

Mapping of Typhoid Research in India: A Scientometric Analysis of Publications Output in 2000-2009

B. M. Gupta

National Institute of Science, Technology & Development Studies
India

bmgupta1@gmail.com

Adarsh Bala

Government Medical College and Hospital
India

adarshbindu@rediffmail.com

Kiran Baidwan

Postgraduate Institute of Medical Education & Research
India

Neelima Chadhha

Postgraduate Institute of Medical Education & Research
India

Harjit Singh Cheema

Postgraduate Institute of Medical Education & Research
India

***Abstract:** This study analyses the research output of India in typhoid during 2000-2009, its growth, rank and global publications share, citation impact, share of international collaborative papers, contribution of major collaborative partner countries, contribution of various subject fields and patterns of research communication in most productive journals. It also analyses the characteristics of most productive institutions, authors and high-cited papers. The publication output, impact and collaborative publications share of India was also compared with China, South Africa and Brazil.*

I. Introduction

Typhoid (TYPHOID) is a severe, contagious and life-threatening disease associated with fever that is most often caused by the typhoid bacillus, *Salmonella enterica enterica*, serovar Typhi. Typhoid fever is transmitted by ingestion of food, including dairy products, or water contaminated by excreta from patients or chronic carriers or handled

by infected persons. It mostly affects school-age children. In adults and older people, typhoid is less frequent but much more severe. It has various names, such as gastric fever, abdominal typhus, infantile remittent fever, slow fever, nervous fever, pythogenic fever, etc. The name of "typhoid" was given by Louis in 1829, as a derivative from typhus (Wikipedia).

Although typhoid has practically disappeared from industrialized countries, it is the 5th most common communicable disease in India where children constitute about 69% of hospitalized typhoid victims. Annually, 4.5 million people suffer from typhoid, with maximum death rate for the age group of 1-4 years old, followed by 15-54 years old. A limited study in an urban slum showed 1% of children up to 17 years of age suffer from typhoid fever every year (aarogya.com).

II. Literature Review

So far no exclusive bibliometric study has been carried out on typhoid literature. However, a few bibliometric studies have been conducted in the past on other diseases in India and worldwide.

Ramos, Padilla, Masia and Gutierrez (2008) analyzed 35,735 articles on tuberculosis in 2,874 journals as indexed in *PubMed* from 1997 to 2006.

Elangovan (2002) analyzed 72,390 articles in 3,669 journals from 94 countries and in 38 languages on tuberculosis from 1966 to 2006. He analyzed the research output by language, medical subject headings, publication type, author address, country of publication, and all other factors to identify the trends in the publications.

Krishnamoorthy, Ramakrishnan and Devi (2009) studied world literature on diabetes between 1995-2004, using MEDLINE.

Garg, Dutt and Kumar (2006) analysed the research output on malaria during between 1900 and 2000, using PubMed and CABI CD-ROM, which includes *Tropical Disease Bulletin* databases.

Lewisson and Srivastava (2008) carried out a study on mapping the world research output on malaria from 1980 to 2004, using SCI database and comparing the output with disease burden.

Garg., Kumar, Madhavi, and Bahl (2009) mapped and analyzed the world research output on malaria vaccines from 1997 to 2004.

Arunachalam and Gunasekaran (2002) mapped tuberculosis and diabetes research in India and China, identifying institutions and cities active in research, journals used for publishing the findings, usage of high impact journals, and impact of their research, as seen from citations received and extent of international collaboration.

Ravi and Kumar (2007) mapped and analyzed 1,310 Indian tuberculosis papers indexed in *PubMed*, *SCI* and *Biochemistry and Biophysics Citations Index* databases from 1996 to 2006. They have identified institutions and cities active in the research, journals used to communicate their findings, use of high impact journals, and studies on the impact of research efforts and extent of international collaboration.

Ratnakar and Satynarayana (2007) analyzed 3,068 research papers on diabetes from India during 1976-2006, using Web of Science database.

III. Objectives of Study

The main objective of this study is to analyze the research performance of India in typhoid research, as reflected in its publications output during 2000-2009. In particular, the study focuses on the following objectives:

- i. To study the Indian research output, its growth, rank and global publications share and impact,
- ii. To study the patterns of international collaboration and major collaborative partners,
- iii. To study the publications productivity and impact of leading institutions and authors of India,
- iv. To study the characteristics of high cited papers and
- v. To study the patterns of research communication in most productive journals.

IV. Research Methodology and Data Source

This study is based on the Indian publications data in typhoid retrieved from the Scopus Citation database for the recent 10 years (2000-2009). The search strategy/keywords used to retrieve the data on typhoid are as follows:

(((((TITLE-ABS-KEY(**typhoid**) AND AFFIL(**india**)) AND PUBYEAR AFT **1999** AND PUBYEAR BEF **2010**) OR ((TITLE-ABS-KEY(**enteric fever**) AND AFFIL(**india**)) AND PUBYEAR AFT **1999** AND PUBYEAR BEF **2010**))) OR ((TITLE-ABS-KEY(**salmon* ent***) AND AFFIL(**india**)) AND PUBYEAR AFT **1999** AND PUBYEAR BEF **2010**)))”.

