization <sup>11</sup>. The general RSV mortality rate in  
89 this demographic varies between 0-33% <sup>10</sup>. Worldwide, up to 199 000 children die  
90 due to RSV infections. 99% of these deaths occur in in developing countries <sup>3</sup> hence,  
91 RSV represents a substantial burden for community health in these nations.  
92 According to WHO field studies in ten developing countries, RSV causes 70 % of all

1  
2  
3 93 acute respiratory-tract infections in children under 5 years of age <sup>12</sup>. Here, the virus is  
4  
5 94 identified in about 15-40 % of the hospitalized children with pneumonia or  
6  
7 95 bronchiolitis <sup>13</sup>. RSV epidemics occur during rainy seasons in tropical climates and  
8  
9 96 during the winter months in temperate zones <sup>4</sup>. Both virus strains, RSV-A and -B, co-  
10  
11 97 circulate during outbreaks in any given year. The A subtype is typically associated  
12  
13 98 with more severe disease <sup>14</sup>. Distinct genotypes of both strains (identified by the  
14  
15 99 genetic classification of their G protein) are predominant in any given year. This  
16  
17 100 pattern is highly flexible, varies by region and may shift to other prominent genotypes  
18  
19 101 the following year <sup>15</sup>. Epidemiological studies are dedicated to characterize the  
20  
21 102 distribution of RSV strains and genotypes worldwide, often leading to the  
22  
23 103 identification of new variants such as the RSV B genotype THB in Thailand <sup>16</sup>.  
24  
25  
26  
27  
28

29 105 Although care of RSV patients has been improved considerably and extensive  
30  
31 106 studies have been launched to estimate viral spread and disease burden in  
32  
33 107 developing countries, tremendous challenges still remain. In regards to the high  
34  
35 108 prevalence, morbidity and mortality of RSV worldwide, we consider that further  
36  
37 109 research and the implementation of related public health measures are crucial for  
38  
39 110 future successes. However, global research funds are limited and their allocation  
40  
41 111 becomes challenging. In this context, the assessment of the scientific performance is  
42  
43 112 a prerequisite for the reasonable distribution of monetary support and the planning of  
44  
45 113 future research endeavors by scientists interested in the field. Hence, we employed  
46  
47 114 scientometric tools with the goals (1) to determine the RSV-related publication output  
48  
49 115 among the extensive amount of biomedical publications and (2) to evaluate the  
50  
51 116 scientific productivity of single countries in the framework of the global research  
52  
53 117 landscape and in relation to socioeconomic and gender aspects. We also identified  
54  
55 118 the 15 most cited landmark articles and the most prolific journals in the field of RSV  
56  
57  
58  
59  
60

1  
2  
3 119 research.  
4  
5 120  
6

7 121 **METHODS**  
8

9  
10 122 **Methodical Platform**

11  
12 123 We used the New Quality and Quantity Indices in Science (NewQIS) platform to  
13 124 assess the worldwide RSV publication activity in a reliable and standardized way.

14  
15 125 This tool combines scientometric methods and “density equalizing mapping  
16 126 projections“ (DEMP) <sup>17-19</sup> to evaluate the publication output regarding quantitative and  
17 127 qualitative aspects, geographical and chronological developments, existing research  
18 128 networks and socio-economic benchmarks.  
19  
20  
21  
22  
23  
24  
25

26 129

27  
28  
29 130 **Density-equalizing mapping**

30  
31 131 DEMP is a state-of-the-art technique to visualize benchmarking processes by  
32 132 anamorphic maps <sup>17, 20</sup>. Based on the algorithm of Gastner and Newman, the size of  
33 133 each country was modified analogously to country-specific data on RSV research  
34 134 leading to a new geographic distribution of the global landscape <sup>17</sup>.  
35  
36  
37  
38  
39

40 135

41  
42  
43 136 **Data collection**

44  
45 137 For data collection, the Web of Science (WoS) Core Collection database (Thomson  
46 138 Reuters) was employed. The following search term was created: Title=(“RSV” OR  
47 139 “Respiratory Syncytial Virus” OR “RS Virus\*”) NOT Topic=(Rous Sarcoma). The  
48 140 Boolean operator NOT was used to exclude all publications concerning the Rous  
49 141 Sarcoma (Virus). We limited our search to original research articles. Following our  
50 142 protocol, the time frame was restricted from 1900 to 2013; publications in 2014 were  
51 143 not regarded due to incomplete data acquisition at the time the study was performed.  
52  
53  
54  
55  
56  
57  
58  
59  
60

10



## 144 **Data analysis**

145 RSV-related articles were analyzed regarding quantitative aspects such as the total  
146 number of publications, citation numbers, countries of article origin (defined as the  
147 'country where the institution is located each author, who worked on publishing the  
148 article, is affiliated'), institutions, languages, cited reference numbers, and publication  
149 date. The number of authors publishing on RSV was only quantified for the years  
150 with 30 or more annual publications. Also, h-Indices, and the average citation number  
151 per item (citation rate, CR) were investigated. Regression analysis was used to  
152 investigate the chronological evolution of RSV research. We calculated the  
153 coefficient of determination ( $r^2$ ) representing the slope of the growth in scientific  
154 output and citations.

## 156 **Modified h-Index**

157 The Hirsch-Index (h-Index) is a recognized semi-qualitative proxy measure to assess  
158 the impact of one author's research output on the scientific community<sup>21, 22</sup>. An h-  
159 index of 12 indicates that out of 12 published papers each has been cited at least 12  
160 times. In this study, we applied this concept to the RSV-specific research productivity  
161 of single countries and calculated a "modified country-specific" h-Index.

## 163 **Country-specific gender analysis**

164 The proportionality of male and female researchers among authors publishing on  
165 RSV was analyzed. Online name databases were utilized to identify the authors'  
166 genders<sup>23</sup>. If first names were not gender-specific or quoted as initials, a manual  
167 search (utilizing websites, corresponding addresses and social networks) was  
168 launched. We only evaluated countries where a minimum of 60 authors were

1  
2  
3 169 affiliated and a minimum of 50 % of authors were identified by gender to ensure a  
4  
5 170 valid analysis. These thresholds were chosen arbitrarily based on previous studies.  
6

7 171

### 10 172 **Cooperation analysis**

12 173 We identified all RSV-associated publications that were issued due to international  
14 174 collaborative efforts. The total count of collaborative items was related to the overall  
16 175 number of publications for each investigated country. In brief, if at least two authors  
18 176 originating from different institutions or countries (as identified by the affiliations in the  
20 177 article) contributed to one article, this publication was defined as a collaborative item.  
22 178 Publications with two or more authors affiliated to the same country were counted  
24 179 one time only towards the complete count of joint publications of this particular  
26 180 country. If an author had two affiliations, these were counted for every country  
28 181 mentioned in the affiliations. Connecting vectors visualized these co-operations; their  
30 182 width and shade of grey reflected the number of joint publications.  
32

34 183

### 37 184 **Journal analysis**

39 185 The journals publishing on RSV were analyzed regarding quantitative and qualitative  
41 186 aspects, e.g. number of published RSV articles as well as citations these items  
43 187 received (CR).  
45

46 188

### 48 189 **Analysis of economic key figures**

50 190 Two quotients were calculated to assess the scientific output of a specific country, (1)  
52 191 in relation to the number of inhabitants (Q1), and (2) in relation to its economic power  
54 192 (as measured by the gross domestic product, GDP, Q2). Data regarding the  
56  
57  
58  
59  
60

1  
2  
3 193 population and GDP of investigated countries were obtained from 2012 from the CIA  
4  
5 194 *World Factbook*<sup>24</sup>. We computed the quotients in the following way:

6  
7 195 1. Articles/population-index (Q1) = number of articles/population in millions

8  
9 196 2. Articles/GDP-index (Q2) = number of articles/GDP in billions

10  
11 197 All countries were classified into high-, upper-middle-, lower-middle- and low-income  
12  
13 198 groups according to World Bank definitions<sup>25</sup>.

14  
15  
16 199

17  
18 200 We compared the total number of RSV articles to the gross domestic expenditure on  
19  
20 201 Research and Development (in % of GDP) as well as to the number of researchers  
21  
22 202 (per billion inhabitants) affiliated to the investigated countries<sup>26</sup>. The analysis was  
23  
24 203 limited to countries that published a minimum of 30 articles in the field of RSV.  
25  
26  
27

28 204

29  
30  
31 205 **RESULTS**

32  
33  
34 206 **Number of published items**

35  
36 207 We identified 4,600 articles on RSV published between 1900 and 2013; 2,645  
37  
38 208 (57.5%) of these were issued after 2000. 1960 and onwards, the number of articles  
39  
40 209 increased significantly over time as indicated by  $r^2=0.9$  (Fig. 1). 10,791 authors  
41  
42 210 published in the field of RSV. The number of authors per article increased by 100% in  
43  
44 211 the investigated timeframe. We identified a mean of 3.8 and a median of 3 authors in  
45  
46 212 1978, which was the first year with more than 30 annual publications. 10 years later,  
47  
48 213 a mean of 4.59 and a median of 4 authors were found, followed by a mean of 5.05  
49  
50 214 and a median of 5 authors in 2000, a mean of 5.95 and a median of 5 authors in  
51  
52 215 2006 and a mean of 7.6 and a median of 6 authors in 2013  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 216  
4  
5

6 217 **Analysis of research origin and citations**  
7

8 218 Although the publications originated from 92 of the 251 investigated countries and  
9  
10 219 autonomous regions the majority of the articles were written in English (4444 articles,  
11  
12 220 96.6 % of all published RSV articles) followed by French (64 articles, 1.4 % of all  
13  
14 221 articles) and German (32 articles, 0.7 % of all articles). More than 85% of the global  
15  
16 222 publication output was issued by authors from high-income economies. The USA  
17  
18 223 was the most productive nation (2,139 articles, 46.5 % of all published RSV articles)  
19  
20 224 followed by the United Kingdom (UK, 583 articles, 12.7 %), the Netherlands (231  
21  
22 225 articles, 5.0 %), Canada (217 articles, 4.7 %) and Germany (196 articles, 4.3 %).  
23  
24 226 Hence, the USA and UK dominated the cartogram, while major parts of Africa (with  
25  
26 227 the exception of South Africa), Asia (with the exception of Japan, China, South  
27  
28 228 Korea, and India) and Central America occupied only minor areas (Fig. 2A).  
29  
30  
31

32 229  
33

34 230 The country-specific citation numbers and modified h-Indices showed a global  
35  
36 231 distribution similar to the number of publications. Articles with US-American affiliation  
37  
38 232 of the authors were cited most (83,000 citations, c), followed by articles from the UK  
39  
40 233 (c = 19,240), the Netherlands (c = 5587), Canada (c = 5549) and Germany (c =  
41  
42 234 5319). Articles published by African, Asian and Middle American authors received  
43  
44 235 hardly any citations.  
45  
46  
47

48 236  
49

50 237 The USA and the UK were the top ranked countries with a modified h-Index of 121  
51  
52 238 (USA) and 68 (UK), followed by the Netherlands (h-Index = 44), Germany (h-Index =  
53  
54 239 43) and Canada (h-Index = 40) (Fig. 2B).  
55  
56

57 240  
58  
59  
60

241 Regarding the country-specific citation rate (average number of citations per total  
 242 number of publications for each country with more than 30 articles, CR), Sweden (CR  
 243 = 40) dominated and was followed by the USA (CR = 38.8), Finland (CR = 34.9), the  
 244 UK and Germany (CR = 27.13).

