

A Neglected Infection in Literature: Childhood Musculoskeletal Tuberculosis – A Bibliometric Analysis of the Most Influential Papers

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Abstract

Pediatric tuberculosis (TB) is known to have a wide range of presentations, and if left untreated, primary TB may lead to bone and joint involvement. The literature on this topic is very scarce, and no comprehensive systematic review or meta-analysis of the current knowledge is available to date. The aim of this study is to identify and analyze the literature with highest impact based on citation rate analysis. All databases of the Thomson and Reuters “Web of Knowledge” were used to conduct our search of the 100 most cited articles on this topic published between 1950 and 2014. The included articles were analyzed in terms of citation rate, age, study type, area of research, level of evidence (LOE), and more. All 100 articles were published between 1967 and 2011 in 51 different journals. The average citation rate was 74.26, all articles were on average 23.1 years, and most studies were originated from India ($n = 22$), followed by the USA ($n = 21$). The majority of publications were review articles (42%), described clinical course ($n = 48$), and assigned an LOE IV (44%). TB infection is a high burden disease in low-income countries but widely studied in a first world setup. This research gap between the geographic distribution of disease burden and origin of publications could initiate possibilities for high-burden countries to share their opinion. Their experience is of a high level of importance and relevance which furthermore is necessary to create a more accurate picture of pediatric musculoskeletal TB burden in literature.

Keywords: Bone, childhood, joint, musculoskeletal, pediatric, tuberculosis

INTRODUCTION

Tuberculosis (TB) is only second to HIV regarding mortality due to a single pathogen.^[1] In 2014, TB infected a total of 9.6 million people, which included an estimated one million children.^[1]

Extrapulmonary involvement accounts for approximately 20% of all TB-infected patients,^[2] and musculoskeletal manifestations may account for 10%–15% of this specific group^[3,4] but can reach 35%.^[5]

For all cases of TB infection, bone and joint involvement may account for 4%–5% of the total patient population.^[4,6]

Pediatric TB is known to have a wide range of presentations, with a variety from limited pulmonary or nodal disease to severe extrapulmonary or disseminated disease.^[7] In children, untreated primary TB may lead to bone and joint involvement in up to 7%.^[8]

Musculoskeletal TB is a serious condition that may have severe consequences for the affected individual, especially in childhood. Known to be regularly misdiagnosed as a pyogenic bone or joint infection, accurate treatment is frequently delayed which influences the clinical outcome negatively.^[3-8]

Bibliometric analysis was originally designed to measure and compare the impact of scientific journals^[5] and is now recognized as a valid technique to analyze the scientific value and impact of articles by means of a quantitative appraisal of citations, articles, and journals.^[9]

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So far, there is no systematic analysis of the scientific literature about this specific topic. This study aims to address this research gap with a bibliometric analysis of the most influential publications in musculoskeletal childhood TB.

MATERIALS AND METHODS

We performed a bibliometric analysis of the 100 most cited articles on musculoskeletal TB infections in children published in any medical or nonmedical journal between 1950 and 2014.

Inclusion criteria

All studies on TB of bones and joints were screened for the patients' age of the study population. Only studies addressing TB in children were included.

Exclusion criteria

Studies focusing only on adults were excluded. Furthermore, studies that did not have any focus on bone or joint involvement due to TB infection were excluded from our analysis. For example, a study describing the clinical course of TB which only focused on the general epidemiology with no records of musculoskeletal involvement was excluded. All studies describing adults with a background of childhood TB were excluded as well.

Data collection

We performed an advanced title and topic search in "all databases" of Thomson and Reuters "Web of Knowledge," using the following Boolean query as a basis: Tubercul* AND (child OR paediatric*). The asterisk (*) implying that the specific word may have different endings to cover all possible meanings (such as tubercular, tuberculous, or tuberculosis). In addition to this, our basic query as mentioned above was followed by any of the terms: AND bone OR joint OR musculoskeletal OR orthopaedic OR osteoarticular OR Potts-disease OR hip OR knee OR ankle OR elbow OR shoulder OR foot OR hand OR wrist OR spinal.

This first search produced 646 articles. We systematically analyzed the titles and abstracts of the top 50 most cited articles of this search to determine further keywords which might have been missed in our first search.

A second search was performed with 22 new keywords (List I) with the following Boolean query as a basis: Tubercul* AND (child* OR pediatric* OR paediatric* OR infant*).

