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Mapping of Indian research output on osteoporosis

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This study focuses on the Indian research output in osteoporosis, one of the leading causes of fractures and disability in the aged. The data for this study was obtained from Scopus database for the period 1973-2012. The study revealed that USA is the most productive country on osteoporosis research with a global share of 27.21% publications. Indian researchers have contributed 921(1.02%) papers in osteoporosis research. All India Institute of Medical Sciences, Dehli is most productive institution in India on osteoporosis research. It has contributed 8.40% of the total research output and India's highest research collaboration has been with United States (6.08%) during the period of study. *Osteoporosis International* (21 papers; IF-4.58) is the most productive journal publishing Indian osteoporosis research and N. Chattopadhyay (25 papers, 12.12%, h-index 12) from Central Drug Research Institute, Lucknow is the most productive author in osteoporosis research.

Keywords: Osteoporosis; research output; bibliometrics

Introduction

Osteoporosis afflicts human bones, debilitates them and causes severe joint pain. The cross sectional microscopic architecture of bone would reveal a honeycomb structure. A patient suffering from osteoporosis has bigger holes and spaces in the honeycomb as compared to healthy bones owing to the loss of density in the bones. Even minor injuries can cause fractures in person having osteoporosis. Experts call it a silent disease, and predict that by 2025 osteoporosis alone will be responsible for approximately three million fractures every year[1]. In a report, National Osteoporosis Foundation (NOF) have arrived at the finding that nearly 1,01,030,00 Americans are afflicted with this disease and has estimated that 1,85,570,00 have low bone mass placing them at an increased risk for osteoporosis[2]. In Europe the fracture rate is feared to double itself from 5,000,00 to 1 million in next 50 years. Owing to this disease, a large number of women over sixty five have suffered vertebral fractures. In an estimate, nearly 15% of the women, and 8% of the men have a risk of hip fracture, and in women sometime it leads to breast, endometrial and ovarian cancer. Unfortunately, it is only after the fracture that the disease gets detected and usually a Bone Mineral Density (BMD) test can identify patients prone to this malady[3].

Overall, osteoporosis can be classified in these categories:(i) primary, (ii) endocrine, (iii) gastrointestinal, (iv) bone marrow disorders and (v) connective tissues diseases[3]. Bisphosphonates are reported to increase the bone mass and reduce the fracture risks[4,5]. Medical science is gradually evolving to combat this affliction. An analysis of the scientific and medical literature helps us understand the progress in this field.

Status of osteoporosis in India

Malhotra and Mithal[6] find that osteoporotic fractures in India occur equally in men and women, specifically in urban population, and they may occur at a younger age compared to western counterparts. A Vitamin D deficiency is the major cause of low bone mineral density (BMD) all across India. Reluctance to toil in sunlight and an extensive use of air-conditioners at home and at work place lead to a risk of this ailment. Nearly, 25 million people in India are estimated to be stricken with this malaise. *Osteoporosis India*[7] reported that an estimated 500,000 spinal fractures (300,000 hip fractures, 200,000 broken wrists, and 300,000 fractures) occur yearly due to this disease in India. Twenty five to sixty percent of women over 60 years of age suffer from counter-spinal compression, while in the age group of 90, one third of all women and 17% of men sustain a hip fracture due to osteoporosis. However, present living style of Indians, and less physical activity have resulted in limited sun exposure. Clothings like 'Burqa', 'Sari', and 'Salwar kameez'

deprives exposure to sunlight, a major source of Vitamin D. Hence, high incidence of this disease is found in India. Another notable point is that the prevalence of osteoporosis is high in postmenopausal women in India compare to their western counterparts.[8]

Review of literature

Rex[9] finds that millions of people in India are suffering from osteoporosis, and in the next ten years nearly half of the Indian population will be in the grip of this disorder. He prescribes physical activities as a preventive measure. Based on the literature reported in the Medline database[10], a bibliometric study on osteoporosis during the period 1985 to 1994 was carried out and the study found that osteoporosis literature were distributed in 1070 journals. United States (42.57%), England (14.73%), Germany (4.97%), France (3.79%) were the most productive countries. Bibliometric studies have been carried out with special reference to India on endocrinology[11], bone marrow[12], stem cell research[13,14], and other diseases such as dementia[15] and diabetes[16,17]. Another study on arthritis and rheumatism was published in 2001.[18,19] However, no bibliometric study has been carried out in context of India so far for this health issue.

The present study will hopefully help researchers to understand progress in this field.