245

## 246 **Analysis of citation performance**

247 The absolute citation count of all identified RSV-related articles resembled the  
 248 growing volume of published papers in the investigated timeframe. We documented a  
 249 significant positive correlation between citation numbers and the time of publication  
 250 (with  $r^2=0.72$  for the timeframe from 1960 to 2008). The annual citation counts grew  
 251 from 1960 to 1994 (e.g. from 19 annual citations in 1960 to 2448 annual citations in  
 252 1994); after 1995, a rapid increase followed until 2003 (e.g. 5274 annual citations in  
 253 1997 and 7790 annual citations in 2003) whereas a steep decline was noticed after  
 254 2006 (e.g. 3147 annual citations in 2006). We identified visible peaks in citation  
 255 activity for 1969 (2294 annual citations), 1986 (3898 annual citations), 2000 (7411  
 256 annual citations), and 2003 (7790 annual citations) (Fig. 3). Additionally, we compiled  
 257 the 15 most cited RSV articles, which constitute the publications that have sparked  
 258 the most documented interest in the field to date (Table 1).

259

260 Table 1. The 15 most cited articles in the area of RSV-related research are displayed  
 261 including their title, publication year, countries of article origin (defined as the  
 262 countries where first, senior- and co-authors are affiliated), citation count and journal.

Title	Publication Year	Country of Article Origin	Citations	Journal
Mortality associated with influenza and respiratory syncytial virus in the United States Thompson WW et al.	2003	United States	1520	JAMA

1 2 3 4 5 6	Pattern recognition receptors TLR4 and CD14 mediate response to respiratory syncytial virus <b>Kurt-Jones EA et al.</b>	2000	United States	856	Nat Immunol
7 8 9 10 11	Respiratory Syncytial Virus Disease In Infants Despite Prior Administration Of Antigenic Inactivated Vaccine <b>Kim HW et al.</b>	1969	United States	848	Am J Epidemiol
12 13 14	Respiratory syncytial virus in early life and risk of wheeze and allergy by age 13 years <b>Stein RT et al.</b>	1999	Brazil, United States	719	Lancet
15 16 17 18 19	Palivizumab, a humanized respiratory syncytial virus monoclonal antibody, reduces hospitalization from respiratory syncytial virus infection in high-risk infants <b>The Impact-RSV Study Group.</b>	1998	United States, Canada, UK	652	Pediatrics
20 21 22 23 24 25	An Epidemiologic Study Of Altered Clinical Reactivity To Respiratory Syncytial (Rs) Virus Infection In Children Previously Vaccinated With An Inactivated RS Virus Vaccine <b>Kapikian et al.</b>	1969	United States	552	Am J Epidemiol
26 27 28	Risk Of Primary Infection And Reinfection With Respiratory Syncytial Virus <b>Glezen et al.</b>	1986	United States	548	Am J Dis Child
29 30 31 32	Respiratory syncytial virus bronchiolitis in infancy is an important risk factor for asthma and allergy at age 7 <b>Sigurs N et al.</b>	2000	Sweden, Iceland	488	Am J Respir Crit Care Med
33 34 35 36 37	Wheezing, Asthma, And Pulmonary Dysfunction 10 Years After Infection With Respiratory Syncytial Virus In Infancy <b>Pullan CR and Hey EN</b>	1982	UK	449	Br Med J
38 39 40	Respiratory syncytial virus infection in elderly and high-risk adults <b>Falsey AR et al.</b>	2005	United States	430	NEJM
41 42 43 44	Prophylactic Administration Of Respiratory Syncytial Virus Immune Globulin To High-Risk Infants And Young-Children <b>Groothuis JR et al.</b>	1993	United States	427	NEJM
45 46 47 48 49	The Development Of Respiratory Syncytial Virus-Specific IgE And The Release Of Histamine In Nasopharyngeal Secretions After Infection <b>Welliver RC et al.</b>	1981	United States	425	NEJM
50 51 52 53	Respiratory-Syncytial-Virus Infections, Re-Infections And Immunity - Prospective, Longitudinal-Study In Young-Children <b>Henderson FW et al.</b>	1979	United States	418	NEJM
54 55 56 57 58 59	Generation of bovine respiratory syncytial virus (BRSV) from cDNA: BRSV NS2 is not essential for virus replication in tissue culture, and the human RSV leader region acts as a functional BRSV genome promoter	1999	Germany	417	J Virol

<b>Buchholz UJ et al.</b>				
Asthma and immunoglobulin-e antibodies after respiratory syncytial virus bronchiolitis - a prospective cohort study with matched controls				
<b>Sigurs N et al.</b>	1995	Sweden	416	Pediatrics

263

264 **Relation to economic parameters**

265 Relating the number of publications to the population of a country, high-income  
 266 countries like Iceland (Q1 = 34.59), the Netherlands (Q1 = 13.90) and Denmark (Q1  
 267 = 12.25), issued a higher number of publications per million inhabitants compared to  
 268 low-or lower-middle-income countries, e.g. Nigeria (Q1 = 0.03) and Indonesia (Q1 =  
 269 0.02) (Fig. 4A). We identified two exceptions, which included the low-income  
 270 countries Guinea Bissau (Q1 = 6.30) and The Gambia (Q1 = 4.76). Both were  
 271 represented among the 15 top ranked countries in this analysis.

272

273 When looking at the publication activity in relation to GDP, two low-income countries  
 274 outperformed high-income nations (Fig. 4B). Guinea Bissau (Q2 = 11.776) and The  
 275 Gambia (Q2 = 8.721) again held leading positions, followed by Iceland (Q2 = 0.810),  
 276 Kenya (Q2 = 0.516), and Croatia (Q2 = 0.319). Besides these two exceptions, other  
 277 low- or lower-middle-income countries showed a weak performance (e.g. Philippines  
 278 with Q2 = 0.004 or Indonesia with Q2 = 0.007). Also, the USA did not remain under  
 279 the top 10 nations and was found at position 18 (Q2 = 0.132).

280

281 Chile, the Netherlands, South Africa, UK and Argentina were leading the analysis  
 282 when the total article count was related to the country-specific Research and  
 283 Development (R&D) expenditures (33.72, 13.32, 12.14, 11.46 and 9.56 articles per  
 284 billion GDP spent on R&D, respectively). The USA dropped to position 11 with 4.52  
 285 articles per billion GDP spent on R&D (Fig. 5A, Table 2A).



1  
2  
3 286

4  
5 287 When we related the article count to the number of researchers (per billion  
6  
7 288 inhabitants) as a proxy measure for the active research community working on RSV  
8  
9 289 and the productivity of these researchers, the USA was leading the field (532.27  
10  
11 290 articles per researcher per billion inhabitants), followed by the UK, China, Chile and  
12  
13 291 South Africa (137.10, 83.55, 77.10, and 76.60 articles per number of researchers per  
14  
15 292 billion inhabitants) (Fig. 5B, Table 2B).  
16  
17  
18  
19

20 293

21 294 Table 2A. Total number of publications related to gross domestic expenditures on  
22  
23 295 Research and Development in Billion USD of countries that have published more  
24  
25 296 than 30 items on RSV.  
26  
27

28 297

Rank	Country	No. of articles	R&D expenditure in % GDP	GDP in billion USD	R&D Expenditure in billion USD	Articles/ billion USD of R&D Expenditure
1	Chile	33	0.38	258	0.98	33.72
2	Netherlands	231	1.97	879	17.34	13.32
3	South Africa	31	0.73	349	2.55	12.14
4	UK	583	1.70	2990	50.85	11.46
5	Argentina	31	0.61	529	3.24	9.56
6	Spain	160	1.23	1381	17.01	9.41
7	Canada	217	1.61	1783	28.73	7.55
8	Denmark	68	3.08	346	10.67	6.37
9	Sweden	99	3.16	571	18.05	5.49
10	Finland	46	3,17	272	8.63	5.33
11	USA	2139	2.73	17348	472.78	4.52

12	Belgium	56	2.46	531	13.09	4.28
13	Italy	84	1.29	2138	27.52	3.05
14	Switzerland	62	2.97	701	20.80	2.98
15	France	189	2.26	2829	63.82	2.96
16	Australia	86	2.20	1454	31.93	2.69
17	Israel	33	4.11	305	12.53	2.63
18	Brazil	75	1.24	2417	29.87	2.51
19	Germany	196	2.87	3868	110.96	1.77
20	Russia	37	1.19	2030	24.09	1.54
21	Japan	192	3.58	4596	164.73	1.17
22	South Korea	36	4.29	1411	60.55	0.59
23	China*	93	2.05	10351	211.79	0.44

298

299 Table 2B. Total number of publications related to articles per researcher (per billion  
 300 inhabitants) of countries that have published more than 30 items on RSV.

301

Rank	Country	Number of RSV articles	Number of researchers per billion inhabitants	Articles/researcher (per billion inhabitants)
1	USA	2139	4.02	532.27
2	UK	583	4.25	137.10
3	China*	93	1.11	83.55
4	Chile	33	0.42	77.11
5	South Africa	31	0.40	76.60
6	Spain	160	2.64	60.55
7	Netherlands	231	4.48	51.58

8	Canada	217	4.52	48.02
9	France	189	4.20	44.99
10	Germany	196	4.38	44.74
11	Italy	84	2.01	41.86
12	Japan	192	5.39	35.65
13	Argentina	31	1.20	25.79
14	Sweden	99	6.87	14.41
15	Switzerland	62	4.48	13.83
16	Belgium	56	4.18	13.41
17	Russia	37	3.10	11.93
18	Denmark	68	7.20	9.45
19	Finland	46	7.00	6.58
20	South Korea	36	6.90	5.22
21	Israel	33	8.26	4.00

302

303

### 304 **Country-specific gender analysis**

305 We identified the gender distribution among authors working on RSV in institutions  
 306 affiliated to 92 countries. Our analysis indicated a larger proportion of male scientists  
 307 in almost all evaluated countries (Fig. 6). Brazil was an exception. 95 authors with  
 308 affiliation to Brazilian institutions were identified as working on RSV. 62 of those were  
 309 identifiable by name and gender. Here, males and females were almost equally  
 310 represented (32 female authors, 51.6% of identifiable authors, 30 male authors,  
 311 48.4 % of identifiable authors). By calculating the proportion of male to female  
 312 scientists (m/f ratio), we documented the lowest ratio (m/f ratio = 0.94) for Brazil,

20

1  
2  
3 313 followed by Germany (m/f ratio = 1.1). Japan had the highest score with m/f ratio =  
4  
5 314 2.8.

6  
7 315

8  
9  
10 316 **International cooperation analysis**

11  
12 317 The first collaborative article on RSV was identified in 1973. It was published by  
13  
14 318 researchers working in institutions located in Switzerland and the USA <sup>27</sup>. Since  
15  
16  
17 319 1973, 614 joint articles were published on RSV accounting for 13.34% of all articles.