The search using the above keywords is our main search string. For citations data, three years, two year and one year citations window has been used for computing average citations per paper for typhoid research publications during 2000-2007, 2008 and 2009. To calculate the total international collaborative papers, a separate search strategy, which combines India’s collaboration with more than 140 major countries, was prepared. This string was combined with the main string to generate India’s total international collaborative output. To analyze institutional, authors and journals output, separate search strategies for were developed, which later combined with the main string to generate the desired output. It should also be noted that the accumulation of typhoid research output published under different subjects comes higher than the total research output in typhoid during 2000-2009, due to the overlapping of subject areas. Similarly, the total of

collaborative papers of partner countries is higher than the total international collaborative research output of India.

5. Findings

1 Global Publication Share & Rank

Overall, the global publication share of the top 21 most productive countries in typhoid research varies from 0.65% to 28.35% during 2000-2009. The United States tops the list with global publications share of 28.35%. The United Kingdom ranks second with global publications share of 9.75%, followed by India, Germany, Canada, France, and Spain with their global publications share ranging from 4.08% to 5.61%. Japan, Italy, South Korea, and Netherlands ranks 8th to 11th with their global publications share ranging from 2.0% to 3.89%. The countries that rank between 12th and 21st positions are Australia, China, Brazil, Switzerland, Turkey, Sweden, Taiwan, Belgium, Poland, and Russia with their global publications share from 0.65% to 1.96% (See Table 1).

Table 1. Publication Output, Share and Rank of Different Countries in Typhoid Research, 2000-2009

| No. | Country | No. of Publications | | | % Share of Publications | | | Rank of Countries | | |
|-----|---------|---------------------|------|-------|-------------------------|-------|-------|-------------------|------|-------|
| | | 2000 | 2009 | 00-09 | 2000 | 2009 | 00-09 | 2000 | 2009 | 00-09 |
| 1. | USA | 379 | 523 | 4747 | 31.35 | 24.70 | 28.35 | 1 | 1 | 1 |
| 2. | UK | 142 | 188 | 1633 | 11.75 | 8.88 | 9.75 | 2 | 2 | 2 |
| 3. | India | 47 | 154 | 940 | 3.89 | 7.27 | 5.61 | 7 | 3 | 3 |
| 4. | Germany | 68 | 107 | 892 | 5.62 | 5.05 | 5.33 | 3 | 6 | 4 |
| 5. | Canada | 48 | 112 | 842 | 3.97 | 5.29 | 5.03 | 6 | 4 | 5 |
| 6. | France | 61 | 83 | 747 | 5.05 | 3.92 | 4.46 | 4 | 9 | 6 |
| 7. | Spain | 45 | 112 | 683 | 3.72 | 5.29 | 4.08 | 8 | 5 | 7 |
| 8. | Japan | 57 | 86 | 651 | 4.71 | 4.06 | 3.89 | 5 | 8 | 8 |
| 9. | Italy | 27 | 52 | 437 | 2.23 | 2.46 | 2.61 | 9 | 12 | 9 |
| 10. | South | 18 | 56 | 363 | 1.49 | 2.65 | 2.17 | 12 | 11 | 10 |

| | | | | | | | | | | |
|-----|-------------|------|------|-------|------|------|------|----|----|----|
| | Korea | | | | | | | | | |
| 11. | Netherlands | 21 | 33 | 335 | 1.74 | 1.56 | 2.00 | 10 | 17 | 11 |
| 12. | Australia | 20 | 44 | 328 | 1.65 | 2.08 | 1.96 | 11 | 14 | 12 |
| 13. | China | 9 | 95 | 322 | 0.74 | 4.49 | 1.92 | 21 | 7 | 13 |
| 14. | Brazil | 18 | 57 | 322 | 1.49 | 2.69 | 1.92 | 13 | 10 | 14 |
| 15. | Switzerland | 18 | 41 | 314 | 1.49 | 1.94 | 1.88 | 14 | 15 | 15 |
| 16. | Turkey | 12 | 50 | 281 | 0.99 | 2.36 | 1.68 | 17 | 13 | 16 |
| 17. | Sweden | 16 | 24 | 265 | 1.32 | 1.13 | 1.58 | 15 | 19 | 17 |
| 18. | Taiwan | 10 | 37 | 259 | 0.83 | 1.75 | 1.55 | 20 | 16 | 18 |
| 19. | Belgium | 12 | 33 | 256 | 0.99 | 1.56 | 1.53 | 18 | 18 | 19 |
| 20. | Poland | 12 | 21 | 171 | 0.99 | 0.99 | 1.02 | 19 | 20 | 20 |
| 21. | Russia | 16 | 17 | 109 | 1.32 | 0.80 | 0.65 | 16 | 21 | 21 |
| | World | 1209 | 2117 | 16742 | | | | | | |

