Measles: A quantitative analysis of world publications during 2001–2010

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ABSTRACT

The study investigates research efforts in measles—ranked among the top ten global burden of diseases, both as a cause of death and as a cause of disability adjusted life years (DALYs). Quantitative analysis of publications output in measles during the period 2001–2010 was undertaken on several parameters including publication growth, citation quality, format, country-wise contribution, subject-wise contribution, collaborative linkages, leading institutions, prolific authors, etc. The study shows the number of publications per capita and per GDP is quite low in developing countries irrespective of the significant number of measles cases found in these countries. The study highlights effective surveillance, holding mass immunization campaigns, improvement in health infrastructure and strengthening of research efforts in measles research are the key strategies to control this disease in the developed and developing countries.

Keywords: Measles, India, Measles Bibliometric Analysis, Research Performance.

INTRODUCTION

Measles (also known as rubeola or morbilli) is one of the world's oldest and most deadly preventable diseases in human beings. It is a highly contagious viral infection and a known infectious disease of the respiratory system caused by a virus of the paramyxovirus family (known as *Morbillivirus*). The isolation of the measles virus in 1954 and the introduction of the vaccine in 1963 represent milestones of scientific efforts concerning measles research.

Measles still plays a significant role in terms of morbidity- and mortality-rates especially in developing countries, particularly in parts of Africa and Asia. However, in the Northern Hemisphere, the incidence tends to rise in winter and in tropical regions epidemics are less marked. In industrialized countries, however, smaller epidemics are occasionally registered. In the pre-vaccination era, the maximum incidence was seen in children aged 5 to 9 years. With the introduction of the vaccine, measles infection has shifted to the teens in countries with an efficient programme. In contrast, in third world countries, measles infection has its greatest incidence in children less than 2 years of age. Severe measles is more likely among poorly nourished young children, especially those with insufficient vitamin A or whose immune systems have been weakened by HIV/AIDS or other diseases.

Worldwide, the number of reported measles cases declined by 67% from 852,937 in 2000 to 278,358 in 2008. Despite the availability of a safe and effective measles vaccine since 1963, an estimated 750, 000 measles deaths occurred worldwide as recently as 2000. In 2005, the WHO made a commitment to reduce measles morbidity by 90% by the end of the first decade of the millennium. The WHO member states reaffirmed the commitment at the 2008 assembly. The WHO-UNICEF strategy was to reduce the measles mortality target in 47 countries for more than 97% immunization coverage with the routinely scheduled first dose of vaccine to be followed by a second routine dose of vaccine (supplementary dose) to the 1-year-old children along with effective laboratory surveillance and provision of appropriate clinical management

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for measles cases. From 2000 to 2008, nearly 700 million children aged 9 months to 14 years living in high-risk countries were vaccinated against the disease. As a result, global measles deaths declined by 78%, from an estimated 733,000 deaths in 2000 to 164,000 in 2008, but the reduction in measles mortality has been leveling off since 2007. The overwhelming majority (more than 95%) of measles deaths occur in countries with low per capita incomes and weak health infrastructures (WHO, 2012).

The Measles Initiative is a collaborative effort of WHO, UNICEF, the American Red Cross, the United States Center for Disease Control and Prevention and the United Nations Foundation which plays a key role in advancing the global measles strategy. The fourth Millennium Development Goal (MDG 4) aims to reduce the under-five mortality rate by two-thirds between 1990 and 2015. Recognizing the potential of measles vaccination to reduce child mortality and given that measles vaccination coverage can be considered a marker of access to child-health services, routine measles vaccination coverage has been selected as an indicator of progress towards achieving MDG 4.

So far only one specific scientometric study of measles research output covering the period, 1900–2008 and using ISI-Web of Science database has been conducted as part of a doctoral thesis (not published and only abstract available), where 14,254 publications could be identified in terms of the years, countries, journals and institutions of publication (Rospino, 2009).

Among other papers, Kouadio, Kamigaki and Oshitani have reviewed the published articles on measles outbreaks that occurred between 1979 and 2005 in Asia and Africa using PubMed database and found that measles patterns have varied over time among populations displaced by natural and man-made disasters (Kouadio, 2010).

Guillaume and Bath have examined the content of mass media articles about the measles, mumps and rubella (MMR) vaccine and found that the content and format of articles between different information sources varied widely (Guillaume, 2008).

OBJECTIVES

The paper analyses the publication growth and citation quality of worldwide research in measles during the period 2001–2010. It analyses the format and type of literature, language and country-wise contribution and collaborative linkages among them, major productive journals, leading institutions and authors contributing to measles research and also analyses the characteristics of its highly-cited papers. In addition, it analyses the subject-wise contribution of measles research, besides identifying important keywords and the different types of complications of measles research. The association of measles with all other diseases was also identified using co-word analysis. It also identifies the focus of measles research on different types of population groups such as children, adults, etc.

METHODOLOGY AND SOURCES

For analyzing the worldwide measles literature, the Scopus database was used to retrieve publication data published during the period 2001–2010. The main search strategy was developed by using and searching the following key terms in 'Title-Abstract-keywords' field of the database: 'measle or rubeola or morbilli' by making the following string:

(TITLE-ABS-KEY(measle*) OR TITLE-ABS-KEY (rubeola OR morbilli)) AND PUBYEAR > 2000 AND PUBYEAR < 2011.

