DESIDOC Journal of Library and Information Technology, Vol. 38, No. 1, January 2018, pp. 41-48, DOI : 10.14429/djlit.38.1.12130
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Mobile Research in India : A Scientometric Assessment of Publications Output during 2007-16

B.M. Gupta[*], S.M. Dhawan[#], and Ritu Gupta[@]

[*]*1173 Sector 15, Panchkula - 134 113, India*
[#]*114 Dayanand Vihar, Delhi - 110 092, India*
[@]*1K/A Arjun Nagar, Safdarjang Enclave, Delhi - 110 029, India*
[*]*E-mail: bmgupta1@gmail.com*

ABSTRACT

The paper examines 13021 Indian publications on mobile research during 2007-16,as covered in Scopus database. The Indian publications were downloaded using a search strategy which uses the search term 'mobile*' in the two tags, namely 'keyword tag' and 'Article Title tag' and restricting it to the India in 'country tag' and period 2007-16 in 'date range tag'. The Indian mobile research output experiencing an annual average growth rate of 22.64 per cent, global share of 5.88 per cent, citation impact of 2.11 and international collaborative publication share of 11.28 per cent during 2007-16. Computer Science, among subjects, contributed the largest publication share (74.61), engineering (38.32%), mathematics and social sciences (6.94% and 6.54), etc. during 2007-16. Amongst14 subfields identified in India's mobile research, mobile networks contributed the largest publication share (53.19%), followed by mobile telecommunication systems (35.09%), Mobile communication (29.22%), mobile ad hoc networks (26.86%), mobile security (20.62%), etc. The most productive 20 Indian organisations and authors together contributed 25.64 per cent and 5.11 per cent share to the overall publications output of India in mobile research during 2007-16.The top 20 journals contributed 23.0 per cent share to the Indian journal output during 2007-16. Only 14 publications have registered citations from 109 to 548 and these together received3259 citations, with 232.79 citations per paper. Conclude that India is still not a leading country in the world on mobile research both in terms of quantity and quality of research. In view of strategic and global importance and to increase the research output and quality, the Indian Government needs to identify this area as one of the national priority area, involving much larger R&D investments and trained manpower and also increase international collaboration with leading mobile research hubs.

Keywords: Mobile research; India; Publications; Bibliometric indicators; International Collaboration; Scientometrics; Bibliometrics

1. INTRODUCTION

Mobile phones in India have become integral part of everyday life, connecting us wirelessly to family, friends, services and work 24/7. Twenty years ago there weren't any mobile phones and since then a lot of things have changed. Mobile phones and mobile internet have changed the way we do things and how we connect with other people. For individuals, mobile devices are not just for communication. They offer rich digital experiences on the go. Traditional services like voice and SMS are gradually being replaced by mobile data services. Mobile content usage is dominated by email, social networking, chat, games and news. People use mobile for data services such as GPS, Google map, data collection, efficiency and data accuracy, real-time analytics, multilingual support, data verification, and voice to text services.

Mobile is going to play a major role in realising the Digital India vision, with mobile emerging as the dominant platform, leading technology for internet access in the country. Accessing the internet using mobile handsets has increased dramatically in recent years. Growing investments in 4G networks promise to drive mobile even more deeply into our economy and society. There are 616 million unique mobile users in India, and by 2020 the number of unique users will touch 951 million with around 1.4 billion mobile connections (SIM)[1]. This makes India the second largest mobile market in the world, after China. Besides, India still continues to be the fastest growing mobile market in the world – It added over 100 million new subscribers in the past 18 months alone from June 2014 to March 2016. Urban mobile subscriber share stands at 56.96 per cent compared to 43.04 per cent of rural subscribers. India's urban tele-density is 148.73 while rural is 50.88[2].