Objectives of the study

- To examine the growth of Indian literature in osteoporosis during the period 1973-2012;
- To understand the India's collaborative research output in the field of osteoporosis;
- To identify the most productive Indian institutions in osteoporosis;
- To list the core journals in the field of osteoporosis research; and
- To identity the highly productive Indian authors.

Methodology

The data for this study has been taken from Scopus multidisciplinary database for a period of 40 years i.e., 1973-2012. Medical Subject Headings (MeSH)[20] was referred to identify the key terms. The four phrases ''Osteoporosis', 'Hernandez Fragoso Syndrome', 'Pseudoglioma Syndrome', 'Hypophosphatemic Macroepiphyseal Dysplasia' have been used in the search window of title, abstract, keywords to retrieve the records. In addition to this, 'India' is used as country of affiliation of author using the following string: (TITLE- ABS- KEY ("Osteoporosis") OR TITLE- ABS- KEY ("Hernandez Fragoso Syndrome") OR TITLE- ABS- KEY("Pseudoglioma Syndrome") OR TITLE- ABS- KEY ("Hypophosphatemic Macroepiphyseal Dysplasia") AND AFFIL (India)) PUBYEAR > 1972 AND PUBYEAR < 2013.

H-index[21] obtained from the database has been used for evaluative performance measurement. Citation counts received by the papers since they were published and available in database have been used as a qualitative measure.

Results

Growth of literature

Scopus has indexed 90,488 documents on osteoporosis during 1973-2012 published globally and out of these, 921 documents have been contributed by Indian researchers. The data analysis shows that the United States of America (USA) is the most productive country. It has contributed the highest number of 24,620 (27.21%) papers on osteoporosis. Top five most productive countries have contributed 56% of total global output of osteoporosis research. The countries other than USA which have contributed most of the papers on osteoporosis are United Kingdom (7,664 papers; 8.47%), Germany (5,775; 6.38%), France (4,553; 5.03%) and Italy (4,124; 4.56%). India's share is negligible at 1.02%.

Figure 1 shows the year wise quantitative growth of research output in the field under study during the period 1973-2012. Table 2 presents the growth of osteoporosis literature during the period 1973-2012 compiled in the cluster of five year periods. It is evident that the growth of literature on osteoporosis shows a continued upward trend. If we analyze the individual countries performance, it is clear from the Table 1 that USA shows a minor decrease of percentage growth during 1983-1987 to 1988-1992 by 0.92% and again by 2.21% from 2003-2007 to 2008-2012. United Kingdom shows decrease in percentage growth from 1978-1982 to 1983-1987 and again in 1998-2002 to 2008-2012. Germany shows continuous decrease in growth of publication from 1973-2012 with minor increase in publication in the year range 1998-2002. Italy shows a decrease in