To retrieve the published data of different countries, the above main string was combined with a particular country string as follows:

(((TITLE-ABS-KEY(measle*) OR TITLE-ABS-KEY (rubeola or morbilli)) AND PUBYEAR > 2000 AND PUBYEAR < 2011) and ((AFFIL(United States) OR AFFIL(USA)) AND PUBYEAR > 2000 AND PUBYEAR < 2011)).

For citation analysis, a 3 year, 2 year and 1 year citation window was been used for computing average citations per paper in measles research during the period 2001–2008, 2009 and 2010. For example, for 2001 papers, citations were calculated for 2002–2004. Citations for publications were covered up to 2011. The retrieved data was then analyzed on the basis of various quantitative techniques.

ANALYSIS

Measles Research Output in the Global Context

The world's cumulative publications output in measles research consists of 9829 papers during the period 2001–2010, with the average number of papers per year as 983 and witnessing an annual average growth rate of 17%. The cumulative world's publications output in

measles research increased from 4701 to 5128 papers from 2001–2005 to 2006–2010, witnessing a growth of 9.08% (Table 1). In terms of citation impact (on a three-years citation window), the world publications on measles received 53,672 citations, registering an impact of 5.46 citations per paper. Of the total papers published, 5518 papers (56.14% share) were published as articles, 2172 papers (22.10%) as reviews, 531 papers (5.40%) as notes, 461 papers (4.69%) as letters, etc. Of the total papers, 8477 papers (86.24% share) were published in English, followed by 334 papers (3.40%) in French, 276 papers (2.81%) in German, 200 papers (2.03%) in Spanish and the rest in 24 other languages.

Table 1. Growth and quality of research output in measles during the period 2001–2010

Year	Number of Papers	Number of Citations	Average Citations per Paper
2001	834	4844	5.81
2002	905	5162	5.70
2003	952	5761	6.05
2004	1037	6990	6.74
2005	973	6482	6.66
2006	986	6845	6.94
2007	1015	7207	7.10
2008	1031	5716	5.54
2009	1061	3357	3.16
2010	1035	1308	1.26
2001–05	4701	29,239	6.22
2006–10	5128	24,433	4.76
2001–2010	9829	53,672	5.46

RESEARCH PROFILE OF PRODUCTIVE COUNTRIES IN MEASLES RESEARCH

Overall, global publication shares of the top 20 countries varied from 0.64% to 27.46% during the period 2001–2010 in measles research. United States tops the list with a global publication share of 27.46% during 2001–2010. United Kingdom ranks second with 11.25% global publication share, followed by Germany, France, India, Japan, Australia, Switzerland, Spain, Canada, China, Italy and Netherlands (their global publication shares ranging from 2.12% to 5.33%). Brazil, Belgium and Sweden rank at 14th to 16th positions (their global publication shares ranging from 1.21% to 1.60%). The countries that rank between 17th and 20th positions are Israel, South Africa, Nigeria and Poland with their global publication shares ranging from 0.64% to 0.96%) (Table 2).

Among developed countries, the countries that have shown a decline in the publication share from 2001–2005 to 2006–2010 are United Kingdom (1.14%), followed by United States (0.90%). In contrast, the developed countries that have shown a rise in their publication share during the same period are Netherlands (2.18%), followed by Canada (1.22%), Switzerland (0.92%), France (0.87%), Spain (0.85%), Japan (0.76%), Germany (0.68%), Sweden (0.40%), Belgium (0.34%), Australia (0.29%), Spain (0.20%), Italy (0.12%) and Poland (0.08%) from 2001–2005 to 2006–2010 (Table 2). In contrast, most developing

Table 2. Global publications output, publication share and rank of top 20 most productive countries in measles research, 2001–2010

Country	2001–05 [Rank] (Number of Papers), (% of Papers)	2006–2010 [Rank] (Number of Papers), (% of Papers)	2001–10 [Rank] (Number of Papers), (% of Papers)	2001–10	
				TC	ACCP
United States	[1] (1310), (27.97)	[1] (1389), (27.09)	[1] (2699), (27.46)	25008	9.27
United Kingdom	[2] (557), (11.85)	[2] (549), (10.71)	[2] (1106), (11.25)	8547	7.73
Germany	[3] (234), (4.98)	[3] (290), (5.66)	[3] (524), (5.33)	3549	6.79
France	[4] (201), (4.28)	[4] (264), (5.15)	[4] (465), (4.73)	3190	6.86
India	[5] (200), (4.25)	[6] (214), (4.17)	[5] (414), (4.21)	1144	2.98
Japan	[6] (165), (3.51)	[5] (219), (4.27)	[6] (384), (3.91)	2220	5.36
Australia	[7] (155), (3.30)	[8] (184), (3.59)	[7] (339), (3.45)	2566	7.59
Switzerland	[9] (139), (2.96)	[7] (199), (3.88)	[8] (338), (3.44)	4299	12.68
Spain	[8] (140), (2.98)	[10] (163), (3.18)	[9] (303), (3.08)	1044	3.97
Canada	[12] (96), (2.04)	[9] (167), (3.26)	[10] (263), (2.68)	2341	7.73
China	[10] (102), (2.17)	[12] (152), (2.96)	[11] (254), (2.58)	462	2.23
Italy	[11] (98), (2.08)	[13] (113), (2.20)	[12] (211), (2.15)	1432	5.64
Netherlands	[16] (46), (0.98)	[11] (162), (3.16)	[13] (208), (2.12)	1801	8.54
Brazil	[13] (72), (1.53)	[14] (85), (1.66)	[14] (157), (1.60)	718	4.57
Belgium	[14] (61), (1.3)	[15] (84), (1.64)	[15] (145), (1.48)	1138	7.85
Sweden	[15] (47), (1.00)	[16] (72), (1.40)	[16] (119), (1.21)	1083	9.10
Israel	[17] (39), (0.83)	[18] (55), (1.07)	[17] (94), (0.96)	864	9.19
South Africa	[18] (29), (0.62)	[17] (65), (1.27)	[18] (94), (0.96)	571	6.07
Nigeria	[20] (20), (0.43)	[19] (48), (0.94)	[19] (68), (0.69)	176	2.59
Poland	[19] (28), (0.60)	[20] (35), (0.68)	[20] (63), (0.64)	190	3.02