18  
19 320 The USA was the preferred partner for international collaborations on RSV. The most  
20  
21 321 productive cooperation was established between the USA and the UK (67 joint  
22  
23 322 works, 10.9 % of collaborative articles), followed by the USA and Canada (45 joint  
24  
25 323 articles, 7.3 % of collaborative articles), and the USA and Germany (34 joint articles,  
26  
27 324 5.5 % of collaborative articles).

28  
29  
30 325

31  
32 326 The most fruitful cooperation not involving the USA existed between the UK and  
33  
34 327 Spain (33 joint articles, 5.4 % of collaborative articles). The most productive  
35  
36 328 cooperation between high- and lower-middle- or low-income economies was set up  
37  
38 329 between Kenya and the UK (18 joint articles, 2.9 % of collaborative articles) followed  
39  
40 330 by Guinea Bissau and Denmark (10 joint articles, 1.6 % of collaborative articles).

41  
42  
43 331 Overall, co-operations with low-income or lower-middle-income countries were less  
44  
45 332 popular (Fig. 7).

46  
47  
48 333

49  
50  
51 334 **Journal analysis**

52  
53 335 When we identified the most prolific journals in RSV research, the "Journal of  
54  
55 336 Virology" led the field (334 articles, CR of 45.49), followed by "The Pediatric  
56  
57 337 Infectious Disease Journal" (198 articles, CR = 24.66) and the "Journal of Infectious

1  
2  
3 338 Diseases" (186 articles, CR 55.18) (Fig. 8). The highest citation rate was achieved by  
4  
5 339 the "Proceedings of the National Academy of Sciences of the United States of  
6  
7 340 America" (42 articles, CR = 81.43), followed by "Pediatrics" (66 articles, CR = 70.80),  
8  
9 341 "Journal of Pediatrics" (65 articles, CR = 64.03), "American Journal of Respiratory  
10  
11 342 Critical Care" (47 articles, CR = 62.55), and „Journal of Infectious Diseases“ (186  
12  
13 343 articles, CR = 55.18).  
14  
15  
16  
17  
18  
19

20 344

## 21 345 **DISCUSSION**

22 346 In the WoS, we documented only 4,600 RSV-related articles since 1900. The first  
23  
24 347 item on the disease in humans was published in 1957<sup>28</sup>. This emphasizes that  
25  
26 348 research on RSV is a relatively new field considering the virus was initially isolated in  
27  
28 349 1956 from laboratory primates<sup>29</sup>. The predominance of English in the majority of  
29  
30 350 identified articles aligns not only with the fact that this language is the recognized  
31  
32 351 "scientific lingua franca" but also reflects the abundant research output of English  
33  
34 352 speaking countries such as USA, Canada and the UK found in our study.  
35  
36  
37  
38

39 353

40 354 The increasing number of RSV publications over time is typical for most biomedical  
41  
42 355 research, e.g. on the John Cunningham Virus, influenza or breast cancer<sup>30, 31</sup>.

43  
44 356 Overall, the steady growth of article numbers can be explained by the rising interest  
45  
46 357 in the field due to the increasing relevance of RSV in pneumonia and child mortality<sup>9</sup>.

47  
48 358 In the first few years after the detection of the virus, basic research was conducted.

49  
50 359 These endeavors, which aimed to characterize the virus, identify immunologic  
51  
52 360 responses and develop vaccines, translated into a growing volume of articles on RSV  
53  
54 361<sup>32-35</sup>. The continuous increase since the beginning of the 1990s may be attributed to

55  
56  
57 362 the launch of a growing number of scientific journals providing a platform for  
58  
59  
60

1  
2  
3 363 publishing. The development of modern communication systems based on new  
4  
5 364 computer technologies like the World Wide Web made it easier to communicate,  
6  
7 365 exchange ideas, and publicize articles in central databases. Also, it is noticeable that  
8  
9 366 the increasing publication output since the 1960s was paralleled by a globally  
10  
11 367 growing funding volume allocated to the R&D sector. In the USA alone, a total of  
12  
13 368 13,711 million US-Dollars (UDS) was allocated to R&D in 1960 as documented by  
14  
15 369 the National Science Foundation. This amount increased to 26,271 million UDS in  
16  
17  
18 370 1970 and 452,556 million USD in 2012  
19  
20 371 (<https://www.nsf.gov/statistics/2015/nsf15315/>).

21  
22 372

23  
24 373 The chronological development in publication quantity (Fig. 1) was resembled by the  
25  
26 374 steady increase of related citations (Fig. 3). Four prominent citation peaks in 1969,  
27  
28 375 1986, 2000 and 2003 coincided with milestone papers the field. In 1969, adverse  
29  
30 376 effects of the formalin-inactivated RSV vaccine in children were reported <sup>36</sup>. Large  
31  
32 377 epidemiologic studies investigated the risks of reinfection and the mortality  
33  
34 378 associated with RSV in 1986 and 2003 <sup>37, 38</sup>. The research on a prophylactic antibody  
35  
36 379 licensed in 1999 and novel insights into immunologic responses involving pattern  
37  
38 380 recognition receptors TLR4 and CD14 may be responsible for the peaking number of  
39  
40 381 publications and citations in 2000 <sup>39</sup>. The citation decline after 2006 can be attributed  
41  
42 382 to the short timespan articles had allotted to receive recognition within the scientific  
43  
44 383 community and obtain the appropriate citation number reflecting their true impact <sup>40</sup>.  
45  
46 384 Hence, we expect this trend to be reversed in the future.

47  
48 385

49  
50 386 The USA dominated RSV research with regards to overall publication quantity,  
51  
52 387 citation numbers and h-index. This corresponds with a previous biomedical  
53  
54 388 benchmarking study. Here, the USA was the most productive nation and authored

55  
56  
57  
58  
59  
60 23

1  
2  
3 389 1,893,800 of 5,527,558 publications related to 22 organ systems from 1961 to 2007  
4  
5 390 <sup>41</sup>. The leading role of the USA might be linked to major financial resources this  
6  
7 391 nation dedicates to research. The US-American National Institutes of Health (NIH)  
8  
9 392 are by far the biggest biomedical funder in the world (e.g. with a funding volume of  
10  
11 393 26.08 billion USD in 2013 compared to the biggest funding source in the EU, the  
12  
13 394 European Commission, with a funding volume of 3.71 billion USD in 2013). Also, the  
14  
15 395 Department of Defense constitutes another large US-American funding organization  
16  
17 396 with a volume of 1.017 billion USD (2013), followed by private philanthropic  
18  
19 397 institutions such as the Howard Hughes Medical Institute or the Bill & Melinda Gates  
20  
21 398 Foundation with impressive funding volumes of 752.0 (2013) and 462.6 million USD  
22  
23 399 (2011), respectively <sup>42</sup>. These funds can support manpower and an outstanding  
24  
25 400 scientific infrastructure illustrated by the fact, that the majority of institutions working  
26  
27 401 on RSV were identified in the USA, and that this nation is a preferred partner for  
28  
29 402 national and international co-operations.  
30  
31  
32  
33

34 403

35  
36 404 The cluster of the USA, Western-European countries (e.g. UK or Germany) and  
37  
38 405 Japan dominated the overall publication output and analyses of citation-based  
39  
40 406 benchmarks. This finding corresponds with other scientometric studies (e.g. on  
41  
42 407 Influenza, Ebola, or Hepatitis B <sup>30, 43</sup>. Although Sweden and Finland published  
43  
44 408 relatively low numbers of articles, they are characterized by the highest citation rates  
45  
46 409 in our analysis indicating the outstanding quality and high recognition their articles  
47  
48 410 received in the scientific community. Furthermore, it was striking that most African,  
49  
50 411 Asian and Central American countries afflicted with a considerable RSV-related  
51  
52 412 burden did not play a visible role in the field. Methodologically, we included only  
53  
54 413 countries in the citation rate analysis that published more than 30 RSV articles  
55  
56 414 aiming to generate a better the validity of the investigation by avoiding overestimation  
57  
58  
59  
60

24

1  
2  
3 415 of few but frequently cited articles. Nevertheless, we want to stress that the absolute  
4  
5 416 number of citations as well as the citation rate should be viewed critically. These  
6  
7 417 parameters can be affected by self-citation and inaccurate citations. Also, the  
8  
9 418 Matthew effect might influence citation-based variables. Here, scientists prefer to cite  
10  
11 419 articles issued by well-known researchers to papers by junior scientists leading to a  
12  
13 420 disproportional increase of the related citation counts<sup>44, 45</sup>. Hence, we also evaluated  
14  
15 421 the modified h-index since it is less influenced by outstanding, frequently or rarely  
16  
17 422 cited articles skewing the citation rate value<sup>21, 22</sup>. Furthermore, all citation-based  
18  
19 423 variables have limitations in assessing the quality of the identified articles because  
20  
21 424 they rather reflect the recognition of the research in the scientific community than  
22  
23 425 measure quality.  
24  
25  
26  
27  
28

29 426  
30 427 We identified an overrepresentation of male authors in the majority of evaluated  
31  
32 428 nations. This corresponds to the study of Head et al. who documented the  
33  
34 429 preferential funding of male researchers by UK institutions in the area of global  
35  
36 430 infectious disease research. Between 1997-2010, funding agencies supported fewer  
37  
38 431 studies of female PIs and awarded less monetary support to research supervised by  
39  
40 432 women. Particularly for RSV, male researchers received 5-times more funding than  
41  
42 433 female scientists, who spearheaded only half the funded studies compared to their  
43  
44 434 male counterparts in the field<sup>46</sup>. In our gender analysis, Brazil was an exception with  
45  
46 435 a majority of women authoring RSV research (Fig. 6). This result correlates with  
47  
48 436 previous investigations on Yellow fever and Rotavirus infections<sup>47</sup> as well as with  
49  
50 437 gender benchmarking studies (e. g. conducted by the “Konrad-Adenauer Foundation”  
51  
52 438 or the “Organization for Women in Science for the Developing World” (OWSD)),  
53  
54 439 which suggests that Brazil pioneers in the support and participation of females in  
55  
56 440 science<sup>48, 49</sup>.  
57  
58  
59  
60



1  
2  
3 441

4  
5 442 Our analysis of RSV publication outputs changed in relation to economic capabilities  
6  
7 443 (Fig. 4). Two developing, low-income nations, The Gambia and Guinea-Bissau,  
8  
9 444 occupied the leading positions. This finding points towards the fact that both prioritize  
10  
11 445 RSV research and might be connected to existing co-operations with a long standing  
12  
13 446 shared history between collaborating nations and their focused support of RSV  
14  
15 447 scientific activities. For example, the United Kingdom's "Medical Research Council  
16  
17 448 The Gambia Unit" and the Danish "Bandim Health Project" encourage medical  
18  
19 449 research in Guinea-Bissau and The Gambia <sup>50, 51</sup>. Also, research in the field is  
20  
21 450 promoted by single researchers with a strong dedication to conduct research in  
22  
23 451 African sites. Here, Sir Brian Greenwood has spearheaded RSV-related research  
24  
25 452 very successfully for decades while being faculty at the London School of Hygiene  
26  
27 453 and Tropical Medicine as well as the Director of the Medical Research Council in The  
28  
29 454 Gambia <sup>52, 53541355, 565758</sup>.