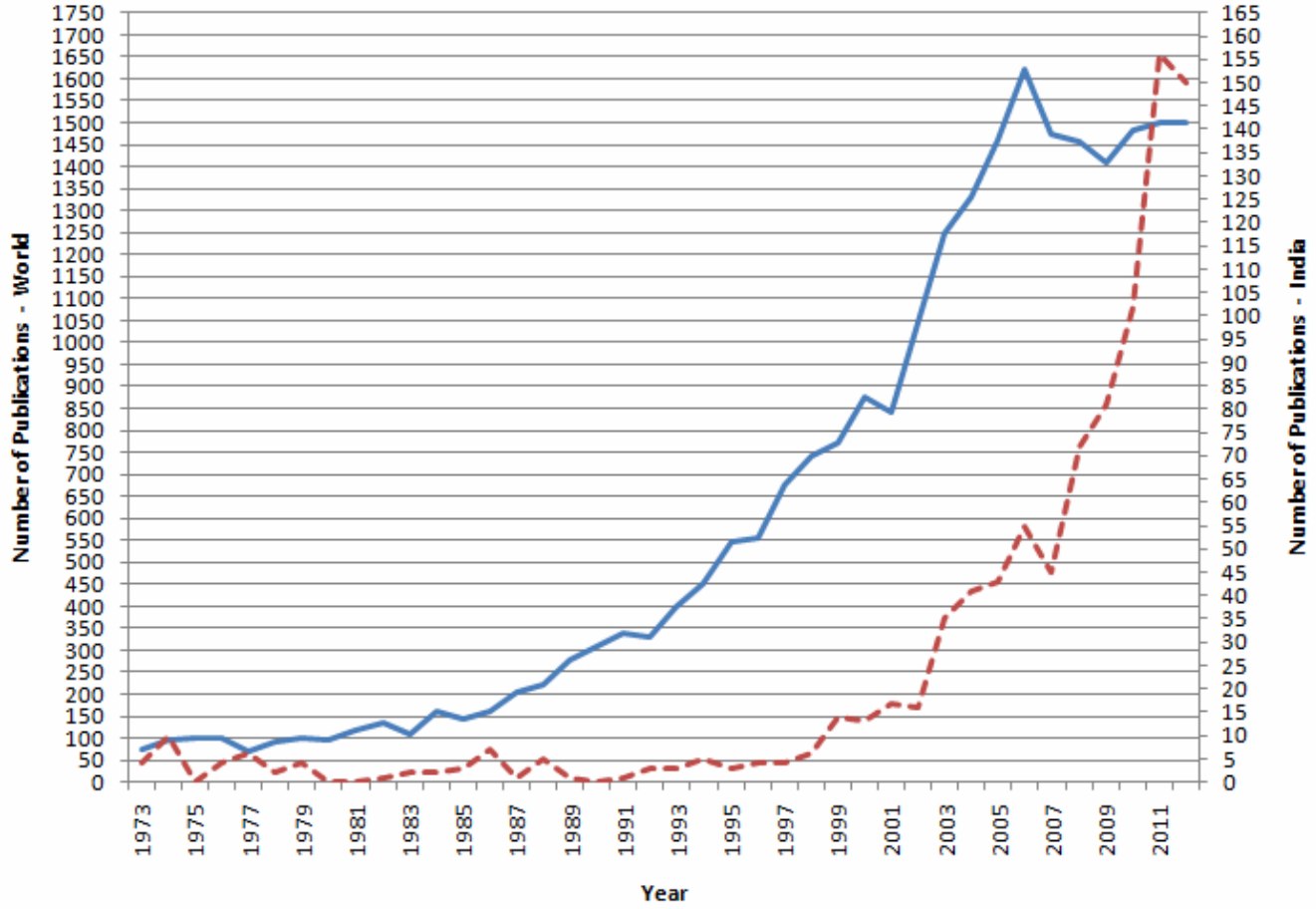

Fig. 1—Growth of Publications

Table 1—Most productive countries and their share of publication on osteoporosis

Country	No. of papers								Share of papers (%)							
	1973-1977	1978-1982	1983-1987	1988-1992	1993-1997	1998-2002	2003-2007	2008-2012	1973-1977	1978-1982	1983-1987	1988-1992	1993-1997	1998-2002	2003-2007	2008-2012
United States	441	540	778	1477	2630	4282	7131	7348	18.30	24.34	26.82	25.90	26.96	27.37	29.09	26.88
United Kingdom	150	179	182	444	956	1439	2071	2258	6.22	8.07	6.27	7.79	9.80	9.20	8.45	8.26
Germany	321	214	190	328	547	980	1623	1739	13.32	9.64	6.55	5.75	5.61	6.26	6.62	6.36
Italy	77	112	137	293	485	638	1094	1421	3.20	5.05	4.72	5.14	4.97	4.08	4.46	5.20
France	172	195	186	358	504	821	1132	1260	7.14	8.79	6.41	6.28	5.17	5.25	4.62	4.61
India	24	7	15	10	19	66	219	561	1.00	0.32	0.52	0.18	0.19	0.42	0.89	2.05
Total World Output	2410	2219	2901	5702	9755	15647	24516	27338								

growth rate from 1978-1997, and thereafter increasing growth trend. France shows a continuing decline from 1983-2012. India registers a continuous positive growth rate throughout the years with minor decrease in publication in year 1978-1983 and 1988-1992.

Publications types of osteoporosis research

Figure 2 shows that majority of findings have been published in the form of journal articles (59%) and reviews (24%). Conference papers is 5% while letters were 4%.

Institution-wise contribution of research

Two hundred and eight Indian organizations have participated in research and produced 921 documents on osteoporosis. Out of these, eighteen Indian institutes have contributed ten or more papers. The institutional performance has been judged on four parameters i.e., total publications, total citations, average citations per paper, and *h*-index.