TP=Total Papers; TC=Total Citations; ACPP=Average Citation per Paper

countries have shown a rise in their publication share from 2001–2005 to 2006–2010: China by 0.79%, followed by South Africa (0.65%), Nigeria (0.51%), Israel (0.24%) and Brazil (0.13%). In contrast, Indian publications decreased by 0.08% during the same period (Table 2).

In terms of citation quality (as measured by the number of citations received on a three-year citation window), Switzerland tops the list with an average citation per paper of 12.68, followed by USA (9.27), Israel (9.19), Sweden (9.10), Netherlands (8.54), Belgium (7.85), UK and Canada (7.73 each), Australia (7.59), etc. (Table 2).

The cumulative publications output of the top 20 most productive countries in measles research output during 2001–2010 was also compared with their population (in millions, 2010–2011) and Gross Domestic Product (PPP, US $, 2010). On a per capita basis, Switzerland produced the highest number of publications (42.95) per million inhabitants during 2001–2010, followed by United Kingdom with 17.84 publications, Australia with 14.97 publications, etc. Among the developing countries, Israel is on the top with 12.14 publications per million inhabitants, followed by South Africa (1.88 publications), Nigeria (0.43 publications), India (0.34 publications) and China (0.19 publications) (Table 3).

On taking the ratio of publications and GDP, Switzerland again tops the list with first rank and 0.10 publications, followed by United Kingdom (0.05 publications), Australia, Belgium and Israel (0.04 publications each), Netherlands and Sweden (0.02 publications each), etc. Among developing countries, Israel tops the list with 0.04 publications, followed by South Africa and Nigeria (0.02 publications each) and India (0.01 publications) (Table 3).

INTERNATIONAL COLLABORATION

The international collaborative publications (ICP) share of various countries in measles research during 2001–2010 varies from 15.70% to 60.65%. Among the top developed countries, the ICP share varies from 25.86% to 60.65%, where the highest ICP share (60.65%) is registered by Switzerland, followed by Belgium (59.31%), Sweden (57.14%), Canada (48.29%), Italy (44.08%), etc. Among the top developing countries, the ICP share varies from 15.70% to 55.32%, where the highest (55.32%) share is scored by South Africa, followed by Israel (42.55%), Brazil (33.12%), China (17.72%) and India (15.70%) (Table 4).

In terms of collaboration among leading countries during 2001–2010, the largest number (148) of collaborative linkages is between United States and United Kingdom, followed by 112 collaborative linkages between United States and Switzerland, 70 collaborative linkages between United States and Canada, 65 collaborative linkages between United States and Germany, 58 collaborative linkages between Germany and United Kingdom, etc. (Table 5).

Table 3. Publications, population and gross domestic data of top 18 most productive countries

Country	Number of Papers 2001–10	Population 2010 (Millions)	Number of Measle Cases (2008)	GDP (PPP) 2010 $Million	Publications per Capita	Publications per GDP
United States	2699	311.64	140	14,657,800	8.66	0.02
United Kingdom	1106	62.01	1 445	2,172,768	17.84	0.05
Germany	524	81.80	917	2,940,434	6.41	0.02
France	465	65.82	604	2,145,487	7.06	0.02
India	414	1,210.19	48 181	4,060,392	0.34	0.01
Japan	384	127.95	11 015	4,309,432	3.00	0.01
Australia	339	22.65	65	882,362	14.97	0.04
Switzerland	338	7.87	2 022	325,305	42.95	0.10
Spain	303	46.15	297	1,368,642	6.57	0.02
Canada	263	34.50	61	1,330,272	7.62	0.02
China	254	1,339.72	131 441	10,085,708	0.19	0.01*
Italy	211	60.63	1 617	1,773,547	3.48	0.01
Netherlands	208	16.68	109	676,700	12.47	0.03
Belgium	145	10.84	98	392,862	13.38	0.04
Sweden	119	9.43	25	352,327	12.62	0.03
Israel	94	7.74	931	218,490	12.14	0.04
South Africa	94	49.99	39	524,341	1.88	0.02
Nigeria	68	158.42	9960	374,323	0.43	0.02

*List of countries by population. http://en.wikipedia.org/wiki/ List_of_countries _by_population; Countries by GDP (PPP). http://en.wikipedia.org/wiki/ List_of_countries _by_ GDP_(PPP); Brazil and Poland is excluded because data on number of measles cases during 2008 is not available; *rounded value*

Table 4. Number and share of international collaborative papers in measles researchof top countries, 2001–2010