This second combined search yielded 4465 results in total, which were sorted based on the number of citations, from highest to lowest. Of the top 338 articles, we chose the 100 most cited studies based on our inclusion and exclusion criteria.

For each single study included, the following parameters were documented: title, journal, year of publication, age, first author, senior author, total citations, citation density, citations in 2014, geographic origin, institution, number of patients, and age group of patients (adults and/or children).

Analysis

The selected articles were analyzed according to subspecialty, type of study, and a level of evidence (LOE). For the LOE, the guidelines of the *Journal of Bone and Joint Surgery, American Volume* were used to assign level I (highest LOE) to V (lowest LOE) for every clinical study. Nonclinical (i.e., basic research) studies were not assigned to an LOE. A consensus approach was used in cases of disagreement between the researchers.

For studies with only one reported author, both first and senior authorship were assigned.

The ranking of included studies was given according to their total number of citations, from highest to lowest citation rate. Studies with an equal number of citations were ranked according to their average citations per year and citations in 2014.

For statistical analysis, the program SPSS (PYTHON Version 3.4.3, SPSS IBM, NY, USA) was used.

RESULTS

Age – Oldest versus newest

All articles included were published between 1967 and 2011, with an average publication age of 23.1 years [Table 1]. The citation rate per publication of the total of 100 studies ranged from 690 to 30, with an average citation rate of 74.26.

The two oldest articles of this selection are from 1967 (*Hodgson et al. The pathogenesis of Pott's Paraplegia* and *Robins' TB of the wrist and hand*) and both have a citation rate of over 30. The most recent article included is on spinal TB by Garg *et al.* and hits 41 citations in total.

Most articles included studies were published in the first decade of 2000 ($n = 30$). There were no publications included from the 1950s although this decade was eligible to be recorded in this bibliometric analysis.

Journals

From 51 journals in which these articles were published [Table 2], the most influential journal was *The Journal of Bone and Joint Surgery-British Volume (J Bone Joint Surg British)*, which accounted for 23% of articles. It was followed by the *Journal of Bone and Joint Surgery American Volume (J Bone Joint Surg Am)* with seven articles and *Spine, International Orthopaedics, and Clinical Orthopaedics and Related Research*, with four articles each (Appendix, List I. Terms). All together, these five journals published for 42% of the chosen articles. Four nonorthopedic journals with main focus on pediatric medicine had two publications or more. These were *Pediatric Infectious Disease Journal* ($n = 3$), *Pediatrics* ($n = 2$), *Pediatric Radiology* ($n = 2$), and *Archives of Disease in Childhood* ($n = 2$).

Authorship

The most influential author was Rajasekaran from India marked as first author of six publications and two as senior