Previously mobile stood separate from other digital technologies. Now, everything digital is also going mobile: computers, software, the internet, cloud and social media. Mobile is also making significant impact on businesses and the society[3]. Mobile is changing how businesses operate, changing interactions with consumers. Mobile is now a popular source of sales / revenue, and a marketing and engagement opportunity, with new behavioural and geo-locational targeting strategies. For some business it is a service delivery channel. Customers use mobile for scanning and comparison shopping, on the spot, in retail store. Search and search engine optimisation are rapidly

Received : 13 July 2017, Revised : 17 October 2017
Accepted : 20 November 2017, Online published : 01 January 2018

changing. The mobile ecosystem is widening encompassing several components such as application developers, content providers, mobile web, M-commerce, and M2M facilitating communication between appliances and mobile technology. Research and innovation across the world is driving the mobile industry, mobile computing and communication technologies. India too is contributing to mobile research and innovation. It should be worthwhile undertaking a study for assessing India's contribution to the mobile research and understand in what areas of mobile research India has made significant contribution and progress over time and how good has been the quality of its research output in mobile research.

1.1 Literature Review

Till date, no study has been reported at the national level on quantitative and qualitative analysis of mobile research in India during the last two decades. However, a few quantitative studies analysing publication output were reported covering some of the subfields of mobile research, namely mobile research[4], mobile technology[5], mobile computing[6-8], mobile commerce[9-10], mobile learning[11-14], mobile payments[15-16], mobile banking[17], etc. Given the fact that no study was available particular at national level on mobile research, the authors, therefore, decided to undertake the present study.

2. OBJECTIVES

The main objectives of this study are to study India's status of performance in mobile research during 2007-2016, based on publications covered in Scopus database. In particular, the study focuses on the following objectives:

- Comparative growth of India and the world on mobile research, ascertain India's global share and determine the citation impact of the Indian research output
- National share of international collaborative papers in the country output and the contribution of important foreign countries in India's international collaborative papers
- To analyse research output by broad subject areas and study the growth pattern across subjects over time
- Citation impact of top 20 most productive organisations and authors and compare their the publication productivity trends
- To study the medium of research communication
- To study the characteristics of top highly cited papers on mobile research in India.

3. METHODOLOGY

The study identified, retrieved and downloaded the global and Indian publication data on mobile research from the Scopus citation database for 10 years during 2007-2016. A well -defined search strategy was formulated which uses the search term 'mobile*' in the two tags, namely 'keyword tag' and 'Article Title tag' and restricting it to the period 2007-2016 in 'date range tag' was used for searching the global publication data. The search has resulted into 2,21,563 global publications on mobile-related research. When this search string was restricted to India in 'country tag', as shown below, the publication data on India's mobile-related research was obtained, resulting in 13,021 publications. By using analytical provisions/ tags available in Scopus database such as 'subject area tag', 'country tag', 'source title tag', 'journal title name' and 'affiliation tag', etc. – the Indian publications output was accordingly refined by subject, collaborating countries, organisation-wise, author-wise and journal-wise, etc. For citation data, citations to publications were also collected from date of publication till 16 December 2016. The Indian publications data was analysed across a series of raw and relative bibliometric indicators with a view to understand the dynamics of Indian research in mobile-related research. A complete counting method, wherein every contributing author or organisation covered in multiple authorship papers was fully counted was used. All authors or organisations to multi-authored papers have received equal credit in data counting and analysis.

KEY (Mobile*) AND PUBYEAR > 2006 AND PUBYEAR < 2017) or (TITLE (Mobile*) AND PUBYEAR > 2006 AND PUBYEAR < 2017)) AND (LIMIT-TO (AFFILCOUNTRY,'India'))

4. ANALYSIS

The global output on mobile research cumulated to 2,21,563 publications during 2007-2016 and that of India it cumulated to 13,021 publications during the same period. India's annual output surged from 409 in 2007 to 1,963 publications in 2016, averaging to 22.64 per cent annual growth, whereas annual world output on mobile research increased from 15,616 to 20,475 publications during the corresponding years, averaging to 4.58 per cent growth. The world output on mobile research registered 15.10 per cent quinquennial growth, whereas India's output registered 121.98 per cent quinquennial growth during the same five-yearly period 2007-2011 and 2012-2016.

India's decennial world publications share on mobile research was 5.88 per cent during 2007-2016; its quinquennial world share increased from 3.93 per cent in 2007-2011 to 7.57 per cent during 2012-2016. The citation impact of mobile research by India averaged to 2.11 citations per publication (CPP) in 10 years during 2007-2016, its quenquennial impact dropped from 4.22 in 2007-2011 to 1.16 citations per publication (CPP) in 2012-2016 as shown in Table 1.