Among developed countries, the countries showing decline in their publications share from 2000 to 2009 are United States by 6.65%, United Kingdom by 2.87%, France by 1.13%, Japan by 0.65%, Germany by 0.57%, Russia by 0.52%, Sweden by 0.19% and Netherlands by 0.18%. In contrast, the developed countries showing rise in their publications share during the same period are Spain by 1.57%, Turkey by 1.37%, Canada by 1.32%, Belgium by 0.57%, Switzerland by 0.45%, Australia by 0.43% and Italy by 0.23%.

Among developing countries, all of them have shown an increase in their publications share in typhoid research from 2000 to 2009: China by 3.75% (from 0.74% to 4.49%), India by 3.38% (3.89% to 7.27%), Brazil by 1.20% (from 1.49% to 2.69%) and Taiwan by 0.92% (from 0.83% to 1.75%) (See Table 1).

India ranks at 3rd position among the top 21 most productive countries in typhoid research with its global publications share of 5.61% during 2000-2009. China and Brazil rank at 13th and 14th positions with global publications share of 1.92% and 1.92% respectively.

India's global publications share has increased from 3.89% to 7.27% and so is its world ranking from 7th to 3rd. China's and Brazil's global publications share have increased from 0.74% to 4.49% and 1.49% to 2.64% respectively and their global ranking are increased from 21st to 7th and 13th to 10th respectively (See Table 1).

2. India's Publications Output in Typhoid

India's cumulative publications output in typhoid consists of 940 papers during 1998-2009, averaging in 94 papers per year. The publications output of China during the same period consists of 322 papers averaging in 32 papers per year. And the publications output of Brazil during the same period consists of 322 papers, averaging in 32 papers per year.

The cumulative publications output of India has increased from 337 papers in 2000-2004 to 603 papers in 2005-2009, witnessing a growth of 78.93% (See Table 2). The cumulative publications output of China has increased from 64 papers in 2000-2004 to 258 papers in 2005-2009, witnessing a growth of 303.12%. And the cumulative publications output of Brazil has increased from 117 papers in 2000-2004 to 205 papers in 2005-09, witnessing a growth of 75.21%. India's annual average publications growth rate during 2000-2009 was 15.07, as compared to 36.23% for China and 15.12% for Brazil (See Table 2).

Table 2. Growth & Impact of Typhoid Publications of India, China and Brazil, 2000-2009

| Year | India | | | China | | | Brazil | | |
|-------------|--------------|-----------|-------------|--------------|-----------|-------------|---------------|-----------|-------------|
| | TP | TC | ACPP | TP | TC | ACPP | TP | TC | ACPP |
| 2000 | 47 | 134 | 2.85 | 9 | 45 | 5 | 18 | 42 | 2.33 |
| 2001 | 53 | 60 | 1.13 | 9 | 27 | 3 | 18 | 49 | 2.72 |
| 2002 | 62 | 151 | 2.44 | 7 | 110 | 15.7 | 23 | 128 | 5.57 |
| 2003 | 90 | 168 | 1.87 | 15 | 53 | 3.5 | 31 | 201 | 6.48 |
| 2004 | 85 | 307 | 3.61 | 24 | 88 | 3.7 | 27 | 109 | 4.04 |

| | | | | | | | | | |
|---|-----|------|------|-----|------|-----|-----|------|------|
| 2005 | 105 | 409 | 3.90 | 24 | 209 | 8.7 | 28 | 131 | 4.68 |
| 2006 | 115 | 452 | 3.93 | 34 | 206 | 6.1 | 39 | 179 | 4.59 |
| 2007 | 109 | 286 | 2.62 | 37 | 213 | 5.8 | 39 | 153 | 3.92 |
| 2008 | 120 | 174 | 1.45 | 68 | 150 | 2.2 | 42 | 74 | 1.76 |
| 2009 | 154 | 80 | 0.52 | 95 | 94 | 1.0 | 57 | 50 | 0.88 |
| 00-04 | 337 | 820 | 2.43 | 64 | 323 | 5.0 | 117 | 529 | 4.52 |
| 05-09 | 603 | 1401 | 2.32 | 258 | 872 | 3.4 | 205 | 587 | 2.86 |
| 00-09 | 940 | 2221 | 2.36 | 322 | 1195 | 3.7 | 322 | 1116 | 3.47 |
| TP = Total Papers; TC = Total Citations; ACPP = Average Citations per Paper | | | | | | | | | |

In terms of impact and quality, the average citation per paper registered by India's publication output on typhoid during 2000-2009 was 2.36 while that for China was 3.70 and that for Brazil was 3.47. The average citation per paper of India's cumulative publications on typhoid has decreased from 2.43 in 2000-2004 to 2.32 in 2005-2009. In comparison, the average citation per paper of cumulative publications on typhoid by China and Brazil has also decreased from 5.00 to 3.44 and 4.52 to 2.86 in the same period respectively (See Table 2).