Table 1: Hundred most influential publications

Rank	Paper	Total	2014	Density
1	Bass, J.B., Farer, L.S., Hopewell, P.C., Obrien, R., Jacobs, R.F., Ruben, F., Snider, D.E. & Thornton, G. 1994, "Treatment of Tuberculosis and Tuberculosis Infection in Adults and Children," <i>American Journal of Respiratory and Critical Care Medicine</i> , vol. 149, no. 5, pp. 1359-1374	690	10	31.41
2	Alvarez, S. & McCabe, W.R. 1984, "Extrapulmonary Tuberculosis Revisited - a Review of Experience at Boston-City and Other Hospitals," <i>Medicine</i> , vol. 63, no. 1, pp. 25-55	304	6	9.50
3	Watts, H.G. & Lifeso, R.M. 1996, "Tuberculosis of bones and joints," <i>Journal of Bone and Joint Surgery-American Volume</i> , vol. 78A, no. 2, pp. 288-298	245	7	11.67
4	Harries, A.D. 1990, "Tuberculosis and Human-Immunodeficiency-Virus Infection in Developing-Countries," <i>Lancet</i> , vol. 335, no. 8686, pp. 387-390	224	1	8.65
5	Shafer, R.W., Kim, D.S., Weiss, J.P. & Quale, J.M. 1991, "Extrapulmonary Tuberculosis in Patients with Human-Immunodeficiency-Virus Infection," <i>Medicine</i> , vol. 70, no. 6, pp. 384-397	217	3	8.68
6	Moon, M.S. 1997, "Spine update tuberculosis of the spine - Controversies and a new challenge," <i>Spine</i> , vol. 22, no. 15, pp. 1791-1797	169	13	8.89
7	Moon, M.S., Woo, Y.K., Lee, K.S., Ha, K.Y., Kim, S.S. & Sun, D.H. 1995, "Posterior Instrumentation and Anterior Interbody Fusion for Tuberculous Kyphosis of Dorsal and Lumbar Spines," <i>Spine</i> , vol. 20, no. 17, pp. 1910-1916	166	0	7.90
8	Casanova, J.L., Blanche, S., Emile, J.F., Jouanguy, E., Lamhamedi, S., Altare, F., Stephan, J.L., Bernaudin, F., Bordigoni, P., Turck, D., Lachaux, A., Bertini, M., Bourrillon, A., Dommergues, J.P., Pocardalo, M.A., LeDeist, F., Gaillard, J.L., Griscelli, C. & Fischer, A. 1996, "Idiopathic disseminated bacillus Calmette-Guerin infection: A French National retrospective study," <i>Pediatrics</i> , vol. 98, no. 4, pp. 774-778	161	8	8.05
9	Peto, H.M., Pratt, R.H., Harrington, T.A., LoBue, P.A. & Armstrong, L.R. 2009, "Epidemiology of Extrapulmonary Tuberculosis in the United States, 1993-2006," <i>Clinical Infectious Diseases</i> , vol. 49, no. 9, pp. 1350-1357	139	28	19.86
10	Rajasekaran, S. & Soundarapandian, S. 1989, "Progression of Kyphosis in Tuberculosis of the Spine Treated by Anterior Arthrodesis," <i>Journal of Bone and Joint Surgery-American Volume</i> , vol. 71A, no. 9, pp. 1314-1323	139	5	5.15
11	Nussbaum, E.S., Rockswold, G.L., Bergman, T.A., Erickson, D.L. & Seljeskog, E.L. 1995, "Spinal Tuberculosis - a Diagnostic and Management Challenge," <i>Journal of Neurosurgery</i> , vol. 83, no. 2, pp. 243-247	137	4	6.52
12	Berney, S., Goldstein, M. & Bishko, F. 1972, "Clinical and diagnostic features of tuberculous arthritis," <i>The American Journal of Medicine</i> , vol. 53, no. 1, pp. 36-42	117	1	2.66
13	Jain, A.K. 2010, "Tuberculosis of the spine A FRESH LOOK AT AN OLD DISEASE," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 92B, no. 7, pp. 905-913	109	30	18.17
14	Desai, S.S. 1994, "Early Diagnosis of Spinal Tuberculosis by Mri," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 76B, no. 6, pp. 863-869	107	3	4.86
15	Yao, D.C. & Sartoris, D.J. 1995, "Musculoskeletal Tuberculosis," <i>Radiologic Clinics of North America</i> , vol. 33, no. 4, pp. 679-689	100	2	4.55
16	Chapman, M., Murray, R.O. & Stoker, D.J. 1979, "Tuberculosis of the Bones and Joints," <i>Seminars in Roentgenology</i> , vol. 14, no. 4, pp. 266-282	99	2	2.68
17	Engin, G., Acunas, B., Acunas, G. & Tunaci, M. 2000, "Imaging of extrapulmonary tuberculosis," <i>Radiographics</i> , vol. 20, no. 2, pp. 471-488	98	5	6.12
18	Davies, P.D.O., Humphries, M.J., Byfield, S.P., Nunn, A.J., Darbyshire, J.H., Citron, K.M. & Fox, W. 1984, "Bone and Joint Tuberculosis - A Survey of Notifications in England and Wales," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 66, no. 3, pp. 326-330	95	2	2.97
19	Rajasekaran, S. & Shanmugasundaram, T.K. 1987, "Prediction of the Angle of Gibbus Deformity in Tuberculosis of the Spine," <i>Journal of Bone and Joint Surgery-American Volume</i> , vol. 69A, no. 4, pp. 503-509	95	5	3.28
20	Bailey, H.L., Gabriel, M., Hodgson, A.R. & Shin, J.S. 1972, "Tuberculosis of the spine in children. Operative findings and results in one hundred consecutive patients treated by removal of the lesion and anterior grafting," <i>The Journal of bone and joint surgery. American volume</i> , vol. 54, no. 8, pp. 1633-57	94	1	2.14
21	Fang, D., Leong, J.C.Y. & Fang, H.S.Y. 1983, "Tuberculosis of the Upper Cervical-Spine," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 65, no. 1, pp. 47-50	90	0	2.73
22	Hsu, L.C.S., Cheng, C.L. & Leong, J.C.Y. 1988, "Potts Paraplegia of Late Onset - the Cause of Compression and Results After Anterior Decompression," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 70, no. 4, pp. 534-538	90	2	2.81
23	Spiegel, P.G., Kengla, K.W., Isaacson, A.S. & Wilson, J.C.J. 1972, "Intervertebral disc-space inflammation in children," <i>The Journal of bone and joint surgery. American volume</i> , vol. 54, no. 2, pp. 284-96	85	4	1.89
24	Jin, D.D., Qu, D.B., Chen, J.T. & Zhang, H. 2004, "One-stage anterior interbody autografting and instrumentation in primary surgical management of thoracolumbar spinal tuberculosis," <i>European Spine Journal</i> , vol. 13, no. 2, pp. 114-121	80	6	6.67
25	Sundararaj, G.D., Behera, S., Ravi, V., Venkatesh, K., Cherian, V.M. & Lee, V. 2003, "Role of posterior stabilisation in the management of tuberculosis of the dorsal and lumbar spine," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 85B, no. 1, pp. 100-106	80	5	5.71