Country	TP	ICP	% Share of ICP
United States	2699	698	25.86
United Kingdom	1106	293	26.49
Germany	524	191	36.45
France	465	189	40.65
India	414	65	15.70
Japan	384	83	21.61
Australia	339	125	36.87
Switzerland	338	205	60.65
Spain	303	61	20.13
Canada	263	127	48.29
China	254	45	17.72
Italy	211	93	44.08
Netherlands	208	103	49.52
Brazil	157	52	33.12
Belgium	145	86	59.31
Sweden	119	68	57.14
Israel	94	40	42.55
South Africa	94	52	55.32
Nigeria	68	19	27.94
Poland	63	18	28.57
Total	9829	2613	26.58

MEASLES RESEARCH OUTPUT IN THE CONTEXT OF DIFFERENT SUBJECTS

On analyzing the publication data, it was found that the world's research output in measles during 2001–2010 has been published in context of 10 broad subjects (as reflected in database classifications based on journal subjects) with the highest publications output coming from medicine (7148 papers and 72.72% share), followed by immunology & microbiology (2460 papers, 25.03% share), biochemistry, genetics and molecular biology (1043 papers, 10.61% share), pharmacology, toxicology and pharmaceutics (795 papers, 8.09% share), veterinary science (662 papers, 6.74% share), agricultural and biological sciences (282 papers, 2.87% share), etc (Table 7). In terms of activity index, the research activities have increased in medicine (from 93.89 to 105.60), immunology & microbiology (from 98.85 to 101.06), biochemistry, genetics and molecular biology (from 76.38 to 121.66), pharmacology, toxicology and pharmaceutics (from 89.68 to 109.46), veterinary science (91.28 to 108.00) and agricultural and biological sciences (71.92 to 125.74) as against a decrease in neurosciences (from 110.64 to 90.25), nursing (from 110.76 to 90.13%) and public health (from 110.90 to 90.00) from 2001–2005 to 2006–2010 (Table 6).

In terms of citation impact (as measured by citations received on a three-years citation window), immunology and microbiology made the highest citation impact of 7.79 citations per paper, followed by biochemistry, genetics and molecular biology (7.54), neurosciences (6.80), veterinary science (5.89), environmental science (5.64), medicine (5.10), agricultural and biological sciences (4.36), public health (4.35) and pharmacology, toxicology and pharmaceutics (3.40) (Table 6).

DISTRIBUTION OF PAPERS BY DIFFERENT TYPES OF POPULATION GROUPS

Of the total papers, 8288 were on humans and 1945 on non-humans during 2001–2010. Similarly 2862 papers were focused on females, compared to 2540 papers on males during 2001–2010. In terms of emphasis on different population groups as reflected through keywords, the largest emphasis (4143 papers, 42.15% share) was on children, followed by adults (1799 papers, 18.30% share), adolescents (1694 papers, 12.23% share), middle aged (531 papers, 5.40% share) and aged (345 papers, 3.51% share). In terms of activity index, the emphasis increased in children (from 99.46 to 100.46), adults (from 94.09 to 105.08)

Table 5. Collaborative linkages among 14 top countries in measles research, 2001–2010

Country	USA	UK	GER	FR	IN	JP	AUST	SWIT	SPAIN	CAN	CHIN	ITAL	NETH	BRAZ
USA	–	148	65	57	30	39	31	112	25	70	20	31	26	25
UK	148	–	58	50	15	13	51	55	21	26	7	30	40	20
GER	65	58	–	32	6	8	14	38	18	10	4	23	33	3
FR	57	50	32	–	8	6	9	31	11	13	2	22	18	3
IN	30	15	6	8	–	2	3	8	0	6	1	4	0	3
JP	39	13	8	6	2	–	2	4	2	5	6	5	6	1
AUST	31	51	14	9	3	2	–	12	8	6	5	10	8	3
SWIT	112	55	38	31	8	4	12	-	16	13	7	12	17	7
SPAIN	25	21	18	11	0	2	8	16	–	3	2	9	8	5
CAN	70	26	10	13	6	5	6	13	3	–	0	3	9	6
CHIN	20	7	4	2	1	6	5	7	2	0	–	1	1	0
ITAL	31	30	23	22	4	5	10	12	9	3	1	–	9	4
NETH	26	40	33	18	0	6	8	17	8	9	1	9	–	1
BRAZ	25	20	3	3	3	1	3	7	5	6	0	4	1	–

Table 6. Subject-wise break-up of publications on measles, 2001–2010

	Number of Papers(TP)			Activity Index		2001–2010	
	2001–05	2006–10	2001–10	2001–05	2006–10	TC	ACPP
Medicine	3210	3938	7148	93.89	105.60	36445	5.10
Immunology & Microbiology	1163	1297	2460	98.85	101.06	19035	7.74
Biochemistry, Genetics & Molecular Biology	381	662	1043	76.38	121.66	7866	7.54
Pharmacology, Toxicology & Pharmaceutics	341	454	795	89.68	109.46	2703	3.40
Veterinary Science	289	373	662	91.28	108.00	3901	5.89
Agricultural & Biological Sci.	97	185	282	71.92	125.74	1230	4.36
Neurosciences	127	113	240	110.64	90.25	1631	6.80
Nursing	89	79	168	110.76	90.13	444	2.64
Environmental Science	54	68	122	92.55	106.83	688	5.64
Public Health	61	54	115	110.90	90.00	500	4.35
Total	4701	5128	9829	100.00	100.00		

TP=Total Papers; TC=Total Citations; ACPP=Average Citations per Paper

and aged (from 99.46 to 100.46), while it decreased in case of adolescents (from 101.71 to 98.53) and middle-aged (from 102.81 to 97.58) during 2001–2005 to 2006–2010. (Table 7).