3. International Collaboration in India's Publication Output

The total cumulative international collaborative papers by India during 2000-2009 were 115 in number, which accounts for 12.23% share in the cumulative output of India on typhoid. Compared to India, China's and Brazil's international collaborative papers share in their cumulative publications output during 2000-2009 was 31.06% (100 collaborative papers) and 21.74% share (70 collaborative papers) respectively.

India witnessed an increase in the share of its international collaborative papers from 8.90% in 2000-2004 to 14.10% in 2005-2009. Compared to India, the international collaborative publications share of China has increased from 25.00% to 32.56% while Brazil has decreased from 23.08% to 20.98% (See Table 3).

Table 3: International Collaborative Publications Share of India, China and Brazil on Typhoid during 2000-2009

| | India | | | China | | | Brazil | | |
|---|-------|-----|-------|-------|-----|-------|--------|-----|-------|
| | TP | ICP | %ICP | TP | ICP | %ICP | TP | ICP | %ICP |
| 2000 | 47 | 6 | 12.77 | 9 | 1 | 11.11 | 18 | 4 | 22.22 |
| 2001 | 53 | 2 | 3.77 | 9 | 1 | 11.11 | 18 | 3 | 16.67 |
| 2002 | 62 | 6 | 9.68 | 7 | 3 | 42.86 | 23 | 4 | 17.39 |
| 2003 | 90 | 4 | 4.44 | 15 | 6 | 40.00 | 31 | 11 | 35.48 |
| 2004 | 85 | 12 | 14.12 | 24 | 5 | 20.83 | 27 | 5 | 18.52 |
| 2005 | 105 | 13 | 12.38 | 24 | 11 | 45.83 | 28 | 7 | 25.00 |
| 2006 | 115 | 16 | 13.91 | 34 | 13 | 38.24 | 39 | 10 | 25.64 |
| 2007 | 109 | 23 | 21.10 | 37 | 17 | 45.95 | 39 | 9 | 23.08 |
| 2008 | 120 | 15 | 12.50 | 68 | 19 | 27.94 | 42 | 6 | 14.29 |
| 2009 | 154 | 18 | 11.69 | 95 | 24 | 25.26 | 57 | 11 | 19.30 |
| 00-04 | 337 | 30 | 8.90 | 64 | 16 | 25.00 | 117 | 27 | 23.08 |
| 05-09 | 603 | 85 | 14.10 | 258 | 84 | 32.56 | 205 | 43 | 20.98 |
| 00-09 | 940 | 115 | 12.23 | 322 | 100 | 31.06 | 322 | 70 | 21.74 |
| TP = Total Papers; ICP = International Collaborative Papers | | | | | | | | | |

Among India's major international collaborative partners, as reflected in its international co-authored papers, 13 countries have published more than 2 collaborative papers with India during 2000-2009 (See Table 4).

Table 4. Major Collaborative Partners of India in Typhoid Research Output during 2000-2009

| No | Collaborating Country | ICP | | | % ICP | | |
|----|-----------------------|-------|-------|-------|-------|-------|-------|
| | | 00-04 | 05-09 | 00-09 | 00-04 | 05-09 | 00-09 |
| 1. | USA | 5 | 38 | 43 | 16.67 | 44.71 | 37.39 |
| 2. | South Korea | 1 | 20 | 21 | 3.33 | 23.53 | 18.26 |
| 3. | UK | 0 | 15 | 15 | 0.00 | 17.65 | 13.04 |

| | | | | | | | |
|---|-------------|----|----|-----|-------|------|-------|
| 4. | Germany | 5 | 7 | 12 | 16.67 | 8.24 | 10.43 |
| 5. | China | 0 | 7 | 7 | 0.00 | 8.24 | 6.09 |
| 6. | Canada | 2 | 3 | 5 | 6.67 | 3.53 | 4.35 |
| 7. | Switzerland | 0 | 3 | 3 | 0.00 | 3.53 | 2.61 |
| 8. | France | 1 | 2 | 3 | 3.33 | 2.35 | 2.61 |
| 9. | Italy | 0 | 3 | 3 | 0.00 | 3.53 | 2.61 |
| 10. | Australia | 0 | 3 | 3 | 0.00 | 3.53 | 2.61 |
| 11. | Japan | 0 | 3 | 3 | 0.00 | 3.53 | 2.61 |
| 12. | Belgium | 0 | 2 | 2 | 0.00 | 2.35 | 1.74 |
| 13. | Brazil | 0 | 2 | 2 | 0.00 | 2.35 | 1.74 |
| | Total | 30 | 85 | 115 | 100 | 100 | 100 |
| ICP =International Collaborative Papers | | | | | | | |