4.1 International Collaboration

India's decennial share of international collaborative publications on mobile research was 11.28 per cent during 2007-2016. Its quinquennial share in ICP dropped from 12.96 per cent in 2007-2011 to 10.53 per cent in 2012-2016. Its 1469 ICPs cumulated to a total of 8692 citations in 10 years, averaging to 5.92 citations per paper during 2007-2016.

India collaborated with 86 countries on mobile research during 2007-2016. Of the collaborating countries, United States accounted the largest international collaborative publications share (38.60 %), followed by U.K. (9.39 %), Canada and South Korea (6.94 % and 6.81 %), China (5.31 %), Australia, Germany, Saudi Arabia and France (from 4.08 to 4.77 per cent), etc. India's collaboration with China on mobile research increased by 5.29 per cent, followed by Saudi Arabia (4.08 %), South Korea (3.46 %), Italy (1.01 %), U.K. (0.96 %), Australia (0.88 %),Germany (0.84 %), Canada (0.11 %) and Malaysia

Table 1. Mobile research in India and the world: Growth, citation impact and international collaboration, 2007-2016

Publication period	World	India					
	TP	TP	TC	CPP	ICP	%ICP	%TP
2007	15616	409	1605	3.92	59	14.43	2.62
2008	20525	624	4187	6.71	85	13.62	3.04
2009	21002	704	3123	4.44	100	14.20	3.35
2010	22823	935	4552	4.87	135	14.44	4.10
2011	23037	1372	3591	2.62	145	10.57	5.96
2012	22689	1318	3953	3.00	179	13.58	5.81
2013	21229	1189	2259	1.90	147	12.36	5.60
2014	24347	1879	2107	1.12	160	8.52	7.72
2015	29820	2628	1959	0.75	269	10.24	8.81
2016	20475	1963	156	0.08	190	9.68	9.59
2007-11	103003	4044	17058	4.22	524	12.96	3.93
2012-2016	118560	8977	10434	1.16	945	10.53	7.57
2007-16	221563	13021	27492	2.11	1469	11.28	5.88

TP=Total Papers; TC=Total Citations; CPP=Citation Per Paper; ICP=International Collaborative Papers

(0.06 %). But with USA its international collaboration dropped by 7.64 per cent, followed by France (1.66 %), Finland (1.57 %), Singapore (0.60 %) and Japan (0.15 %) from 2007-2011 to 2012-2016 as shown in Table 2.

4.2 Mobile Research Output by Subject

India's output on mobile research during 2007-2016 intersected with ten top sub-fields (as reflected in Scopus database classification). Its publications output was highest (74.61 %) in computer science, followed by engineering (38.32 %), mathematics and social sciences (6.94 % and 6.54 %), medicine, physics and astronomy, biochemistry, genetics and molecular biology and chemistry (from 3.06 % to 3.82 %), materials science and business, accounting and management (2.90 % and 2.64 %) during 2007-2016. The research activity on mobile research, as seen from activity index measure, went up 63.55 per cent in physics and astronomy, 42.62 per cent in medicine, 22.86 per cent in business, accounting and management, 5.38 per cent in engineering, 5.06 per cent in materials science, and by 0.06 per cent in computer science. The activity index dropped by 127.17 per cent in chemistry, 70.63 per cent in social sciences, and by 13.43 per cent in biochemistry, genetics and molecular biology from 2007-2011 to 2012-2016 as shown in Table 3.

Table 2. Share of leading countries collaborating with India on mobile research during 2007-16

Collaborative country	Number of international collaborative papers			Share of international collaborative papers		
	2007-11	2012-16	2007-16	2007-11	2012-16	2007-16
USA	228	339	567	43.51	35.87	38.60
U.K.	46	92	138	8.78	9.74	9.39
Canada	36	66	102	6.87	6.98	6.94
South Korea	24	76	100	4.58	8.04	6.81
China	10	68	78	1.91	7.20	5.31
Australia	22	48	70	4.20	5.08	4.77
Germany	20	44	64	3.82	4.66	4.36
Saudi Arabia	8	53	61	1.53	5.61	4.15
France	27	33	60	5.15	3.49	4.08
Japan	18	31	49	3.44	3.28	3.34
Finland	21	23	44	4.01	2.43	3.00
Singapore	17	25	42	3.24	2.65	2.86
Malaysia	13	24	37	2.48	2.54	2.52
Italy	8	24	32	1.53	2.54	2.18
World	524	945	1469	100.00	100.00	100.00