It has been found that during the period 1973-2012, All India Institute of Medical Sciences (AIIMS) has been the most productive institution with 77 publications. It has contributed 8.40% of total Indian publications on osteoporosis with a citation count of 334 and an average 4.34 citations per paper. CDRI, Lucknow has the highest *h*-index of 14 followed by AIIMS with *h*-index value 11. Between 2007-2009, 192 research publication records are found and in 2010-2012 the number of records has doubled to 399. Top 20 institutions have contributed 378 papers, which is 41.04% of the total records with an average of 18.95 papers per institution. It is apparent that in recent years there has been a sharp rise in research on the disease. After AIIMS, Central Drug Research Institute, Lucknow contributed 40 (4.34%) papers. Sanjay Gandhi Postgraduate Institute of Medical Sciences has contributed 26 (2.82%) papers. A list of most productive Indian institutions with more than ten contributions is given below in Table 2.

Collaborative research in osteoporosis

India collaborated with 62 countries for research on osteoporosis. Based on the publication data, the total cumulative collaborative papers during 1973-2012 numbers 300 papers, which is 32.57% share of total publication output. Table 3 shows the top 20 collaborative countries on osteoporosis. India's highest collaborative research was done with United States (6.08%) followed by United Kingdom (2.82%) and Canada (2.28%). Research collaboration output with Australia and Switzerland was 1.30% each.

Productive journals

India's contribution on osteoporosis has appeared in 160 national and international journals. Analysis shows that there are 15 journals which have published 10 or more papers during the period of study which can be considered as the most productive journals. These journals share is 24.75% publication of total research output. It is found that *Osteoporosis International* (21 papers) is the most productive journal followed by *Journal of International Medical Science Academy* (20 papers). *Indian Journal of Rheumatology, JK Science*, and *Journal of Indian*

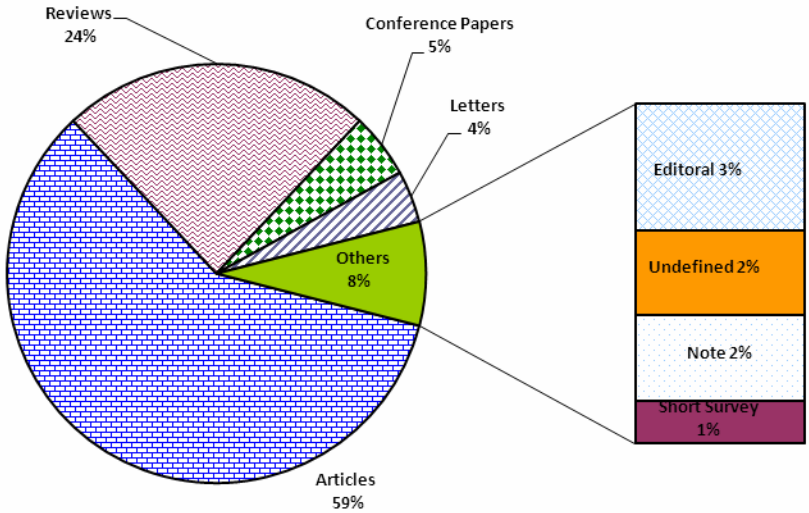

Fig. 2—Type of documents on osteoporosis

Table 2—Most productive Indian institutions

Sl. no	Affiliation	TP	%	TC	ACPP	*h*-index
1	All India Institute of Medical Sciences, New Delhi	77	8.40	334	4.34	11
2	Central Drug Research Institute, Lucknow	40	4.34	676	16.90	14
3	Postgraduate Institute of Medical Education and Research, Chandigarh	29	3.16	106	3.66	6
4	Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow	26	2.82	153	5.88	7
5	Christian Medical College, Vellore	23	2.49	45	1.96	3
6	King Edward Memorial Hospital India, Mumbai	20	2.01	179	8.95	7
7	Indraprastha Apollo Hospitals, New Delhi	19	2.06	427	22.47	6
8	Kasturba Medical College, Manipal, Karnataka	16	1.73	155	9.69	7
9	Banaras Hindu University, Institute of Medical Sciences, Varanasi	14	1.52	82	5.86	5
10	Maulana Azad Medical College, Delhi	13	1.41	90	6.92	5
11	Government Medical College, Srinagar	13	1.41	24	1.85	3
12	Jawaharlal Nehru University, New Delhi	13	1.41	70	5.38	5
13	Dayanand Medical College and Hospital, Ludhiana	12	1.30	21	1.75	2
14	SRM University, Kancheepuram	11	1.19	11	1.00	6
15	Chhatrapati Shahuji Maharaj Medical University, Lucknow	10	1.08	51	5.10	3
16	Presidency College, Kolkata	10	1.08	82	8.20	6
17	Lady Hardinge Medical College, New Delhi	10	1.08	17	1.70	1
18	Pandit Bhagwat Dayal Sharma Postgraduate Institute of Medical Sciences, Rohtak	10	1.08	69	6.90	5