United States was the largest collaborating partner of India in 2000-2009 by contributing 37.39% publications share, followed by South Korea (18.26% share), United Kingdom (13.04%), Germany (10.43%), China (6.09%), Canada (4.35%), Switzerland (2.61%) France (2.61%), Italy (2.61%) and Brazil (2.61%) in India's total international collaborative papers on typhoid.

On analyzing the shift in international collaborative publications share of the major collaborative partner countries of India from 2000-2004 to 2005-2009, it was found that the publications share of Germany has decreased by 8.43%, followed by Canada (3.14%) and France (0.98%), while the share of all other collaborating countries have increased, such as United States (28.04%), followed by South Korea (20.20%), United Kingdom (17.65%), China (8.24%), Switzerland (3.53%), Italy (3.53%), Australia (3.53%) and Japan (3.53%), and Belgium (2.35%) and Brazil (2.35%) (See Table 4).

4 Typhoid Research Output in Different Subjects

The publication data shows that the Indian research output in typhoid during 2000-2009 has been published in 8 subject areas, with highest publications output coming from medicine (493 papers and 52.45% publications share), followed by immunology and

microbiology (246 papers and 26.17% publications share), biochemistry, genetics & molecular biology (226 papers and 24.04% publications share), etc. (See Table 5). Of the eight subject areas, chemistry has scored the highest impact (3.26 citations per paper), followed by pharmacology, toxicology & pharmaceuticals (3.13 citations per paper), Immunology and Microbiology (2.85 citations per paper), biochemistry, genetics & molecular biology (2.58 citations per paper), medicine (2.41 citations per paper), etc. (See Table 5).

Table 5. Subject Break-up of Indian Typhoid Publications in 2000-2009

| Subject | No. of Papers | | | No. of Citations | | | ACPP | | |
|--|---------------|-------|-------|------------------|-------|-------|-------|-------|-------|
| | 00-04 | 05-09 | 00-09 | 00-04 | 05-09 | 00-09 | 00-04 | 05-09 | 00-09 |
| Medicine | 176 | 317 | 493 | 422 | 768 | 1190 | 2.40 | 2.42 | 2.41 |
| Immunology & Microbiology | 66 | 180 | 246 | 257 | 443 | 700 | 3.89 | 2.46 | 2.85 |
| Biochemistry, Genetics & Molecular Biology | 63 | 163 | 226 | 228 | 356 | 584 | 3.62 | 2.18 | 2.58 |
| Agri. & Biol Sciences | 48 | 81 | 129 | 84 | 119 | 203 | 1.75 | 1.47 | 1.57 |
| Pharmacology, Toxicology & Pharmaceuticals | 15 | 47 | 62 | 64 | 130 | 194 | 4.27 | 2.77 | 3.13 |
| Veterinary Science | 36 | 40 | 76 | 24 | 39 | 63 | 0.67 | 0.98 | 0.83 |
| Environment Science | 16 | 43 | 59 | 41 | 92 | 133 | 2.56 | 2.14 | 2.25 |
| Chemistry | 10 | 28 | 38 | 53 | 71 | 124 | 5.30 | 2.54 | 3.26 |

5 Contribution & Impact of Most Productive Indian Institutions on Typhoid

The top 16 most productive Indian institutions involved in typhoid research have published 12 or more papers each during 2000-2009. The publications profile of these 16 Indian institutions along with their research output, citations received and h-index values are presented in Table 6.

Table 6. Productivity & Impact of 16 Major Indian Institutions on Typhoid, 2000-2009

| No. | Name | TP | TC | ACPP | H-Index |
|------------|---|-----------|-----------|-------------|----------------|
| 1 | All India Institute of Medical Sciences, New Delhi | 43 | 241 | 5.60 | 15 |
| 2 | Postgraduate Institute of Medical Education and Research, Chandigarh | 36 | 96 | 2.67 | 7 |
| 3 | Indian Veterinary Research Institute, Izatnagar | 35 | 84 | 2.40 | 4 |
| 4 | National Instituted of Chloera & Enteric Diseases, Kolkata | 34 | 178 | 5.24 | 9 |
| 5 | Banaras Hindu University Institute of Medical Sciences, Varanasi | 23 | 85 | 3.70 | 6 |
| 6 | Panjab University, Chandigarh | 22 | 80 | 3.64 | 6 |
| 7 | Christian Medical College, Vellore | 20 | 62 | 3.10 | 5 |
| 8 | Maulana Azad Medical College, Delhi | 16 | 51 | 3.19 | 5 |
| 9 | ICAR Research Complex for NEH Region | 16 | 9 | 0.56 | 3 |
| 10 | School of Tropical Medicine, Kolkata | 14 | 43 | 3.07 | 4 |
| 11 | University of Madras | 14 | 35 | 2.50 | 5 |
| 12 | Indian Institute of Science, Bangalore | 14 | 57 | 4.07 | 4 |
| 13 | Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi | 14 | 43 | 3.07 | 4 |
| 14 | Assam Agricultural University | 13 | 7 | 0.54 | 3 |
| 15 | Bhabha Atomic Research Centre, | 13 | 37 | 2.85 | 4 |