SUBJECT-WISE DISTRIBUTION USING KEYWORDS

In terms of important keywords, the largest emphasis was on measles vaccine (with 2520 papers), followed by measles virus (2505 papers), immunization (2111 papers), clinical study (1278 papers), risk factors (980 papers), drug safety (980 papers), incidence (883 papers), clinical trials (868 papers), disease outbreaks (791 papers), health surveys (708 papers), mortality (675 papers), immunology (596 papers), preventive health service (562 papers), prevalence (506 papers), disease transmission (425 papers), immuno-gencity (410 papers), healthcare policy (390 papers), morbidity (386 papers), virology (382 papers), population surveillance (362 papers), epidemiology (355 papers), genetics (323 papers), serology (290 papers), etc.

DISTRIBUTION OF PAPERS BY MEASLES COMPLICATIONS

Among measles complications, the largest number of papers were on respiratory infection (777 papers), followed by encephalitis (735 papers), pneumonia (615 papers), diarrhoea (560 papers), ear infections (511 papers), pregnancy (506 papers), subactute sclerosing (330 papers), actute encephalitis (138 papers), otitis media (126 papers), etc. during 2001–2010. In terms of activity index, the emphasis increased in the case of respiratory infections, pneumonia, diarrhea, blindness, bronchitis, thrombocytopenia purpura, mycarditis, corneal scarring and corneal ulceration, as against a decrease in the case of encephalitis, ear infection, pregnancy and sub actuate sclerosing from 2001–2005 to 2006–2010 (Table 8).

RELATEDNESS OF VARIOUS DISEASES TO MEASLES AS REFLECTED THROUGH CO-OCCURENCES

A number of other diseases play an important role in the spread of measles. In this section, the co-occurrences of keywords associated with measles with a number of other diseases were studied during 2001–2010. It was found that measles keywords have comparatively a higher frequency of co-occurrences with rubella (4353), followed by mumps (4129 papers), tetanus (2122 papers), diphtheria (2039 papers), pertusis (2031 papers), poliomyelitis (1878 papers), hepatitis B (1859 papers), hepatitis A (1717 papers), influenza (1593 papers), chickenpox (1267 papers), pneumococcus (825 papers), tuberculosis

Table 7. Measles publications among different population groups (2001–2010)

Population Group	Number of Papers			Activity Index	
	2001–2005	2006–2010	2001–2010	2001–2005	2006–2010
Children's	2150	1993	4143	99.46	100.46
Adolescents (13–19 years)	779	915	1694	101.71	98.53
Adults (20–40 years)	846	953	1799	94.09	105.08
Middle Aged (40–60 years)	231	300	531	102.81	97.58
Aged (60 & more years)	164	181	345	99.46	100.46
Total	2020	2349	4369	100.0	100.0

Table 8. Measles publications according to measles–complications/diseases, 2001–2010

Complications/Diseases	Number of Papers			Activity Index	
	2001–2005	2006–2010	2001–2010	2001–2005	2006–2010
Respiratory Infection	354	423	777	98.13	101.62
Encephalitis	353	382	735	103.45	97.01
Pneumonia	281	334	615	98.41	101.37
Diarrhoea	250	310	560	96.16	103.33
Ear Infection	239	272	511	100.74	99.36
Pregnancy	248	258	506	105.57	95.18
Sub actuate sclerosing	157	173	330	102.47	97.86
Acute Encephalitis	62	76	138	96.77	102.80
Otitis Media	64	62	126	109.41	91.85
Sub actuate Encephalitis	48	42	90	114.88	87.11
Blindness	37	47	84	94.87	104.44
Bronchitis	22	43	65	72.90	123.48
Thrombocytopenia purpura	20	30	50	86.16	112.00
Myocarditis	17	29	46	79.60	117.68
Corneal scarring	5	6	11	97.91	101.82
Corneal ulceration	0	2	2	0.00	186.66
Total	2157	2489	4646	100.00	100.00

(701 papers), malaria (550 papers), AIDS/HIV (492 papers), smallpox (469 papers), yellow fever (435 papers), rabies (411 papers), typhoid (373 papers), rotavirus (352 papers), multiple sclerosis (212 papers) and distemper (153 papers). In terms of activity index, the emphasis has increased in the case of pertusis, tetanus, chickenpox, hepatitis A, hepatitis B, pneumococcus, tuberculosis, AIDS/HIV, malaria, multiple sclerosis, yellow fever and smallpox as against a decrease in poliomyelitis, diphtheria, influenza, distemper, mumps, rubella, rotavirus, typhoid and rabies from 2001–2005 to 2006–2010 (Table 9).