Table 3—Collaborative research publications with foreign countries

Sl. no.	Country	TP	TICP
1	United States	56	6.08
2	United Kingdom	26	2.82
3	Canada	21	2.28
4	Australia	12	1.30
5	Switzerland	12	1.30
6	Belgium	11	1.19
7	Germany	11	1.19
8	France	9	0.97
9	Japan	9	0.97
10	Lebanon	8	0.86
11	Netherlands	8	0.86
12	Mexico	7	0.76
13	Italy	7	0.76
14	Spain	5	0.54
15	Brazil	5	0.54
16	South Africa	5	0.54
17	Argentina	4	0.43
18	Hong Kong	4	0.43
19	Sweden	3	0.32
20	South Korea	3	0.32

TP- Total Publications, TICP-Total International Collaborative Papers

Medical Association have published 18 papers each; while *Journal of Association of Physicians of India* and *Indian Pediatrics* have published 16 papers each. *Indian Journal of Medical Research* and *Indian Journal of Radiology & Imaging* have published 15 and 14 papers respectively. *Indian Journal of Dermatology, Venereology and Leprology* & *Indian Journal of Paediatrics* have published 13 papers each whereas *Indian Journal of Orthopaedics* & *National Medical Journal of India* has published 12 papers. Eleven papers each was published by *International Journal of Pharma and Bio Sciences*, and *International Journal of Pharmaceutical Sciences Review and Research*. Out of these 15 most productive journals, only seven journals have impact factor (IF) (Table 4).

Productivity and citation impact of most productive authors

Table 5 lists the top ten most prolific authors contributing to the osteoporosis research in India. They have contributed 141 papers which constitutes 15.31% of total Indian publications. Of these ten most productive authors, five are affiliated to Central Drug Research Institute (CDRI), Lucknow. N.Chattopadhyay (25 papers, 12.12 citations per paper) is the researcher with most number of papers wheras A. Mithal of Medanta Medicity is most cited with 23.84 citations per paper.

Table 4—Most productive journals

Sl. no.	Journal	Papers	IF
1	*Osteoporosis International*	21	4.58
2	*Journal International Medical Sciences Academy*	20	-
3	*Indian Journal of Rheumatology*	18	-
4	*JK Science*	18	-
5	*Journal of the Indian Medical Association*	18	
6	*Journal of Association of Physicians of India*	16	-
7	*Indian Pediatrics*	16	0.9
8	*Indian Journal of Medical Research*	15	1.837
9	*Indian Journal of Radiology and Imaging*	14	-
10	*Indian Journal of Dermatology Venereology and Leprology*	13	0.979
11	*Indian Journal of Pediatrics*	13	0.521
12	*Indian Journal of Orthopaedics*	12	0.503
13	*National Medical Journal of India*	12	0.595
14	*International Journal of Pharma and Bio Sciences*	11	-
15	*International Journal of Pharmaceutical Sciences Review and Research*	11	-

Table 5—Research output, citations and *h*-Index of leading Indian authors

Authors	Institute	TP	TC	ACPP	*h*-Index
Chattopadhyay, N.	Central Drug Research Institute India, Lucknow	25	303	12.12	12
Mithal, A.	Medanta Medicity, Gurgaon	19	453	23.84	7
Maurya, R.	Medicinal and Process Chemistry Division, New Delhi	13	149	11.46	9
Trivedi, R.	Central Drug Research Institute, Lucknow	13	133	10.23	6
Tandon, N.	All India Institute of Medical Sciences, New Delhi	13	87	6.69	5
Sharan, K.	Central Drug Research Institute India, Lucknow	12	178	14.83	10
Anburajan, M.	SRM University, Department of Biomedical Engineering, Kanchipuram	12	13	1.08	2
Swarnkar, G.	Central Drug Research Institute, Lucknow	12	141	11.75	9
Tandon, V.R.	Govt Medical College, Jammu	11	35	3.18	3
Siddiqui, J.A.	Central Drug Research Institute India, Lucknow	11	165	15	9

The top two authors with highest h-index value are N. Chattopadhyay (*h*-index 12) and K. Saran (*h*-index 10). Though the highest citations was received by A. Mithal (19 papers; 453 citations; 23.84 citations per paper), the *h*-index value is only 7.