| | | | | | |
|--|--|-------|------|------|------|
| | Bombay | | | | |
| 16 | Government Medical College & Hospital Chandigarh | 12 | 9 | 0.75 | 2 |
| | Total | 339 | 1117 | 3.29 | 5.37 |
| | Country Output | 940 | | | |
| | Share of 16 Institutions in Country Output | 36.06 | | | |
| TP =Total Papers; TC = Total Citations; ACPP = Average Citations Per Paper | | | | | |

These 16 Indian institutions involved in typhoid research together have contributed 36.06% share (with 339 papers) in the cumulative publications output of India, with an average of 21.2 papers per institution. Only 6 Indian institutions have registered higher publications share than the group average. These are All India Institute of Medical Sciences (AIIMS), New Delhi with 43 papers, followed by Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh (36 papers), Indian Veterinary Research Institute, Izatnagar (35 papers), National Institute of Communicable & Enteric Diseases, Kolkata (34 papers), Banaras Hindu University Institute of Medical Sciences, Varanasi (23 papers), and Panjab University, Chandigarh (22 papers).

The average citation per paper registered by the total papers of these 16 Indian institutions in typhoid search was 3.29. Only 5 Indian institutions have registered comparative higher impact than the group average. The highest impact of 5.60 citations per paper was scored by the All India Institute of Medical Sciences, New Delhi, followed by National Institute of Communicable & Enteric Diseases, Kolkata (5.24 citations per paper), Indian Institute of Science, Bangalore (4.07 citations per paper), Banaras Hindu University Institute of Medical Sciences, Varanasi (3.70 citations per paper) and Panjab University, Chandigarh (3.64).

The average h-index value of these 16 Indian most productive institutions was 5.37 during 2000-2009. Five Indian institutions have scored higher h-index value than group's average of 5.37.

6. Contributions and Impact of Most Productive Authors in Indian Typhoid Research

Based on the publication data, 15 authors have been identified as prolific authors who have published 12 or more papers in typhoid research. Of these 15 authors, 3 each are affiliated to National Institute of Cholera & Enteric Diseases, Kolkata and Calcutta School of Tropical Medicine, 2 each to Vardhman Mahavir Medical College & Safdarjung Hospital, New Delhi, Indian Veterinary Research Institute, Izatnagar and Sant Parmanand Hospital, Delhi, and 1 each to College of Veterinary Science, Guwahati, Panjab University, Chandigarh and Institute of Medical Sciences, BHU, Varanasi (Table 7). These 15 authors together contributed 192 papers with an average of 13 papers per author and account for 20.42% share in the cumulative publications output of India during 2000-2009. Seven authors have published more papers than the group's average. They are: H. Rahman with 17 papers, followed by P. Rishi (16 papers), S.K. Bhattacharya (16 papers), S.C. Arya (14 papers), P. Aggarwal (13 papers), M. Chandra (13 papers) and D. Sur (13 papers). Regarding the quality/impact of papers, these productive authors have received a total of 634 citations for 192 papers with an average of 3.30 citations per paper. Five authors have registered higher impact than the group's average impact of all authors (3.30). Measuring the performance of these authors on the basis of h- index, six authors have achieved the higher h-index value than the group's average of 4.13 (Table7).

Table 7. Productivity & Impact of 20 Most Productive Indian Authors on Typhoid, 2000-2009

| No | Name | Address | TP | TC | ACPP | H-Index |
|-----------|------------------|---|-----------|-----------|-------------|----------------|
| 1 | H.Rahman | College of Veterinary Science, Guwahati | 17 | 15 | 0.88 | 5 |
| 2 | P.Rishi | Panjab University, Chandigarh | 16 | 51 | 3.19 | 5 |
| 3 | S.K.Bhattacharya | National Institute of Cholera & Enteric Diseases, Kolkata | 16 | 98 | 6.13 | 8 |