4.3 Mobile Research Output by Major Subfields

About 14 subfields of mobile research have been identified and India's mobile research output was accordingly classified for subject analysis as shown in Table 4. The subfields so identified are not mutually exclusive but overlap and interpenetrate one another. The mobile research output (6926 papers, 53.19 %) was the largest in mobile networks, followed by mobile telecommunication systems (4569 papers, 35.09 %), mobile communication (3805 papers, 29.22 %), mobile ad hoc networks (3497 papers, 26.86 %), mobile security (2685 papers, 20.62 %), etc. The research output in these subfields registered both growth as well as decline over time from 2007-2011 to 2012-2016 as shown in Table 4.

4.4 Top 20 Most Productive Organisations

The publication productivity of 20 most productive Indian organisations in mobile research varied over a wide range from 91 to 532 publications. Together these top 20 organisations contributed 25.64 per cent publication share (3339 publications), 33.51 per cent citation share (9212) to total publications output by India on mobile research during 2007-2016. The scientometric profile of these 20 Indian organisations is presented in Table 5.

- Seven of the top 20 organisations registered publications output above the group average of 166.95 publications per organisation.
- Eight organisations registered citation impact above the average citations per publication (2.76) of the top 20 organisations during 2007-2016: IIT-Madras (7.89), IIT-Bombay (4.75), IIT-Kanpur (4.26), IIT-Delhi (4.21), IIT-Kharagpur (3.91), Indian Institute of Science, Bangalore (3.37), NIT-Rourkela (3.33) and Thapar University, Patiala (2.81) during 2007-2016.
- Eight organisations registered h-index above the group average (9.6): IIT-Kharagpur (17), Jadavpur University, Kolkata (15),IIT-Madras, IIT- Delhi and Indian Institute of Science, Bangalore (14 each), Anna University, Chennai (12), IIT-Bombay (11) and NIT- Rourkela (10) during 2007-2016.
- Eight organisations contributed international collaborative publications share above the group

Table 3. Subject-wise break-up of publications output by India in mobile research during 2007-16

Subject	Number of papers (TP)			Activity index		TC	CPP	%TP
	2007-11	2012-16	2007-16	2007-11	2012-16	2007-16	2007-16	2007-16
Computer science	3016	6699	9715	99.96	100.02	13970	1.44	74.61
Engineering	1492	3497	4989	96.29	101.67	10170	2.04	38.32
Mathematics	293	611	904	104.36	98.04	1847	2.04	6.94
Social science	393	458	851	148.69	78.06	1597	1.88	6.54
Medicine	109	388	497	70.62	113.24	2571	5.17	3.82
Physics and astronomy	78	369	447	56.18	119.74	1602	3.58	3.43
Biochemistry, genetics and molecular biology	151	294	445	109.26	95.83	2239	5.03	3.42
Chemistry	232	166	398	187.69	60.50	2353	5.91	3.06
Materials science	113	264	377	96.51	101.57	2126	5.64	2.90
Business, accounting and management	90	254	344	84.24	107.10	653	1.90	2.64
Total output	4044	8977	13021	100.00	100.00			

TP = Total Papers; TC = Total Citations; CPP = Citation Per Paper

Table 4. India's Mobile Research Output by Major Sub-Fields during 2007-16

Sub-Field	Number of papers			Share of papers		
	2007-11	2012-16	2007-16	2007-11	2012-16	2007-16
Mobile networks	2248	4678	6926	55.59	52.11	53.19
Mobile telecommunication systems	1851	2718	4569	45.77	30.28	35.09
Mobile communication	1274	2531	3805	31.5	28.19	29.22
Mobile ad hoc networks	1133	2364	3497	28.02	26.33	26.86
Mobile security	468	2217	2685	11.57	24.7	20.62
Mobile devices	577	1317	1894	14.27	14.67	14.55
Mobile applications	486	1237	1723	12.02	13.78	13.23
Mobile computing	493	1172	1665	12.19	13.06	12.79
Mobile technology	737	915	1652	18.22	10.19	12.69
Mobile architecture	283	447	730	7	4.98	5.61
Mobile robots	209	429	638	5.17	4.78	4.9
Mobile standards	236	325	561	5.84	3.62	4.31
Mobile software	192	323	515	4.75	3.6	3.96
Mobile health	129	350	479	3.19	3.9	3.68
Total	4044	8977	13021			