Highly cited Indian research articles

The citation status of 921 Indian documents on osteoporosis reveals that 535 (58.09%) documents have been cited at least once. These 535 papers were cited 6053 times at the rate of 5.58 average citations per paper. Table 6 presents the list of 14 papers that have been cited 50 or more times till July 2013.

Conclusion

India's contribution to the global research output is just about 1.02%. Given the growing incidence of the disease, it is necessary to enhance research on the osteoporosis. Funding agencies should formulate policies to foster the research and developments between India and developing countries in this area.

Table 6—Highly cited research papers on osteoporosis

Sl. no.	Title	Source title	Cited by
1	Maternal and child undernutrition: consequences for adult health and human capital *Victora C.G., Adair L., Fall C., Hallal P.C., Martorell R., Richter L., Sachdev H.S.*	*The Lancet* 371(9609) (2008) 340-357	386
2	Structure and mechanical quality of the collagen-mineral nano-composite in bone *Fratzl P., Gupta H.S., Paschalis E.P., Roschger P.*	*Journal of Materials Chemistry* 14(14) (2004) 2115-2123	372
3	Global vitamin D status and determinants of hypovitaminosis D *Mithal A., Wahl D.A., Bonjour J.-P., Burckhardt P., Dawson-Hughes B., Eisman J.A., El-Hajj Fuleihan G., Josse R.G., Lips P., Morales-Torres J.*	*Osteoporosis International* 20(11) (2009)1807-1820	214
4	Applications of inulin and oligofructose in health and nutrition *Kaur N., Gupta A.K.*	*Journal of Biosciences* 27(7) (2002) 703-714	174
5	Herbal medicine *Kamboj V.P.*	*Current Science* 78(1) (2000) 35-39	136
6	Lasofoxifene in postmenopausal women with osteoporosis *Cummings S.R., Ensrud K., Delmas P.D., LaCroix A.Z., Vukicevic S., Reid D.M., Goldstein S., Sriram U., Lee A., Thompson J., Armstrong R.A., Thompson D.D., Powles T., Zanchetta J., Kendler D., Neven P., Eastell R.*	*New England Journal of Medicine* 362(8) (2010) 686-696	118
7	IOF position statement: Vitamin D recommendations for older adults *Dawson-Hughes B., Mithal A., Bonjour J.-P., Boonen S., Burckhardt P., Fuleihan G.E.-H., Josse R.G., Lips P., Morales-Torres J., Yoshimura N.*	*Osteoporosis International* 21(7) (2010) 1151-1154	103
8	Ovariectomy induces oxidative stress and impairs bone antioxidant system in adult rats *Muthusami S., Ramachandran I., Muthusamy B., Vasudevan G., Prabhu V., Subramaniam V., Jagadeesan A., Narasimhan S.*	*Clinica Chimica Acta* 360(2005) 81-86	97
9	Physical illness in patients with severe mental disorders. I. Prevalence, impact of medications and disparities in health care *De Hert M., Correll C.U., Bobes J., Cetkovich-Bakmas M., Cohen D.A.N., Asai I., Detraux J., Gautam S., Moller H.-J., Ndetei D.M., Newcomer J.W., Uwakwe R., Leucht S.*	*World Psychiatry* 10(1) (2011) 52-77	87
10	Pharmacological inhibition of gut-derived serotonin synthesis is a potential bone anabolic treatment for osteoporosis *Yadav V.K., Balaji S., Suresh P.S., Liu X.S., Lu X., Li Z., Guo X.E., Mann J.J., Balapure A.K., Gershon M.D., Medhamurthy R., Vidal M., Karsenty G., Ducy P.*	*Nature Medicine* 16 (3) (2010) 308-312	80
11	A duality in the roles of reactive oxygen species with respect to bone metabolism *Sontakke A.N., Tare R.S.*	*Clinica Chimica Acta* 318 (2002) 145-148	77
12	Statins and osteoporosis: New role for old drugs *Jadhav S.B., Jain G.K.*	*Journal of Pharmacy and Pharmacology* 58(1) (2006) 3-18	72
13	Prevalence of vitamin D insufficiency in postmenopausal south Indian women *Harinarayan C.V.*	*Osteoporosis International* 16(4) (2005) 397-402	60
14	The biology and chemistry of hyperlipidemia *Jain K.S., Kathiravan M.K., Somani R.S., Shishoo C.J.*	*Bioorganic and Medicinal Chemistry* 15 (14) (2007) 4674-4699	54

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