| | | | | | | |
|----|------------|--|-------|-----|------|----|
| 4 | S.C.Arya | Sant Parmanand Hospital, Delhi | 14 | 18 | 1.29 | 2 |
| 5 | P.Aggarwal | Vardman Mahavir Medical College & Safdarjung Hospital, Delhi | 13 | 43 | 3.31 | 4 |
| 6 | M.Chandra | Indian Veterinary Research Institute, Izatnagar | 13 | 27 | 2.08 | 3 |
| 7 | D.Sur | National Institute of Cholera & Enteric Diseases, Kolkata | 13 | 85 | 6.54 | 5 |
| 8 | B.R.Singh | Indian Veterinary Research Institute, Izatnagar | 12 | 23 | 1.92 | 3 |
| 9 | M.D.Mandal | Calcutta School of Tropical Medicine, Kolkata | 12 | 37 | 3.08 | 4 |
| 10 | N.K.Paul | Calcutta School of Tropical Medicine, Kolkata | 12 | 35 | 2.92 | 4 |
| 11 | S.Mandal | Calcutta School of Tropical Medicine, Kolkata | 11 | 35 | 3.18 | 4 |
| 12 | N.Agarwal | Sant Parmanand Hospital, Delhi | 11 | 11 | 1.00 | 1 |
| 13 | S.Dutta | National Institute of Cholera & Enteric Diseases, Kolkata | 11 | 95 | 8.64 | 6 |
| 14 | G.Nath | Institute of Medical Sciences, BHU, Varanasi | 11 | 46 | 4.18 | 5 |
| 15 | D.Nair | Vardman Mahavir Medical College & Safdarjung Hospital, Delhi | 10 | 15 | 1.50 | 3 |
| | | Total | 192 | 634 | 3.30 | 62 |
| | | Country Output | 940 | | | |
| | | Share of 15 authors in Country Output | 20.42 | | | |

| |
|---|
| TP = Total Papers; TC = Total Citations; ACPP = Average Citations Per Paper |
|---|

7. Research Communication in High Productive Journals

The top 30 most productive Indian and foreign journals publishing Indian research papers in typhoid research contributed 428 papers, which accounts for 45.53% share in the cumulative publications output of India in 2000-2009. The cumulative publications share of these 30 most productive journals showed a decrease in India's publications output from 45.70% in 2000-2004 to 45.44% in 2005-2009 (See Table 8).

Table 8: List of Most Productive Journals Publishing Indian Papers on Typhoid, 2000-2009

| No | Name of the Journal | Number of Papers | | |
|----|--|------------------|-------|-------|
| | | 00-04 | 05-09 | 00-09 |
| 1 | Indian Journal of Medical Research | 20 | 22 | 42 |
| 2 | Indian Journal of Medical Microbiology | 9 | 25 | 34 |
| 3 | Asian Journal of Microbiology, Biotechnology & Environmental Science | 4 | 29 | 33 |
| 4 | Indian Journal of Animal Science | 19 | 11 | 30 |
| 5 | Indian Pediatrics | 10 | 17 | 27 |
| 6 | Indian Journal of Pediatrics | 11 | 13 | 24 |
| 7 | Indian Journal of Experimental Biology | 7 | 11 | 18 |
| 8 | Indian Journal of Pathology & Microbiology | 2 | 15 | 17 |
| 9 | Journal of Medical Microbiology | 4 | 12 | 16 |
| 10 | Indian Veterinary Journal | 1 | 14 | 15 |
| 11 | Journal of Association of Physicians of India | 8 | 5 | 13 |
| 12 | Tropical Doctor | 3 | 10 | 13 |
| 13 | Medical Journal Armed Forces India | 4 | 9 | 13 |

| | | | | |
|----|--|-------|-------|-------|
| 14 | Japanese Journal of Infectious Diseases | 5 | 6 | 11 |
| 15 | Indian Journal of Medical Science | 5 | 6 | 11 |
| 16 | Transactions of the Royal Society of Tropical Medicine & Hygiene | 0 | 10 | 10 |
| 17 | World Journal of Microbiology & Biotechnology | 4 | 6 | 10 |
| 18 | Vaccine | 2 | 7 | 9 |
| 19 | Journal of Communicable Diseases | 6 | 3 | 9 |
| 20 | African Journal of Biotechnology | 0 | 8 | 8 |
| 21 | National Medical Journal of India | 5 | 3 | 8 |
| 22 | Journal of Clinical Microbiology | 2 | 5 | 7 |
| 23 | Journal of Tropical Pediatrics | 4 | 3 | 7 |
| 24 | Journal of Food Science & Technology | 3 | 4 | 7 |
| 25 | Journal of Indian Medical Association | 3 | 3 | 6 |
| 26 | Molecular & Cellular Biotechnology | 4 | 2 | 6 |
| 27 | Journal of Postgraduate Medicine | 2 | 4 | 6 |
| 28 | Indian Journal of Biotechnology | 1 | 5 | 6 |
| 29 | Phytotherapy Research | 1 | 5 | 6 |
| 30 | Annals of Tropical Pediatrics | 5 | 1 | 6 |
| | Total | 154 | 274 | 428 |
| | Country Total | 337 | 603 | 940 |
| | Share of Top 30 Journals in Country Output | 45.70 | 45.44 | 45.53 |