average (13.6 %) of all organisations: University of Delhi (46.15 %), IIT-Kanpur (31.87 %), IIT-Madras (26.32 %), Thapar University, Patiala (24.24 %), IIT-Delhi (24.16 %), IIT-Bombay (23.4 %), IIT-Kharagpur (19.05 %) and Indian Institute of Science, Bengaluru (18.23 %) during 2007-2016.

- Eight organisations registered relative citation index above the group average (1.32) of all organisations: IIT-Madras (3.74), IIT- Bombay (2.25), IIT-Kanpur (2.02), IIT-Delhi (1.99), IIT-Kharagpur (1.85),Indian Institute of Science, Bengaluru (1.6), NIT-Rourkela (1.58) and Thapar University, Patiala (1.33) during 2007-2016.

4.5 Top 20 Most Productive Authors

The publications productivity of top 20 most productive Indian authors varied over a wide range from 25 to 60 publications. Together these top 20 Indian authors contributed 5.11 per cent publications share (665 publications) and accounted for 7.32 per cent citations share (2013) during 2007-2016. The scientometric profile of these 20 Indian authors is presented in Table 6.

- Six of top 20 authors registered their productivity above the group average of 33.25 as seen in Table 6.
- Six of top authors have registered citation impact above the group average of 3.03 citations per publication of all authors: S. Misra (7.83), S.S. Manvi (7.70), N. Kumar (5.38), D.R. Parhi (4.68), S.K. Dhurandher (4.0) and S. Nandi (3.19)during 2007-2016.
- Seven of top authors registered h-index above the group average (4.7) of all authors: S. Misra (11), S.S. Manvi (10), D.R. Parhi (9), N. Kumar and S.K. Dhurandher (8 each), S. Nandi (60) and G.S. Tomar (5) during 2007-2016.

Table 5. Scientometric profile of top 20 most productive Indian organisations in mobile research in India during 2007-16

Organisation	TP	TC	CPP	HI	ICP	ICP (%)	RCI
Anna University, Chennai	532	858	1.61	12	21	3.95	0.76
Indian Institute of Technology (IIT), Kharagpur	294	1150	3.91	17	56	19.05	1.85
Jadavpur University, Kolkata	289	753	2.61	15	28	9.69	1.23
Vellore Institute of Technology, Vellore	194	277	1.43	7	21	10.82	0.68
Indian Institute of Science (IISc), Bangalore	192	647	3.37	14	35	18.23	1.60
Indian Institute of Technology (IIT), Delhi	178	749	4.21	14	43	24.16	1.99
Sathyabama University, Chennai	168	102	0.61	4	3	1.79	0.29
Indian Institute of Technology (IIT), Madras	152	1199	7.89	14	40	26.32	3.74
National Institute of Technology (NIT), Rourkela	141	470	3.33	10	12	8.51	1.58
Indian Institute of Technology (IIT), Bombay	141	670	4.75	11	33	23.40	2.25
Indian Institute of Technology (IIT), Roorkee	135	350	2.59	8	18	13.33	1.23
Tata Consulting Services (TCS)	135	328	2.43	9	15	11.11	1.15
Indian Institute of Technology (IIT), Guwahati	120	326	2.72	8	14	11.67	1.29
Pondicherry Engineering College	103	60	0.58	4	0	0.00	0.28
Thapar University, Patiala	99	278	2.81	9	24	24.24	1.33
Jawaharlal Nehru Technological University, Hyderabad	97	138	1.42	6	9	9.28	0.67
SRM University	94	113	1.20	6	6	6.38	0.57
Amrita VishwaVidyapeetham University, Coimbatore	93	119	1.28	7	5	5.38	0.61
Indian Institute of Technology (IIT), Kanpur	91	388	4.26	9	29	31.87	2.02
University of Delhi	91	237	2.60	8	42	46.15	1.23
Total of 20 organisations	3339	9212	2.76	9.6	454	13.60	
Total of India	13021	27492					
Share of top 20 organisations in India's total	25.64	33.51					