RESEARCH PROFILE OF MOST PRODUCTIVE INSTITUTIONS IN MEASLES RESEARCH

The top 15 most productive institutions involved in measles research have published 58 and more papers each

Table 9. Measles association and related diseases, 2001–2010

Related Diseases	Number of Papers			Activity Index	
	2001–2005	2006–2010	2001–2010	2001–2005	2006–2010
Poliomyelitis	934	944	1878	100.49	99.55
Diphtheria	980	1059	2039	100.99	99.09
Pertusis	981	1050	2031	89.78	109.37
Influenza	684	909	1593	101.49	98.64
Tetanus	1030	1092	2122	93.57	105.90
Chickenpox	567	700	1267	95.47	104.26
Hepatitis A	784	934	1717	98.30	101.56
Hepatitis B	874	985	1859	90.98	108.27
Pneumococcus	359	466	825	96.64	103.08
Tubercerculosis	324	377	701	96.04	103.63
AIDS/HIV	226	266	492	98.08	101.76
Malaria	258	292	550	97.03	102.73
Distemper	71	82	153	104.52	95.86
Mumps	2064	2065	4129	103.60	96.70
Rubella	2157	2196	4353	104.54	95.84
Multiple Sclerosis	106	106	212	90.84	108.39
Yellow Fever	189	246	435	97.63	102.17
Smallpox	219	250	469	76.62	126.87
Rotavirus	129	233	352	102.02	98.15
Typhoid	182	191	373	104.80	95.60
Rabies	206	205	411	100.00	100.00
Total	4701	5128	9829	103.98	96.35

during 2001–2010. The publications profile of these 15 institutions along with their research output and citations received are presented in Table 12. These 15 institutions involved in measles research together have contributed 17.34% share (with 1704 papers) in the cumulative publications output in measles, with an average of 113.6 papers per institution. Only 5 institutions have registered higher publications share than the group average. These are: Centre for Disease Control and Prevention, USA with 443 papers followed by Mayo Clinic or Mayo Medical School, USA (241 papers), Organisation Mondialede la Sante, Switzerland (188 papers), John Hopkins Bloomberg School of Public Health, USA (140 papers) and London School of Hygiene and Tropical Medicine, London, UK (138 papers) (Table 12). The average citation per paper registered by the total papers of these 15 institutions is 11.27. The highest impact of 14.44 citations per paper was scored by the John Hopkins Bloomberg School of Public Health, USA, followed by Mayo Clinic or Mayo Medical School, USA (14.30 citations per paper), Organisation Mondialede la Sante, Switzerland and Emory University, USA (13.95 citations per paper each), London School of Hygiene and Tropical Medicine, London (12.89 citations per paper) and Kyushu University, Japan (12.03 citations per paper (Table 10).

CONTRIBUTIONS AND IMPACT OF MOST PRODUCTIVE AUTHORS IN MEASLES RESEARCH

Fifteen authors have been identified, who have published 35 and above papers in measles. These 15 authors together contributed 744 papers with an average of 49.6 papers per author and account for 7.57% share in the cumulative publications output of measles during 2001–2010. Seven authors have published a higher number of papers than the group average (49.6). Considering the quality/impact of papers, these productive authors have received a total of 9359 citations for 744 papers with an average of 12.58 citations per paper. Six authors have registered a higher impact than the average impact of papers of all authors (12.58). Table 11 highlights these facts.

RESEARCH COMMUNICATION IN HIGHLY PRODUCTIVE JOURNALS

The top 20 most productive journals publishing research papers in measles together contributed 1090 papers, which accounts for 22.41% share in the cumulative publications output of India during 2001–2010. The cumulative publications share of these 20 most productive journals showed a decrease in world publications output from 23.19% during 2001–2005 to 21.90% during 2006–2010. Among the most productive journals contributing to measles research during 2001–2010, the largest number of papers (490) is contributed by *Vaccine*, followed by *Journal of Virology* and *Lancet* (170 papers each), *Journal of Infectious Diseases* (164 papers), *Pediatrics* (126 papers), *Pediatrics Infectious Diseases Journal* (121 papers), etc. (Table 12).

HIGHLY CITED PAPERS

The papers that received above 100 citations (since their publication till May 2011) are considered as highly cited

Table 10. Productivity and impact of top fifteen institutions in measles, 2001–2010

S.No.	Name	TP	TC	ACPP
1	Centre for Disease Control and Prevention, National Centre for Immunization and Respiratory Diseases, USA	443	4464	10.08
3	Mayo Clinic or Mayo Medical School, USA	241	3446	14.30
2	Organisation Mondialede la Sante, Switzerland	188	2623	13.95
4	John Hopkins Bloomberg School of Public Health, USA	140	2021	14.44
5	London School of Hygiene and Tropical Medicine, London	138	1779	12.89
6	Health Protection Agency, London	103	982	9.53
7	Statens Serum Institute, Denmark	85	793	9.33
8	Inserm, France	72	645	8.96
9	Julius-Maximilians Universital, Germany	65	622	9.57
10	Kyushu University, Japan	64	770	12.03
11	Na. Inst. of Public Health and Environment, Netherlands	64	456	7.13
12	Erasmus University, Netherlands	64	547	8.55
13	Na. Inst. of Infectious Diseases, Japan	60	332	5.53
14	Emory University, USA	59	823	13.95
15	Glaxo Smith Kline, USA	58	472	8.14

TP=Total Papers; TC=Total Citations; ACPP=Average Citations per Paper

Table 11. Productivity and impact of top 10 most productive authors in measles, 2001–2010