8. Characteristics of Highly-Cited Papers

The 100 most highly-cited papers have received citations (from their publication dates to June 2010) 11 to 94 times in 2000-2009 each. These 100 high-cited papers have received 2,187 citations altogether, with an average of 22 citations per paper. Of these 100 papers, 80 appeared as articles, 12 as reviews, 5 as letters, 2 as conference papers, and 1 as short

survey. Of these 100 papers, 22 are of international collaboration (14 bilateral and 8 multilateral), 69 of national collaboration, and 9 of zero collaboration.

Of the 100 most cited papers, 5 papers are in citation range of 51-100, 4 in citation range of 41-50, 5 in citation range of 31-40, 18 in citation range of 21-30, and 68 in citation range of 11-20. The authors of these highly-cited papers are affiliated to 66 Indian institutions, including 16 papers from All India Institute of Medical Sciences, New Delhi, 6 papers from National Institute of Cholera and Enteric Diseases, Kolkata, 5 papers from Christian Medical College & Hospital, Vellore.

The 100 highly-cited papers in typhoid research appeared in 73 journals, including 10 papers in *Indian Journal of Medical Research*, 4 papers in *International Journal of Food Microbiology*, 3 papers each in *Transactions of the Royal Society of Tropical Medicine & Hygiene*, *Journal of Medical Microbiology* and *Emerging Infectious Diseases*, 2 papers each in *Tropical Gastroenterology*, *Journal of Tropical Pediatrics*, *Journal of Ethnopharmacology*, *Journal of Clinical Microbiology*, *Indian Journal of Medical Science*, *Indian Journal of Experimental Biology*, *Diagnostics Microbiology & Infectious Diseases*, *Bulletin of WHO* and *Antimicrobial Agents & Chemotherapy*, and 1 paper each in 59 other journals.

VI. Further Findings

Indian scientists together have published 940 papers in typhoid research in 2000-2009, compared to 322 papers each by China and Brazil during the same period. India ranks at 3rd position among the top 21 countries in typhoid research, with its global publication share of 5.61% in 2000-2009. Compared to India, China and Brazil ranks at 13th and 14th positions, with global publication share of 1.92% each in 2000-2009.

India has witnessed an increase in its global publications share, rising from 3.89% in 2000 to 7.27% in 2009. India's annual average publication growth rate in 2000-2009 was 15.07%, compared to 36.23% for China and 15.12% for Brazil.

The average number of citations per paper registered by India's publications in typhoid research in 2000-2009 was 2.36, which is lower than China (3.7) and Brazil (3.47).

The share of international collaborative publications (115 papers) in India's typhoid output accounts for 12.23% in 2000-2009, compared to China (31.06% share) and Brazil (21.74%).

The international collaborative publication share of India in its total publications output has increased from 8.90% in 2000-2004 to 14.10% in 2005-2009. Among the India's major collaborative partners in 2000-2009, United States has contributed the largest publications share.

VII. Conclusion

Compared to the share of disease burden, India's publications output is very small and the quality of research is also low as compared to China and Brazil. India has to substantially increase its investments in R&D and train much more scientists to work in this area. International collaboration can also be substantially increased to boost the output and enhance the quality of research.

As typhoid is a major public health problem in India, the Indian public health authorities should devise ways to improve the immunization programs at nursery and school level as well as to monitor their public health impact. To prevent this disease, essential hygiene measures must be implemented. Health education is paramount to raise public awareness about the preventive measures. Programs to educate people about proper sanitation, food safety and safe water should be organized to reduce the outbreak of this disease. These health education programs for the vulnerable communities need to be adapted to local conditions and translated into local language. All possible means of communication like media, schools, women's group, and religious group should be utilized. Moreover government should also invest in biotechnology and improve the various tools and techniques already available so as to assist researchers in their efforts to eliminate typhoid in India.

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Authors:

B. M. Gupta, National Institute of Science, Technology & Development Studies, New Delhi 110 012, India. Email: bmgupta1@gmail.com

Adarsh Bala, Government Medical College and Hospital, Sector 32, Chandigarh, PIN-160030, India. Email: adarshbindu@rediffmail.com

Kiran Baidwan, Postgraduate Institute of Medical Education & Research, Sector-12, Chandigarh PIN-160012, India

Neelima Chadha, Postgraduate Institute of Medical Education & Research, Sector-12, Chandigarh PIN-160012, India

Harjit Singh Cheema, Postgraduate Institute of Medical Education & Research, Sector-12, Chandigarh PIN-160012, India

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Harjit Singh Cheema

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