30  
31  
32  
33  
34 455

35  
36 456 If the RSV article counts were related to R&D expenditures and number of  
37  
38 457 researchers in specific countries, a different, more refined picture emerged compared  
39  
40 458 to the assessments based on absolute publications numbers or related to socio-  
41  
42 459 economic variables. Here, two Latin American countries gained importance, Chile  
43  
44 460 and Argentina. It appears that these nations invest funding very efficiently in RSV  
45  
46 461 research, with Chile ranked first position with 33.72 RSV articles per billion USD in  
47  
48 462 R&D expenditures followed by Argentina in fifth position (9.56 articles per billion USD  
49  
50 463 in R&D). Both nations' interest to fund RSV research might be linked to the fact that  
51  
52 464 respiratory infections and RSV in particular impose a heavy burden on the local  
53  
54 465 pediatric population. Respiratory infections constitute the second leading cause of  
55  
56 466 death in Latin American children aged 5 years or under with RSV as the causative

57  
58  
59  
60 26

1  
2  
3 467 agent in 70.0% of these infections.<sup>3,459, 60</sup>. In the temperate climate of Chile and  
4  
5 468 Argentina, RSV causes predictable outbreaks during the summer months. A  
6  
7 469 particular high RSV burden of up to 70% was reported in Chilean children aged 0-11  
8  
9 470 months with lower respiratory tract infection. This was substantially higher than in  
10  
11 471 other Latin American countries (e.g.18.2 % Argentina and 44% in Brazil)<sup>61</sup>. Hence,  
12  
13 472 RSV is constantly in the focus of the local health authorities, which routinely monitor  
14  
15 473 and report the trends in RSV infections to better allocate resources for pediatric  
16  
17 474 patients and limit related morbidity and mortality<sup>61,62</sup>.  
18  
19  
20  
21 475

22  
23 476 Collaborations are becoming increasingly important in the field of RSV research as  
24  
25 477 indicated by existing tight-knit networks and the growing numbers of authors per  
26  
27 478 article over time. We link this development to the globalization process, which  
28  
29 479 connects scientists worldwide to exchange ideas, resources and knowledge  
30  
31 480 facilitated by the growing availability of information technology. Further, it is  
32  
33 481 noticeable that countries such as the USA or European nations play a more  
34  
35 482 prominent role in international collaborations compared to low- and lower-middle-  
36  
37 483 income countries. As exceptions, we could identify productive co-operations between  
38  
39 484 the UK and Kenya as well as Denmark and Guinea-Bissau. The relation between  
40  
41 485 Kenya and the UK might be based on their shared history and facilitated by  
42  
43 486 implemented programs such as the “*KEMRI Welcome Trust Research Program*”  
44  
45 487 between the Kenya Medical Research Institute and the University of Oxford<sup>63</sup>. As  
46  
47 488 revealed by Fitchett et al.<sup>64</sup>, a substantial funding volume goes to infectious disease  
48  
49 489 research in countries with colonial ties to the UK such as Kenya and The Gambia.  
50  
51 490 From 1997 – 2010, these countries received 13.13 million £ (The Gambia) and 12.92  
52  
53 491 million £ (Kenya) of biomedical funding by UK based institutions. Research activity on  
54  
55 492 RSV in Guinea-Bissau is also supported by the aforementioned Danish “Bandim  
56  
57  
58  
59  
60

1  
2  
3 493 Health Project", which was founded by the anthropologist Sir Peter Aaby in the  
4  
5 494 1970s. It gathers local epidemiological data on more than 200,000 individuals. Since  
6  
7 495 its foundation, this group has published more than 600 items on vaccines, maternal  
8  
9 496 mortality and childhood infections such as RSV <sup>50</sup>.

10  
11 497

12  
13  
14 498 Timing, intensity and clinical impact of RSV infections vary worldwide <sup>3</sup>. Hence,  
15  
16 499 research is still needed to alleviate the burden related to RSV in high-risk  
17  
18 500 populations. Interventions should focus on data collection via established  
19  
20 501 surveillance systems (e.g. aiming to define local morbidity and mortality, assist  
21  
22 502 disease modeling, and guide prophylactic measures and vaccine development) <sup>65</sup>. In  
23  
24 503 this context, our study revealed a striking discrepancy in scientific productivity and  
25  
26 504 collaborative involvement between high- and low-income countries. Also, attention  
27  
28 505 should be drawn to a further problem concerning low-income nations or countries  
29  
30 506 whose researchers have a limited financial budget to pay for publication in renowned  
31  
32 507 open access journals. This issue increases the apparent discrepancies regarding  
33  
34 508 publication activities even further. To minimize this problem, a number of waiver  
35  
36 509 programs currently exist, i.e. for journals like PLOS, Biomed Central or BMJ OPEN <sup>66-</sup>  
37  
38 510 <sup>68</sup>, but these should be expanded more broadly. However, we can deduce from our  
39  
40 511 findings, that developing nations - although experiencing the most significant  
41  
42 512 consequences of RSV epidemics - cannot compete equally in the field of RSV  
43  
44 513 research due to the lack of funding and infrastructure. Therefore, we want to  
45  
46 514 emphasize the need – an almost ethical responsibility - to involve these nations in  
47  
48 515 funding programs and successful international collaborations as seen for Guinea-  
49  
50 516 Bissau, Kenya and The Gambia. We acknowledge that the establishment of  
51  
52 517 collaborations between high- and low-income nations is challenging due to the lack of  
53  
54 518 resources, manpower and funding opportunities, the political climate, cultural  
55  
56  
57  
58  
59  
60

28

1  
2  
3 519 differences between the potential partners and a unrealistic assessment of the local  
4  
5 520 research capacity and resources <sup>69</sup>. Also, existing collaborations and funding streams  
6  
7 521 need to be viewed critically since they should rather reflect local disease burden,  
8  
9 522 apparent healthcare disparities and scientific capability than being allocated based  
10  
11 523 on a shared language or history between countries (e.g. guided by former colonial  
12  
13 524 ties). Therefore, funding institutions should revise their policies appropriately <sup>64</sup>. Also,  
14  
15 525 global investment surveillance systems need to be established such as the  
16  
17 526 “Research Fairness Initiative” led by Cohred to guide and monitor sustainable,  
18  
19 527 transparent and effective partnerships in research ([http://rfi.cohred.org/origin-of-the-](http://rfi.cohred.org/origin-of-the-rfi/)  
20  
21 528 [rfi/](http://rfi.cohred.org/origin-of-the-rfi/)). Nevertheless, tight-knit networks would be key for developing countries to  
22  
23 529 participate in the international exchange of data, resources and knowledge, and to  
24  
25 530 facilitate their involvement in high quality research efforts despite an unequal starting  
26  
27  
28  
29 531 point.  
30  
31

32 532

### 33 533 **Study Limitations**

34  
35  
36 534 Our study has several limitations. Using the WoS to conduct this analysis is  
37  
38 535 associated with an important strength but also with a weakness of the study. The  
39  
40 536 WoS enabled us to assess not only quantitative but also qualitative aspects of the  
41  
42 537 publication output related to RSV research. This is a unique feature allowing a  
43  
44 538 multifaceted evaluation of the publication productivity. On the other hand, the WoS  
45  
46 539 displays a strong preference for English journals. Therefore, not all articles ever  
47  
48 540 published on RSV could be analyzed here. However, we regard this bias as limited  
49  
50 541 as the majority of high quality data is commonly published in international journals  
51  
52 542 indexed by the WoS and therefore definitely included in our search. Also, we  
53  
54 543 acknowledge that not all eligible RSV publications were detected by the conducted  
55  
56 544 “TITLE”-search. This approach was preferred to a “TOPIC” search, which identifies  
57  
58  
59  
60

29

1  
2  
3 545 the search term in the abstract and the keywords leading to a significant amount of  
4  
5 546 off-topic publications compromising the validity of our data collection. We  
6  
7 547 concentrated our study on original articles to focus on published “cutting edge  
8  
9 548 research” in the field of RSV. We acknowledge that this strategy narrowed down the  
10  
11 549 focus on the topic since other publication types such as commentaries, reviews, case  
12  
13 550 reports, or meeting reports were not included. Further, we did not employ any  
14  
15 551 additional platforms such as PubMed, Google Scholar or Scopus to collect  
16  
17 552 bibliometric data because the management, organization and the scope of data is  
18  
19 553 slightly different among these databases. This would affect triangulating, comparing  
20  
21 554 and integrating data related to RSV research in a meaningful way.  
22  
23  
24  
25

26 555

27 556 We identified the first collaborative article on RSV in 1973, which would indicate that  
28  
29 557 researchers from different countries did not work together on RSV before this point in  
30  
31 558 time. This assumption is not necessarily true. In 1972, the WoS indexed author  
32  
33 559 affiliations for the first time, which indicates that articles published in a joint effort  
34  
35 560 before 1972 would not have been detected by our methodological approach. The  
36  
37 561 evaluation of country-specific publication performance by gender is meaningful but  
38  
39 562 should be evaluated critically. Not all first names were included in our analysis since  
40  
41 563 some were gender-neutral, not listed in name databases or displayed as initials.  
42  
43 564 Therefore, the threshold of at least 60 publishing scientists and 50% gender  
44  
45 565 definability was implemented to include only countries providing meaningful and valid  
46  
47 566 data. Further, we identified “Mortality associated with influenza and respiratory  
48  
49 567 syncytial virus in the United States” by Thompson et al. as the most cited journal  
50  
51 568 article in the field of RSV. It received 1520 citations representing its outstanding  
52  
53 569 recognition in the scientific community. The publication covers the topics RSV as well  
54  
55 570 as Influenza, so the limitation has to be mentioned that our computed approach did  
56  
57  
58  
59  
60

30

1  
2  
3 571 not differentiate if the article was cited in “influenza” or “RSV” papers. Employing a  
4  
5 572 manual analysis, we found that 70,3 % of citing articles can be attributed to influenza,  
6  
7 573 only 15,8 % to RSV, and 2.2 % were covering both topics. Hence, the impact of this  
8  
9 574 particular paper on the field of RSV must be considered as less than it initially  
10  
11 575 appeared based on the citation count alone.  
12  
13  
14 576

## 17 577 **Conclusion**

18  
19 578 We evaluated the worldwide RSV-related research output and demonstrated large  
20  
21 579 differences between high-, middle-income or low-income nations regarding most  
22  
23 580 scientometric variables. These discrepancies partly diminished when country-specific  
24  
25 581 scientific activities were related to economic key measures; here, the leading position  
26  
27 582 of the USA in science was challenged by other nations. Hence, calculating these  
28  
29 583 quotients is beneficial for the comparison of countries with unequal conditions and  
30  
31 584 different scientific infrastructures. However, we can deduce from our study that  
32  
33 585 research efforts of middle-income or low-income nations have to be strengthened,  
34  
35 586 e.g. by the reduction of journal fees and inclusion in international collaborations, so  
36  
37 587 apparent disparities can be minimized and higher mortality rates related to RSV in  
38  
39 588 developing nations can be tackled successfully.  
40  
41  
42  
43  
44 589