S.No	Name	Address	TP	TC	ACPP
1	W.J. Bellini	National Centre for Immunization and Respiratory Diseases, USA	72	765	10.63
2	G.A. Poland	Mayo Clinic, USA	68	854	12.56
3	S.J. Russell	Mayo Clinic, USA	64	1147	17.92
4	P. Aaby	Danish Epidemiology Sc. Centre, Denmark	55	445	8.09
5	R.M. Jacobson	Mayo Clinic, USA	54	720	13.33
6	R.B. Cattaneo	Mayo Clinic, USA	53	1003	18.92
7	P.A. Rota	Centre for Disease Control and Prevention, USA	51	692	13.57
8	Y. Yanagi	Kyushu University, Japan	48	698	14.54
9	R.A. Vierkant	Mayo Clinic, USA	45	376	8.36
10	I.G. Ovsyannikova	Mayo Clinic, USA	45	468	10.40
11	D.E. Griffin	John Hopkins School of Medicine, USA	43	411	9.56
12	C.P. Muller	University of Trier, Germany	38	258	6.79
13	K.W. Peng	Mayo Clinic, USA	37	765	20.68
14	W.J. Moss	John Hopkins Bloomberg School of Public Health, USA	36	347	9.64
15	E.K. Miller	Health Protection Agency, London	35	410	11.71

TP=Total Papers; TC=Total Citations; ACPP=Average Citations per Paper

papers. Among these 77 highly-cited papers, 1 paper received above 1000 citations, 5 papers between 501–1000 citations, 3 papers between 301–400 citations, 7 papers between 201–300 citations and 61 papers between 100–200 citations. These 77 papers received 15,157 citations in all, with an average citation of 196.84 per paper. Of the 77 high-cited papers, 38 appeared as articles, 33 as reviews, 4 as conference papers and 1 each as note and short survey. Among the 77 high-cited papers, 18 were internationally collaborated (12 involved bilateral and 6 multilateral collaborations), 20 were national collaborative and 39 zero collaborative.

These 77 high-cited papers involved institutions from 19 countries, with the highest number of papers (41 from 38 institutions) from USA, followed by UK (15 papers from 17 institutions), Switzerland (8 papers from 5 institutions), Germany (6 papers from 6 institutions), Canada (6 papers from 6 institutions), Australia (3 papers),

Table 12. List of most productive journals publishing papers in measles, 2001–2010

S.No	Name of the Journal	Number of Papers			IF (2009)
		2001–2005	2001–2005	2001–2005	
1	Vaccine	209	281	490	3.616
2	Journal of Virology	94	76	170	5.150
3	Lancet	111	59	170	30.758
4	Journal of Infectious Diseases	119	45	164	5.865
5	Pediatrics	53	73	126	4.687
6	Pediatrics Infectious Disease Journal	56	65	121	2.854
7	Eurosurveillance Bulletin European Communicable Disease Bulletin	19	95	114	NA
8	Expert Review of Vaccine	30	51	81	4.214
9	BMJ Clinical Res Ed	38	37	75	NA
10	Clinical Infectious Diseases	24	48	72	8.195
11	Pharmaceutical Journal	52	18	70	NA
12	Journal of General Virology	41	28	69	3.26
13	Bulletin of World Health Organization	38	27	65	5.302
14	British Medical Journal	20	45	65	13.66
15	Morbidity and Mortality Weekly Report	37	28	65	NA
16	Indian Pediatrics	38	36	64	0.962
17	Virology	35	26	61	3.042
18	Epidemiology & Infection	26	31	57	2.365
19	Archives of Disease in Childhood	23	31	54	2.657
20	Journal of Medical Virology	27	23	50	2.470
	Total	1090	1123	2203	
	World Total	4701	5128	9829	
	Share of Top 20 Journals in World Total	23.19	21.90	22.41	

Netherlands, Argentina and Ireland (2 papers each) and France, Ukraine, Russia, Bangladesh, Sweden, Spain, Croatia, Denmark and Tanzania (1 paper each).The largest number of papers (6) were from Mayo Clinic & Foundation, USA, followed by Johns Hopkins Bloomberg School of Public Health, USA (5 papers), Centre for Disease Control & Prevention, USA (3 papers), University of Washington, School of Medicine, USA (3 papers), London School of Hygiene & Tropical Medicine, UK (3 papers), Mount Senai School of Medicine, USA (2 papers), National Institute of Allergy & Infectious Diseases, Besthesda, USA (2 papers), University of Cambridge, UK (2 papers), Institute of Psychiatry, Kings College, London, UK (2 papers), WHO, Switzerland (2 papers), Ludwig Maximillans University, Germany (2 papers), McGill University, Canada (2 papers) and Lady Davis Institute of Medical Research, Montreal, Canada (2 papers).

The 77 high-cited papers were published in 46 journals, with the largest number of papers (12) from *Lancet*, followed by *Journal of Virology* (8 papers), *Pediatrics* (4 papers), *Vaccine* (3 papers), *British Medical Journal, Bulletin of WHO, Cancer Research, Nature Immunology, Neurology* and *New England Journal of Medicine* (2 papers each) and 1 papers each in 38 other journals. A list of the top 20 most cited papers is given in Table 13.