- Four of top 20 authors contributed international collaborative publications share above the group average (23.91 %) of all authors: S.K. Dhurandher (83.33 %), N. Rajput (67.74 %), S. Misra (64.58 %) and N. Kumar (62.50 %) during 2007-2016.
- Seven authors registered relative citation index above the group average (1.20) of all authors: S. Misra (3.71), S.S. Manvi (3.65), N. Kumar (2.55), D.R. Parhi (2.22), S.K. Dhurandher (1.90) S. Nandi (1.51) and G.S. Tomar (1.21) during 2007-2016.

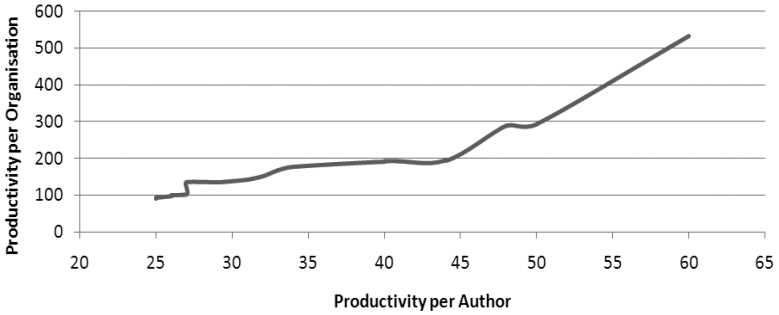

Figure 1. High productivity: Authors *vs* Organisations.

4.6 High Productivity: Authors *vs* Organisations

Based on publication productivity data in Tables 5 and 6, it is discovered that there is a strong positive correlation between high productivity authors and high productivity organisations (r = 0.946) as shown in Fig. 1.

4.7 Medium of Research Communication

The top 20 most productive journals which reported mobile research papers by India over a wide range varying from 26 to 175 papers per journal. Together they accounted for 26.88 per cent share (1087 papers) of India's total publication output on mobile research during 2007-2016. The publication share of these top 20 most productive journals in five years increased from 23.0 per cent to 28.40 per cent during 2007-2011 and 2012-2016. The most productive journal (with 175 papers) was *International Journal of Applied Engineering Research*, followed by *Wireless Personal Communications* (168 papers), *Journal of Planar Chromatography Modern TLC* (85 papers), *Journal of Theoretical and Applied Information Technology* (73 papers), etc. during 2007-2016 as shown in Table 7.

4.8 Highly Cited Papers

In all, 14 papers received high citations from 109 to 548 per paper during 2007-2016 and they together received 3,259 citations, averaging to 232.79 citations per paper. Of the 14 highly cited papers, 4 resulted from stand-alone single organisations (non-collaborative publications) and 10 from participation by two or more organisations (1 as national

Table 6. Scientometric profile of top 20 most productive Indian authors in mobile research in India during 2007-16