## 46 590 **Acknowledgements:**

47  
48 591 We thank Cristian Scutaru for the development and provision of the NewQIS  
49  
50 592 analyzing tools. We also thank Mario Schwarzer, MD for supporting the study and  
51  
52 593 helpful discussions as well as Jenny M. Jaque, MD for thoroughly editing our  
53  
54 594 manuscript.  
55  
56  
57  
58  
59  
60

1  
2  
3 595 **Source of Funding:**  
4  
5

6 596 This research received no specific grant from any funding agency in the public,  
7  
8 597 commercial or not-for-profit sectors  
9

10 598

11  
12 599 **Conflicts of Interest:**  
13

14 600 All authors state that they have no conflicts of interest to declare.  
15  
16

17 601

18  
19  
20 602 **Data Sharing Statement:**  
21

22  
23 603 Datasets of this study are available from the corresponding author upon request.  
24  
25

26 604

27  
28  
29 605 **Authors' contributions:**  
30

31  
32 606 DB, CK, DK, DAG, DO, JB and MB have made substantial contributions to the  
33  
34 607 conception and design of the study, acquisition of the study data and have been  
35  
36 608 involved in drafting and revising the manuscript. All authors have read and approved  
37  
38 609 the final manuscript.  
39

40  
41  
42 610  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 611 **Figure Legends**  
4

5 612 Figure 1: Chronological development of the number of articles.  
6

7 613 Figure 2: Density equalizing mapping projections (DEMP).  
8

9 614 A) Number of publications B) Modified h-Index  
10

11 615 Figure 3: Chronological development of annual citation numbers.  
12

13 616 Figure 4: Density equalizing mapping projections (DEMP).  
14

15 617 A) Articles/population-index (Q1)  
16

17 618 B) Articles/GDP-index (Q2)  
18

19 619 (Threshold  $\geq 15$  articles)  
20

21 620 Figure 5: Density equalizing mapping projections (DEMP)  
22

23 621 A) Articles/ R&D Expenditure in billion USD -index  
24

25 622 B) Articles/ researcher (per billion inhabitants)-index  
26

27 623 (Threshold  $\geq 30$  articles)  
28

29 624 Figure 6: Country specific gender analysis of the authors publishing articles referring  
30  
31  
32  
33  
34 625 to RSV of countries.

35 626 (Threshold:  $> 50\%$  definable genders,  $> 60$  authors per country)  
36

37 627 Figure 7: International cooperation (threshold  $\geq 2$  cooperations).  
38

39 628 Numbers in brackets (number of publications/number of publications in  
40

41 629 cooperation  
42

43 630 Figure 8: Most prolific journals in the field of RSV research in regards to overall  
44

45 631 publication numbers and the average citation rate.  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



## 632 References

- 633 1. Murphy BR, Prince GA, Collins PL, *et al*. Current approaches to the development of  
634 vaccines effective against parainfluenza and respiratory syncytial viruses. *Virus*  
635 *Res* 1988;**11**:1-15 Online First: 1988/08/01].
- 636 2. Collins PL, Graham BS. Viral and host factors in human respiratory syncytial virus  
637 pathogenesis. *J Virol* 2008;**82**:2040-55 doi: 10.1128/jvi.01625-07published  
638 Online First: 2007/10/12].
- 639 3. Nair H, Nokes DJ, Gessner BD, *et al*. Global burden of acute lower respiratory  
640 infections due to respiratory syncytial virus in young children: a systematic  
641 review and meta-analysis. *Lancet* 2010;**375**:1545-55 doi: 10.1016/s0140-  
642 6736(10)60206-1published Online First: 2010/04/20].
- 643 4. Borchers AT, Chang C, Gershwin ME, *et al*. Respiratory syncytial virus--a  
644 comprehensive review. *Clin Rev Allergy Immunol* 2013;**45**:331-79 doi:  
645 10.1007/s12016-013-8368-9published Online First: 2013/04/12].
- 646 5. Blanken MO, Rovers MM, Molenaar JM, *et al*. Respiratory syncytial virus and recurrent  
647 wheeze in healthy preterm infants. *N Engl J Med* 2013;**368**:1791-9 doi:  
648 10.1056/NEJMoa1211917published Online First: 2013/05/10].
- 649 6. Wu P, Dupont WD, Griffin MR, *et al*. Evidence of a causal role of winter virus infection  
650 during infancy in early childhood asthma. *Am J Respir Crit Care Med*  
651 2008;**178**:1123-9 doi: 10.1164/rccm.200804-5790Cpublished Online First:  
652 2008/09/09].
- 653 7. Graham BS. Vaccines against respiratory syncytial virus: The time has finally come.  
654 *Vaccine* 2016;**34**:3535-41 doi: 10.1016/j.vaccine.2016.04.083published Online  
655 First: 2016/05/18].
- 656 8. Polack FP. The changing landscape of respiratory syncytial virus. *Vaccine*  
657 2015;**33**:6473-8 doi: 10.1016/j.vaccine.2015.06.119published Online First:  
658 2015/08/08].
- 659 9. CentersforDiseaseControlandPrevention. Respiratory Syncytial Virus Infection (RSV).  
660 Secondary Respiratory Syncytial Virus Infection (RSV). 2016.  
661 <http://www.cdc.gov/rsv/about/index.html>.
- 662 10. Welliver RC, Sr., Checchia PA, Bauman JH, *et al*. Fatality rates in published reports of  
663 RSV hospitalizations among high-risk and otherwise healthy children. *Curr Med*  
664 *Res Opin* 2010;**26**:2175-81 doi: 10.1185/03007995.2010.505126published  
665 Online First: 2010/07/30].
- 666 11. Hall CB, Weinberg GA, Iwane MK, *et al*. The burden of respiratory syncytial virus  
667 infection in young children. *N Engl J Med* 2009;**360**:588-98 doi:  
668 10.1056/NEJMoa0804877published Online First.

- 1  
2  
3 669 12. Selwyn BJ. The epidemiology of acute respiratory tract infection in young children:  
4 670 comparison of findings from several developing countries. Coordinated Data  
5 671 Group of BOSTID Researchers. *Rev Infect Dis* 1990;**12 Suppl 8**:S870-88 Online  
6 672 First: 1990/11/01].
- 8 673 13. Weber MW, Mulholland EK, Greenwood BM. Respiratory syncytial virus infection in  
9 674 tropical and developing countries. *Trop Med Int Health* 1998;**3**:268-80 Online  
10 675 First: 1998/06/12].
- 12 676 14. Walsh EE, McConnochie KM, Long CE, *et al.* Severity of respiratory syncytial virus  
13 677 infection is related to virus strain. *J Infect Dis* 1997;**175**:814-20 Online First:  
14 678 1997/04/01].
- 16 679 15. Peret TC, Hall CB, Schnabel KC, *et al.* Circulation patterns of genetically distinct group  
17 680 A and B strains of human respiratory syncytial virus in a community. *J Gen Virol*  
18 681 1998;**79 ( Pt 9)**:2221-9 doi: 10.1099/0022-1317-79-9-2221published Online  
19 682 First: 1998/09/25].
- 21 683 16. Auksornkitti V, Kamprasert N, Thongkomplew S, *et al.* Molecular characterization of  
22 684 human respiratory syncytial virus, 2010-2011: identification of genotype ON1  
23 685 and a new subgroup B genotype in Thailand. *Arch Virol* 2014;**159**:499-507 doi:  
24 686 10.1007/s00705-013-1773-9published Online First: 2013/09/27].
- 26 687 17. Gastner MT, Newman ME. Diffusion-based method for producing density-equalizing  
27 688 maps. *Proc Natl Acad Sci U S A* 2004;**101**:7499-504 doi:  
28 689 10.1073/pnas.0400280101published Online First: 2004/05/12].
- 30 690 18. Scutaru C, Quarcoo D, Sakr M, *et al.* Density-equalizing mapping and scientometric  
31 691 benchmarking of European allergy research. *J Occup Med Toxicol* 2010;**5**:2 doi:  
32 692 10.1186/1745-6673-5-2published Online First: 2010/10/12].
- 34 693 19. Groneberg-Kloft B, Quarcoo D, Scutaru C. Quality and quantity indices in science: use  
35 694 of visualization tools. *EMBO Rep* 2009;**10**:800-3 doi:  
36 695 10.1038/embor.2009.162published Online First: 2009/08/04].
- 38 696 20. Gerber A, Klingelhofer D, Groneberg D, *et al.* Antineutrophil cytoplasmic antibody-  
39 697 associated vasculitides: a scientometric approach visualizing worldwide research  
40 698 activity. *Int J Rheum Dis* 2014;**17**:796-804 doi: 10.1111/1756-  
41 699 185x.12376published Online First: 2014/04/08].
- 43 700 21. Hirsch JE. An index to quantify an individual's scientific research output. *Proc Natl*  
44 701 *Acad Sci U S A* 2005;**102**:16569-72 doi: 10.1073/pnas.0507655102published  
45 702 Online First: 2005/11/09].
- 47 703 22. Hirsch JE. Does the H index have predictive power? *Proc Natl Acad Sci U S A*  
48 704 2007;**104**:19193-8 doi: 10.1073/pnas.0707962104published Online First:  
49 705 2007/11/28].
- 51 706 23. Namepedia. Namepedia. Secondary Namepedia 2016. <http://www.namepedia.org/>.