Table 13. List of top 20 most highly cited papers in measles, 2001–2010

S.No	Authors	Title	Source Title	Number of Citations
1	Schaid D.J., Rowland C.M., et al	Score tests for association between traits and haplotypes when linkage phase is ambiguous (Article)	American Journal of Human Genetics 2002, 70(2), 425–34	1077
2	Parato K.A., Senger D., et al	Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data (Article)	Lancet 2006, 367(9524), 1747–57	989
3	Klinman D.M.	Where and why are 10 million children dying every year? (Review)	Lancet 2003, 361(9376), 2226–34	736
4	Chin C.D., Linder V., Sia S.K.	Clinical epidemiology of inflammatory bowel disease: Incidence, prevalence, and environmental influences (Review)	Gastroenterology 2004, 126(6), 1504–17	655
5	Shanahan F.	How many child deaths can we prevent this year? (Review)	Lancet 2003, 362(9377), 65–71	609
6	Muhle R., Trentacoste S.V., et al	WHO estimates of the causes of death in children (Article)	Lancet 2005, 365(9465), 1147–52	519
7	Walker C.F., Black R.E.	The genetics of autism (Review).	Pediatrics 2004, 113(5), 472–86	376
8	Taylor B., Miller E., et al	Immunotherapeutic uses of CpG oligodeoxynucleotides (Review)	Nature Reviews Immunology 2004, 4(4), 249–58	355
9	Menge T., Hemmer B., et al	Crohn's disease (Conference Paper)	Lancet 2002. 359(9300), 62–69	319
10	Bieback K., Lien E., et al	Neonatal and early life vaccinology (Review)	Vaccine 2001, 359(9300), 62–69	281
11	Tatsis N., Ertl H.C.	Travelling waves and spatial hierarchies in measles epidemics (Article)	Nature 2001, 414(6865), 716–23	255
12	Lopez A.D., Mathers C.D., et al	A population-based study of measles, mumps, and rubella vaccination and autism (Article)	New England Journal of Medicine 2002,347(19), 1477–82	240
13	Vasconcelos P.F.C., Luna E.J., et al	Acute disseminated encephalomyelitis: A long-term follow-up study of 84 pediatric patients (Article)	Neurology 2002, 59(8), 1224–31	237
14	Schlender J., Hornung V., et al	Hemagglutinin protein of wild-type measles virus activates Toll-like receptor 2 signaling (Article)	Journal of Virology 2002, 76(17), 8729–36	230
15	Caulfield L.E., de Onis M., et al	Translating innate immunity into immunological memory: Implications for vaccine development (Review)	Cell 2006, 124(4), 849–63	222
16	Boehme K.W., Compton T.	Showing your ID: Intrinsic disorder as an ID for recognition, regulation and cell signaling (Review)	Journal of Molecular Recognition 2005, 18(5), 343–84	220
17	Jones G., Steketee R.W., et al	Childhood blindness in the context of VISION 2020 - The right to sight (Article)	Bulletin of the World Health Organization 2001, 79(3), 227–32	199
18	Von Mutius E.	Mumps, measles, and rubella vaccine and the incidence of autism recorded by general practitioners: A time trend analysis (Article)	British Medical Journal 2001, 322(7284), 460–63	195
19	Offit P.A., Quarles J., et al	Intermittent treatment for malaria and anaemia control at time of routine vaccinations in Tanzanian infants: A randomised, placebocontrolled trial (Article)	Lancet 2001, 357(9267), 1471–77	194
20	Siegrist C.-A.	Recent progress in the battle between oncolytic viruses and tumours (Review)	Nature Reviews Cancer 2005, 5(12), 965–76	192

DISCUSSION AND CONCLUSION

Measles remains one of the leading causes of death among young children globally (see for example Wairagkar, et al., 2011). An estimated 1,64,000 people died (mostly children under age of five) from measles as per 2008 estimates, despite the availability and use of a safe and effective vaccine for over forty years. An analysis of worldwide scientific efforts in terms of publications published during last ten years (2001–2010) on measles research witnessed that globally 9829 papers were published on measles research with an average annual growth rate of 16.99% and registering an impact of 5.46 citations per paper. Among the countries, USA leads and contributes 27.46% share of global publications in measles research. In contrast, Switzerland scored the first rank in terms of measles publications per capita (42.95), per GDP (0.10), international collaborative publication share (60.65%) and registered the highest impact of 12.68 citations per paper during 2001–2010. Among the select prolific authors and productive institutions of the world, eleven authors and five institutions belonged to USA, respectively. W.J. Bellini and National Centre for Immunization and Research Diseases, USA were identified as prolific author and productive institution in the world with their highest contributions of 72 papers and 443 papers respectively in measles research. Similarly, among 77 highly-cited papers, USA contributed the highest number of 41 papers from 38 institutions.

Most measles deaths are caused by complications associated with diseases and roles of other diseases in spreading this disease. In this regard, worldwide distribution of measles research publications witnessed the highest publications in medicine (with 7148 papers), measles vaccine (2520 papers), respiratory infections (777 papers), poliomyelitis (1878 papers) in terms of broad subject areas, keywords, measles complications and role of other diseases in the spread of measles disease. Journal '*Vaccine*' has published the highest number of measles publications during 2001–2010.

Measles remains an important cause of death and disability in less developed countries as evident from their number of measles cases (2008) particularly in India[1], China, Nigeria and their research efforts in terms of publications are disproportionate to the burden of the disease (Dandona et al., 2004). Thus, there is a need to improve the measles vaccine policy and delivery strategies among the developing countries. To reduce the global burden of the disease, routine measles vaccination for children combined with mass immunization campaigns, effective surveillance in all countries to quickly recognize and respond to measles outbreaks should be key public health strategies. We have highlighted that only a few studies have investigated research efforts in measles based on publication analysis. This study was guided by this consideration and attempted to assess the macro research activity in this area as reflected by publications. Further studies such as research efforts/emphasis given by countries in different aspects of measles research can be useful to monitor the research efforts at the micro level (country level), identify missing gaps and undertake plausible corrective action.

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