Name of the Author	Affiliation of the Author	TP	TC	CPP	HI	ICP	%ICP	RCI
S.K. Dhurandher	NetajiSubhash Institute of Technology, Delhi	60	240	4	8	50	83.33	1.9
D.R. Parhi	NIT-Rourkela	50	234	4.68	9	0	0	2.22
S. Misra	IIT-Kharagpur	48	376	7.83	11	31	64.58	3.71
S.S. Manvi	Basaveshwar Engineering College, Bagalkot	44	339	7.7	10	2	4.55	3.65
N. Kumar	Thapar University, Patiala	40	215	5.38	8	25	62.5	2.55
M.S. Gaur	Malaviya NIT-Jaipur	34	67	1.97	4	7	20.59	0.93
V. Laxmi	Malaviya NIT-Jaipur	33	67	2.03	4	7	21.21	0.96
S. Neogy	Jadavpur University, Kolkata	32	30	0.94	2	1	3.13	0.44
S. Nandi	IIT-Guwhati	31	99	3.19	6	1	3.23	1.51
N. Rajput	IBM India Research Lab, New Delhi	31	21	0.68	3	21	67.74	0.32
K. Majumdar	WB University of Technology, Kolkata	29	13	0.45	2	2	6.9	0.21
P. Venkataram	IISc-Bangalore	27	52	1.93	4	0	0	0.91
C. Kumar	Indian School of Mines, Dhanbad	27	33	1.22	3	2	7.41	0.58
G.S. Tomar	Machine Intelligence Research Lab, Gwalior	27	69	2.56	5	4	14.81	1.21
L.M. Patnaik	IISc-Bangalore	26	14	0.54	2	3	11.54	0.26
A.K. Singh	NIT-Kurukshetra	26	33	1.27	3	1	3.85	0.6
L.K. Awasthi	NIT-Hamirpur	25	39	1.56	3	0	0	0.74
R. Chaki	WB University of Technology, Kolkata	25	29	1.16	3	0	0	0.55
D. Das	IIIT-Bangalore	25	12	0.48	2	2	8	0.23
M.V. Ramesh	Amrita VishwaVidyapeetham University, Kollam	25	31	1.24	2	0	0	0.59
	Total of 20 authors	665	2013	3.03	4.7	159	23.91	
	Total of India	13021	27492					
	Share of 20 authors in total of India	5.11	7.32					

collaborative publication and 9 international collaborative publications). India collaborated with France, Finland, Germany, Australia, USA, South Korea, Italy and U.K in publishing 9 international collaborative papers. The 14 highly cited papers involved the participation of 69 authors (27 Indian) from 38 organisations (14 Indian). Among the Indian organisations, Microsoft Research India, Bangalore contributed 4 papers and 13 other organisations contributed only 1 paper each: IIT-Chennai, IIT-Bombay, IIT-Kanpur, IIT-Delhi, NIIST-Thiruvanathapuram, NPL-Delhi, BITS, Pilani, Maulana Azad NIT, Bhopal, University of Rajasthan, MD University, Rohtak, National Instruments, India, NTT DOCOMO, Inc., India and Karthekaya Medical Research and Diagnostic Center, Bombay. Of the 14 highly cited papers, 8 were published as articles, 2 as review papers and 4 as conference papers. These 14 highly cited papers were published in 9 journals. *IEEE Communication Magazine* published 6 and 8 other journals - *IEEE Journal on Selected Areas in Communication, International Journal of Hydrogen Energy, International Materials Review, Information Society, Fertility and Sterility, Nano scale, Journal of Control Theory and Applications and Journal of Telemedicine and Telecare* published only 1 paper each.

5. SUMMARY

The study provides quantitative and qualitative description of the mobile research in India covering 10-years publications data 2007-2016, sourced from Scopus database. India cumulated a total of 1,3021 publications on mobile research which appeared during 2007-2016. Its annual output surged from 409 publications in 2007 to 1963 publications in 2016, averaging 22.64 per cent annual growth, and 121.98 per cent quinquennial growth between 2007-2011 and 2012-2016. The decennial publications share of India to the world output on mobile research was 5.88 per cent during 2007-2016; its quinquennial world share on mobile research surged from 3.93 per cent during 2007-2011 to 7.57 per cent during 2012-2016.

The mobile research output in India registered citation impact of 2.11 citations per paper. It showed downward trend since its quinquennial citation impact went down from 4.22 in 2007-2011 to 1.16 citations per paper in 2012-2016. India's share of international collaborative publications on mobile research was 11.28 per cent during 2007-2016. It suffered a downward trend since its quinquennial share dropped from 12.96 per cent in 2007-2011 to 10.53 per cent in 2012-2016. Computer Science accounts for the largest publication share (74.61) in mobile research in India, followed by engineering (38.32 %), mathematics and social sciences (6.94 % and 6.54 %), etc. during 2007-2016. Mobile networks accounted for the largest share (53.19 %) of India's output on mobile research, followed by sub-fields such as mobile telecommunication systems (35.09 %), mobile communication (29.22 %), mobile ad hoc networks (26.86 %), mobile security (20.62 %), etc.