- 1  
2  
3 707 24. Anonymus. World Economic Outlook Database. Secondary World Economic Outlook  
4 708 Database 2013 2013.  
5 709 <http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?pr.x=7>  
6 710 [5&pr.y=10&sy=2012&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=](http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?pr.y=10&sy=2012&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=193%2C223%2C924%2C132%2C134%2C146%2C136%2C158%2C112%2C111&s=NGDPD&grp=0&a=)  
7 711 [193%2C223%2C924%2C132%2C134%2C146%2C136%2C158%2C112%2C](http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?pr.y=10&sy=2012&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=193%2C223%2C924%2C132%2C134%2C146%2C136%2C158%2C112%2C111&s=NGDPD&grp=0&a=)  
8 712 [111&s=NGDPD&grp=0&a=.](http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?pr.y=10&sy=2012&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=193%2C223%2C924%2C132%2C134%2C146%2C136%2C158%2C112%2C111&s=NGDPD&grp=0&a=)  
9  
10 713 25. WorldBank. Country and Lending Groups. Secondary Country and Lending Groups  
11 714 2015. <http://data.worldbank.org/about/country-and-lending-groups>.  
12  
13 715 26. OECD. Main Science and Technology Indicators. Secondary Main Science and  
14 716 Technology Indicators 2013.  
15 717 [http://www.oecd.org/sti/2013\\_1\\_documentation\\_e.pdf](http://www.oecd.org/sti/2013_1_documentation_e.pdf).  
16  
17 718 27. Bachi T, Howe C. Morphogenesis and ultrastructure of respiratory syncytial virus. *J*  
18 719 *Virol* 1973;**12**:1173-80 Online First: 1973/11/01].  
19  
20 720 28. Chanock R, Roizman B, Myers R. Recovery from infants with respiratory illness of a  
21 721 virus related to chimpanzee coryza agent (CCA). I. Isolation, properties and  
22 722 characterization. *Am J Hyg* 1957;**66**:281-90 Online First.  
23  
24 723 29. Blount RE, Jr., Morris JA, Savage RE. Recovery of cytopathogenic agent from  
25 724 chimpanzees with coryza. *Proc Soc Exp Biol Med* 1956;**92**:544-9 Online First:  
26 725 1956/07/01].  
27  
28 726 30. Fricke R, Uibel S, Klingelhoef D, *et al*. Influenza: a scientometric and density-  
29 727 equalizing analysis. *BMC Infect Dis* 2013;**13**:454 doi: 10.1186/1471-2334-13-  
30 728 454published Online First: 2013/10/02].  
31  
32 729 31. Zheng HC, Yan L, Cui L, *et al*. Mapping the history and current situation of research  
33 730 on John Cunningham virus - a bibliometric analysis. *BMC Infect Dis* 2009;**9**:28 doi:  
34 731 10.1186/1471-2334-9-28published Online First: 2009/03/17].  
35  
36 732 32. Simoes EA. Respiratory syncytial virus infection. *Lancet* 1999;**354**:847-52 doi:  
37 733 10.1016/s0140-6736(99)80040-3published Online First: 1999/09/15].  
38  
39 734 33. Collins PL, Hill MG, Camargo E, *et al*. Production of infectious human respiratory  
40 735 syncytial virus from cloned cDNA confirms an essential role for the transcription  
41 736 elongation factor from the 5' proximal open reading frame of the M2 mRNA in  
42 737 gene expression and provides a capability for vaccine development. *Proc Natl*  
43 738 *Acad Sci U S A* 1995;**92**:11563-7 Online First: 1995/12/05].  
44  
45 739 34. Cranage MP, Gardner PS. Systemic cell-mediated and antibody responses in infants  
46 740 with respiratory syncytial virus infections. *J Med Virol* 1980;**5**:161-70 Online  
47 741 First: 1980/01/01].  
48  
49 742 35. Fulginiti VA, Eller JJ, Sieber OF, *et al*. Respiratory virus immunization. I. A field trial of  
50 743 two inactivated respiratory virus vaccines; an aqueous trivalent parainfluenza  
51 744 virus vaccine and an alum-precipitated respiratory syncytial virus vaccine. *Am J*  
52 745 *Epidemiol* 1969;**89**:435-48 Online First: 1969/04/01].  
53  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 746 36. Kim HW, Canchola JG, Brandt CD, *et al.* Respiratory syncytial virus disease in infants  
4 747 despite prior administration of antigenic inactivated vaccine. *Am J Epidemiol*  
5 748 1969;**89**:422-34 Online First: 1969/04/01].
- 7 749 37. Glezen WP, Taber LH, Frank AL, *et al.* Risk of primary infection and reinfection with  
8 750 respiratory syncytial virus. *Am J Dis Child* 1986;**140**:543-6 Online First:  
9 751 1986/06/01].
- 11 752 38. Thompson WW, Shay DK, Weintraub E, *et al.* Mortality associated with influenza and  
12 753 respiratory syncytial virus in the United States. *JAMA* 2003;**289**:179-86 Online  
14 754 First: 2003/01/09].
- 16 755 39. Kurt-Jones EA, Popova L, Kwinn L, *et al.* Pattern recognition receptors TLR4 and  
17 756 CD14 mediate response to respiratory syncytial virus. *Nat Immunol* 2000;**1**:398-  
18 757 401 doi: 10.1038/80833published Online First: 2001/03/23].
- 20 758 40. Testa J. The Thomson Scientific journal selection process. *Int Microbiol* 2006;**9**:135-8  
21 759 Online First: 2006/07/13].
- 23 760 41. Groneberg-Kloft B, Scutaru C, Kreiter C, *et al.* Institutional operating figures in basic  
24 761 and applied sciences: scientometric analysis of quantitative output  
26 762 benchmarking. *Health Res Policy Syst* 2008;**6**:6 doi: 10.1186/1478-4505-6-  
27 763 6published Online First: 2008/06/17].
- 29 764 42. Viergever RF, Hendriks TC. The 10 largest public and philanthropic funders of health  
30 765 research in the world: what they fund and how they distribute their funds. *Health*  
31 766 *Res Policy Syst* 2016;**14**:12 doi: 10.1186/s12961-015-0074-zpublished Online  
32 767 First: 2016/02/20].
- 34 768 43. Schmidt S, Bundschuh M, Scutaru C, *et al.* Hepatitis B: global scientific development  
35 769 from a critical point of view. *J Viral Hepat* 2013 doi: 10.1111/jvh.12205published  
37 770 Online First: 2013/11/12].
- 39 771 44. Fassoulaki A, Paraskeva A, Papilas K, *et al.* Self-citations in six anaesthesia journals  
40 772 and their significance in determining the impact factor. *Br J Anaesth*  
41 773 2000;**84**:266-9 Online First: 2000/04/01].
- 43 774 45. Merton RK. The Matthew effect in science. The reward and communication systems  
44 775 of science are considered. *Science* 1968;**159**:56-63 Online First.
- 46 776 46. Head MG, Fitchett JR, Cooke MK, *et al.* Differences in research funding for women  
47 777 scientists: a systematic comparison of UK investments in global infectious disease  
48 778 research during 1997-2010. *BMJ Open* 2013;**3**:e003362 doi: 10.1136/bmjopen-  
50 779 2013-003362published Online First: 2013/12/12].
- 52 780 47. Koster C, Klingelhofer D, Groneberg DA, *et al.* Rotavirus - Global research density  
53 781 equalizing mapping and gender analysis. *Vaccine* 2016;**34**:90-100 doi:  
54 782 10.1016/j.vaccine.2015.11.002published Online First: 2015/11/28].
- 56 783 48. Konrad-Adenauer-Stiftung. Frauen in Brasilien. Secondary Frauen in Brasilien 2014.  
57 784 [http://www.kas.de/wf/doc/kas\\_17800-1522-1-30.pdf?091024002708](http://www.kas.de/wf/doc/kas_17800-1522-1-30.pdf?091024002708).

- 1  
2  
3 785 49. Huyer S, Hafkin N. Scorecard on Gender Equality in the Knowledge Society.  
4 786 Secondary Scorecard on Gender Equality in the Knowledge Society 2014.  
5 787 [http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows)  
6 788 [and-innovation-study-shows](http://www.elsevier.com/connect/brazilian-women-lead-in-science-technology-and-innovation-study-shows).
- 7  
8 789 50. BandimHealthProject. About BHP. Secondary About BHP.  
9 790 <http://www.bandim.org/about-bhp.aspx>.
- 10  
11 791 51. Council. MR. Medical Research Council: The Gambia Unit. Secondary Medical  
12 792 Research Council: The Gambia Unit. <http://www.mrc.gm/our-research/themes>.
- 13  
14 793 52. Adegbola RA, Falade AG, Sam BE, *et al*. The etiology of pneumonia in malnourished  
15 794 and well-nourished Gambian children. *Pediatr Infect Dis J* 1994;**13**:975-82 Online  
16 795 First: 1994/11/01].
- 17  
18 796 53. Suara RO, Piedra PA, Glezen WP, *et al*. Prevalence of neutralizing antibody to  
19 797 respiratory syncytial virus in sera from mothers and newborns residing in the  
20 798 Gambia and in The United States. *Clin Diagn Lab Immunol* 1996;**3**:477-9 Online  
21 799 First: 1996/07/01].
- 22  
23 800 54. Weber MW, Dackour R, Usen S, *et al*. The clinical spectrum of respiratory syncytial  
24 801 virus disease in The Gambia. *Pediatr Infect Dis J* 1998;**17**:224-30 Online First:  
25 802 1998/04/16].
- 26  
27 803 55. Weber MW, Milligan P, Hilton S, *et al*. Risk factors for severe respiratory syncytial  
28 804 virus infection leading to hospital admission in children in the Western Region of  
29 805 The Gambia. *Int J Epidemiol* 1999;**28**:157-62 Online First: 1999/04/09].
- 30  
31 806 56. Weber MW, Milligan P, Sanneh M, *et al*. An epidemiological study of RSV infection in  
32 807 the Gambia. *Bull World Health Organ* 2002;**80**:562-8 Online First: 2002/08/07].
- 33  
34 808 57. Weber MW, Milligan P, Giadom B, *et al*. Respiratory illness after severe respiratory  
35 809 syncytial virus disease in infancy in The Gambia. *J Pediatr* 1999;**135**:683-8 Online  
36 810 First: 1999/12/10].
- 37  
38 811 58. Loscertales MP, Roca A, Ventura PJ, *et al*. Epidemiology and clinical presentation of  
39 812 respiratory syncytial virus infection in a rural area of southern Mozambique.  
40 813 *Pediatr Infect Dis J* 2002;**21**:148-55 Online First: 2002/02/13].
- 41  
42 814 59. Salomao Junior JB, Gardinassi LG, Simas PV, *et al*. Human respiratory syncytial virus  
43 815 in children hospitalized for acute lower respiratory infection. *J Pediatr (Rio J)*  
44 816 2011;**87**:219-24 doi: doi:10.2223/JPED.2085published Online First:  
45 817 2011/04/05].
- 46  
47 818 60. Pineros JG, Baquero H, Bastidas J, *et al*. Respiratory syncytial virus infection as a  
48 819 cause of hospitalization in population under 1 year in Colombia. *J Pediatr (Rio J)*  
49 820 2013;**89**:544-8 doi: 10.1016/j.jpmed.2013.04.002published Online First:  
50 821 2013/09/14].
- 51  
52 822 61. Bardach A, Rey-Ares L, Cafferata ML, *et al*. Systematic review and meta-analysis of  
53 823 respiratory syncytial virus infection epidemiology in Latin America. *Rev Med Virol*  
54 824 2014;**24**:76-89 Online First: 2014/04/24].



- 1  
2  
3 825 62. Avendano LF, Palomino MA, Larranaga C. Surveillance for respiratory syncytial virus  
4 826 in infants hospitalized for acute lower respiratory infection in Chile (1989 to  
5 827 2000). *J Clin Microbiol* 2003;**41**:4879-82 Online First: 2003/10/09].
- 7 828 63. KEMRIWellcomeTrustResearchProgramm. KEMRI Wellcome Trust Research  
8 829 Programm. Secondary KEMRI Wellcome Trust Research Programm.  
9 830 <http://www.kemri-wellcome.org>.
- 11 831 64. Fitchett JR, Head MG, Atun R. Infectious disease research investments follow colonial  
12 832 ties: questionable ethics. *Int Health* 2014;**6**:74-6 doi:  
13 833 10.1093/inthealth/ih036published Online First: 2014/01/28].
- 16 834 65. Haynes AK, Manangan AP, Iwane MK, *et al*. Respiratory syncytial virus circulation in  
17 835 seven countries with Global Disease Detection Regional Centers. *J Infect Dis*  
18 836 2013;**208 Suppl 3**:S246-54 doi: 10.1093/infdis/jit515published Online First:  
19 837 2013/12/07].
- 21 838 66. PLOS. Publication fees. Secondary Publication fees.  
22 839 <http://www.plos.org/publications/publication-fees>.
- 25 840 67. BioMedCentral. Can charges be waived if the author cannot pay? Secondary Can  
26 841 charges be waived if the author cannot pay?  
27 842 <http://www.biomedcentral.com/about/apcfaq/waivers>.
- 29 843 68. BMJOpen. Instructions for authors. Secondary Instructions for authors.  
30 844 <http://bmjopen.bmj.com/site/about/guidelines.xhtml>.
- 32 845 69. Akinremi TO. Research collaboration with low resource countries: overcoming the  
33 846 challenges. *Infect Agent Cancer* 2011;**6 Suppl 2**:S3 doi: 10.1186/1750-9378-6-S2-  
34 847 S3published Online First.

848

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

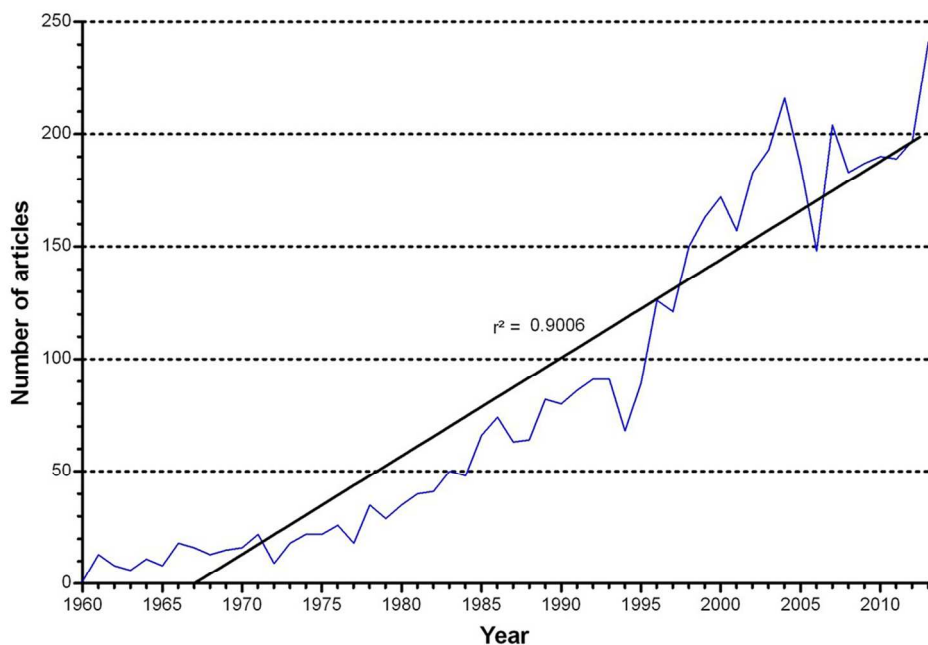


Figure 1: Chronological development of the number of articles.

109x75mm (300 x 300 DPI)

view only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

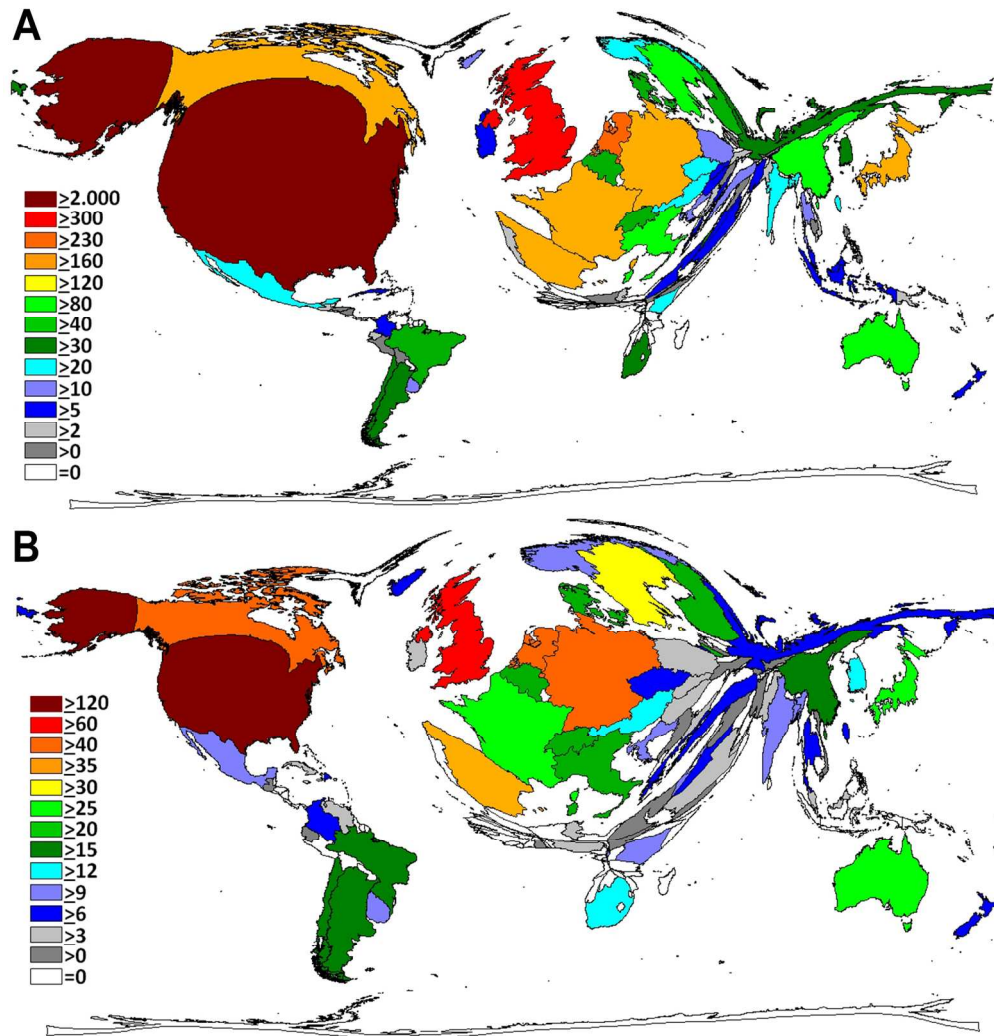


Figure 2: Density equalizing mapping projections (DEMP).  
A) Number of publications  
B) Modified h-Index

203x212mm (300 x 300 DPI)



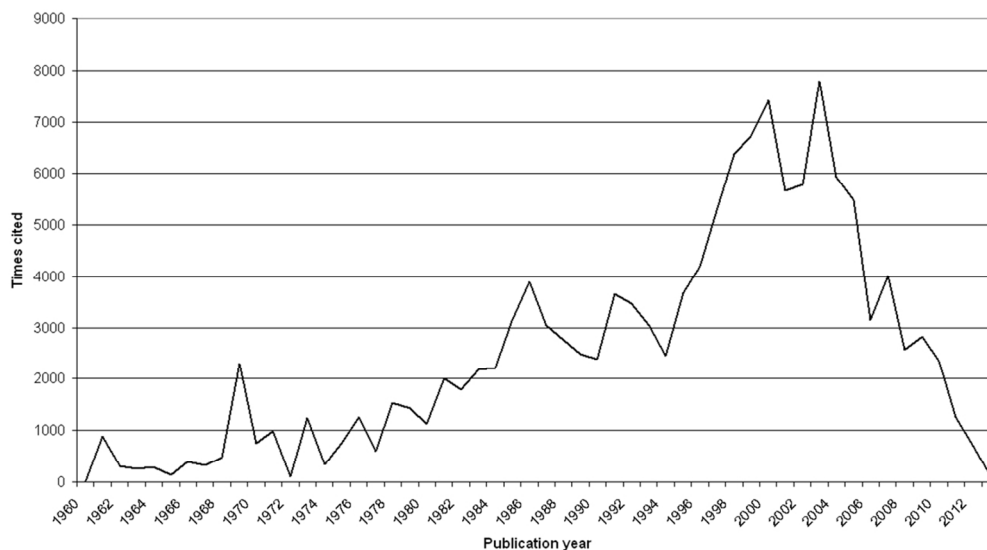


Figure 3: Chronological development of annual citation numbers.

109x61mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

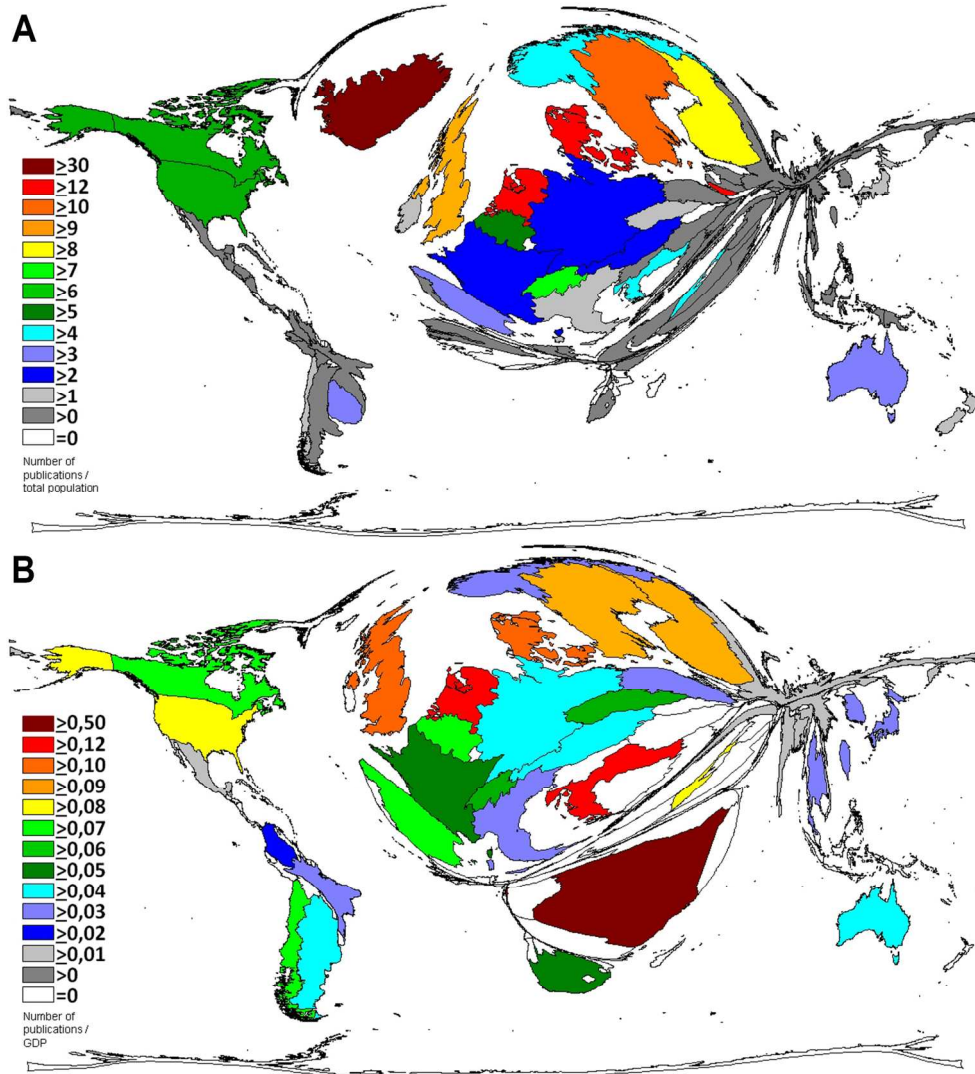


Figure 4: Density equalizing mapping projections (DEMP).  
 A) Articles/population-index (Q1)  
 B) Articles/GDP-index (Q2)  
 (Threshold > 15 articles)