Table 7. Top 20 most productive journals reporting mobile research in India during 2007-16

Journals	Number of Papers		
	2007-11	2012-2016	2007-16
International Journal of Applied Engineering Research	0	175	175
Wireless Personal Communications	18	150	168
Journal of Planar Chromatography Modern TLC	63	22	85
Journal of Theoretical and Applied Information Technology	3	70	73
Indian Journal of Science and Technology	1	60	61
Wireless Networks	4	52	56
Journal of Computer Science	22	31	53
Journal of AOAC International	40	11	51
European Journal of Scientific Research	23	21	44
ARPN Journal of Engineering and Applied Science	0	34	34
Microwave and Optical Technology Letters	6	27	33
International Journal of Pharmacy and Technology	1	29	30
Journal of Liquid Chromatography and Related Technologies	18	12	30
LET Communications	11	18	29
International Review of Computers and Software	4	25	29
International Journal of Communication Networks and Distributed Systems	10	18	28
Security and Communication Networks	4	24	28
International Journal of Engineering and Technology	4	23	27
International Journal of Security and its Applications	4	23	27
World Academy of Science Engineering and Technology	26	0	26
Total of 20 journals	262	825	1087
Total of India in journal output	1139	2905	4044
Share of 20 journals in India journal output	23.00	28.40	26.88

The top 20 most productive India's organisations and authors together contributed 25.64 per cent and 5.11 per cent share respectively to the overall publications output of India in mobile research during 2007-2016.

Of the total output of 4044 journal papers on mobile research in India, the top 20 journals accounted 23 per cent share during 2007-2016. India published 14 highly cited papers on mobile research, accounting for 109 to 548 citations per paper and cumulating a total of 3259 citations, averaging 232.79 citations per paper. These 14 highly cited papers involved the participation of 69 authors (27 Indian) and 38 organisations (14 Indian), with Microsoft Research India, Bengaluru accounting for 4 papers and 13 others accounting for 1 paper each. These 14 highly cited papers were published in 9 journals.

6. CONCLUSIONS

Mobile networks is India's most preferred area of research in mobile world accounting for the largest share (53.19 %) to the national output on mobile research. The other areas of mobile research in India are mobile telecommunication systems, mobile communication, and mobile security, etc. but with insignificant contributions. Mobile applications -- like mobile banking, mobile payments, mobile commerce, mobile health, and mobile education –are still not the top priority of research of the country. The top 20 most productive organisations in India in mobile research account for just 25.64 per cent share in the national output. These top organisations are still not contributing significantly and fail to give India a leading edge in the world mobile research. India's world share to mobile research is just 5.88 per cent. In 10 years, India could contribute only 14 highly cited papers out of a total of 13021 publications that the country published on mobile research during 2007-2016. In sum, despite its IT dominance, India is still not a leading country in the world on mobile research both in terms of quantity and quality of research. In view of its growing global importance of mobile research, it is imperative for India to develop a strategy to increase research output, improve research quality and give more emphasis on international collaboration. The Indian Government needs to identify this area as one of the national priority area, involving much larger R&D investments and trained manpower and also increase international collaboration with leading mobile research hubs.

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CONTRIBUTORS

Dr B.M. Gupta received his BLibSci, Associateship in Documentation and PhD. He is a recipient of the Fullbright Professional Fellowship in Library and Information Science (1999) and Fellow of the Society for Information Science (2007). Retired Scientist G and Emeritus Scientist from CSIR-NISTADS, Delhi in 2013. He has published more than 200 research papers mainly in the area of scientometrics in journals and conferences.
He conceived the idea, downloaded the publications data and analysed the data and wrote the first draft.

Dr S.M. Dhawan received his MSc (Physics) from Sardar Patel University, MLIS from University of New York, USA, and PhD in Library Science. He superannuated as Scientist 'F' from CSIR-National Physical Laboratory, Delhi in 2005. He has worked for innovation supporting library transformation into digital era and in addition has successfully completed several biliometric/scientometric projects. He has authored several research papers, research reports covering several areas of library science, library management systems and scientometrics.
He contributed in writing of paper and giving it a final shape.

Dr Ritu Gupta has completed BCom from Delhi University, Bachelors and Masters in Library and Information Science from Annamalai University and PhD in Library and Information Sciences from Shri Venkateshwara University. She has contributed more than 70 papers in the area of bibliometrics and scientometrics research in professional journals.
She helped in downloading the data, analyses of data and in writing the first draft of the paper.