203x220mm (300 x 300 DPI)

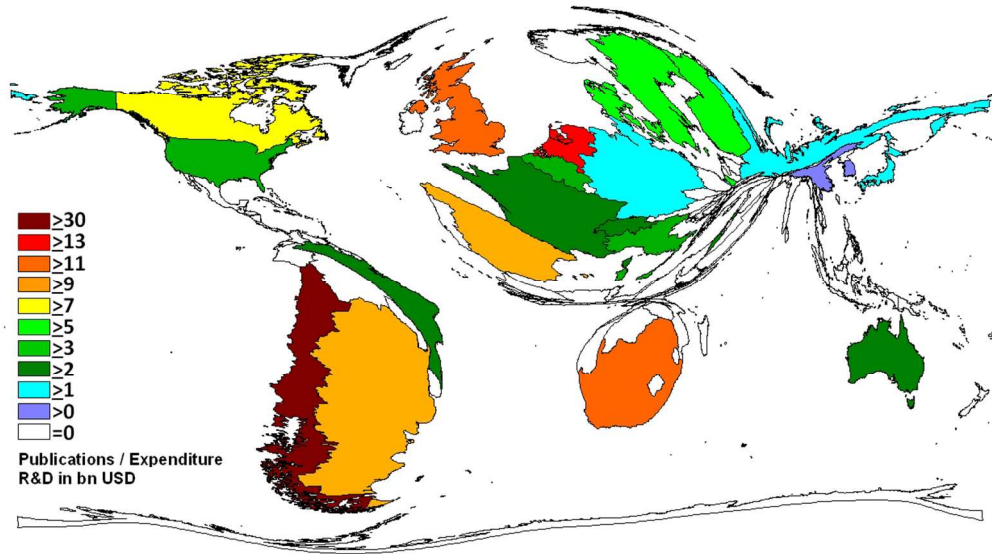


Figure 5A: Density equalizing mapping projections (DEMP). Articles/ R&D Expenditures in billion USD –index. (Threshold > 30 articles)

300x167mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

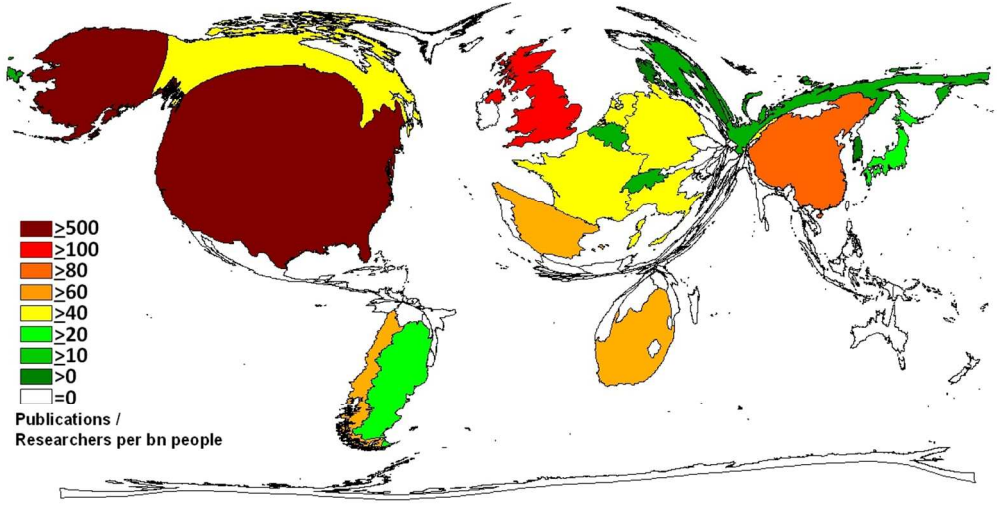


Figure 5B: Density equalizing mapping projections (DEMP). Articles/ researcher (per billion inhabitants)-index. (Threshold > 30 articles)

439x223mm (72 x 72 DPI)

review only

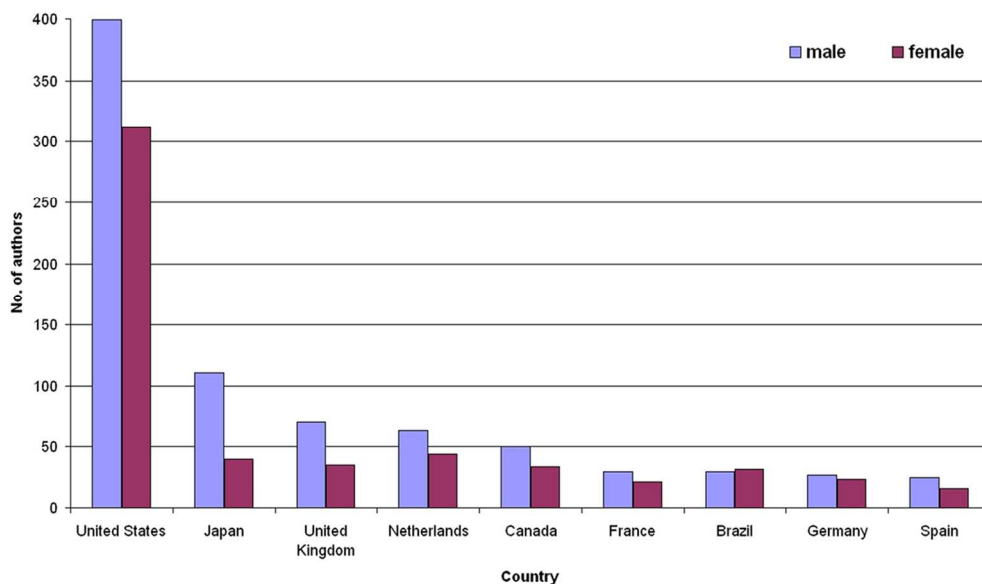


Figure 6: Country specific gender analysis of the authors publishing articles referring to RSV of countries.  
 !! † (Threshold: > 50% definable genders, > 60 authors per country)!! †

109x65mm (300 x 300 DPI)

review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

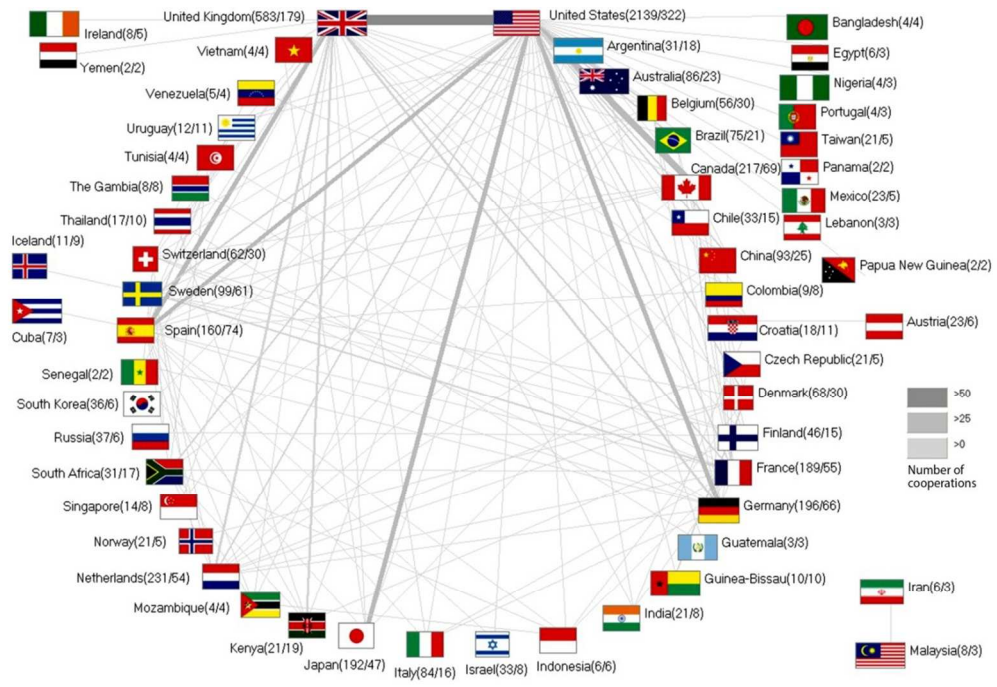


Figure 7: International cooperation (threshold > 2 cooperations). !! + Numbers in brackets (number of publications/number of publications in cooperation)!! +

203x138mm (300 x 300 DPI)

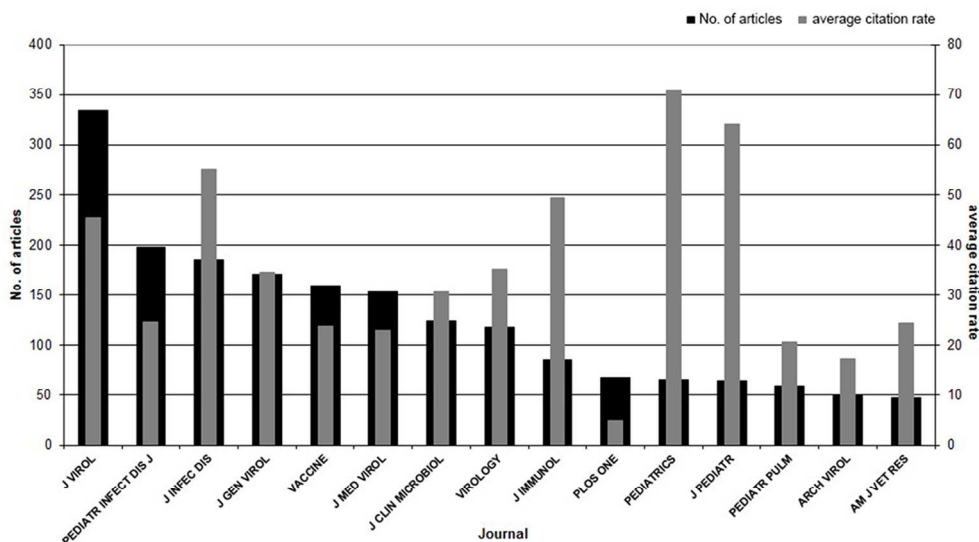


Figure 8: Most prolific journals in the field of RSV research in regards to overall publication numbers and the average citation rate.

109x65mm (300 x 300 DPI)

Review only

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60