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Rank	Paper	Total	2014	Density
26	De Vuyst, D., Vanhoenacker, F., Gielen, J., Bernaerts, A. & De Schepper, A.M. 2003, "Imaging features of musculoskeletal tuberculosis," <i>European Radiology</i> , vol. 13, no. 8, pp. 1809-1819	75	9	5.77
27	Rajasekaran, S. 2001, "The natural history of post-tubercular kyphosis in children - Radiological signs which predict late increase in deformity," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 83B, no. 7, pp. 954-962	75	7	5.00
28	Newton, P., Sharp, J. & Barnes, K.L. 1982, "Bone and Joint Tuberculosis in Greater Manchester 1969-79," <i>Annals of the Rheumatic Diseases</i> , vol. 41, no. 1, pp. 1-6	71	0	2.09
29	Jaovisidha, S., Chen, C., Ryu, K.N., Siriwongpairat, P., Pekan, P., Sartoris, D.J. & Resnick, D. 1996, "Tuberculous tenosynovitis and bursitis: Imaging findings in 21 cases," <i>Radiology</i> , vol. 201, no. 2, pp. 507-513	70	2	3.50
30	Bates, J.H. 1979, "Diagnosis of Tuberculosis," <i>Chest</i> , vol. 76, no. 6, pp. 757-763	68	1	1.84
31	Enarson, D.A., Fujii, M., Nakielna, E.M. & Grzybowski, S. 1979, "Bone and Joint Tuberculosis - Continuing Problem," <i>Canadian Medical Association Journal</i> , vol. 120, no. 2, pp. 139-145	68	0	1.84
32	Talu, U., Gogus, A., Ozturk, C., Hamzaoglu, A. & Domanic, U. 2006, "The role of posterior instrumentation and fusion after anterior radical debridement and fusion in the surgical treatment of spinal tuberculosis: Experience of 127 cases," <i>Journal of Spinal Disorders & Techniques</i> , vol. 19, no. 8, pp. 554-559	68	10	6.18
33	BoachieAdjei, O. & Squillante, R.G. 1996, "Tuberculosis of the spine," <i>Orthopedic Clinics of North America</i> , vol. 27, no. 1, pp. 95-&	67	3	3.35
34	Goldblatt, M. & Cremin, B.J. 1978, "Osteo-Articular Tuberculosis - its Presentation in Colored Races," <i>Clinical Radiology</i> , vol. 29, no. 6, pp. 669-677	67	0	1.76
35	Rajasekaran, S. 2002, "The problem of deformity in spinal tuberculosis," <i>Clinical Orthopaedics and Related Research</i> , no. 398, pp. 85-92	67	6	4.79
36	Vohra, R., Kang, H.S., Dogra, S., Saggarr, R.R. & Sharma, R. 1997, "Tuberculous osteomyelitis," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 79B, no. 4, pp. 562-566	67	2	3.35
37	Hoffman, E.B., Crosier, J.H. & Cremin, B.J. 1993, "Imaging in Children with Spinal Tuberculosis - a Comparison of Radiography, Computed-Tomography and Magnetic-Resonance-Imaging," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 75, no. 2, pp. 233-239	65	1	2.83
38	Rajasekaran, S., Shanmugasundaram, T.K., Prabhakar, R., Dheenadhayalan, J., Shetty, A.P. & Shetty, D.K. 1998, "Tuberculous lesions of the lumbosacral region - A 15-year follow-up of patients treated by ambulant chemotherapy," <i>Spine</i> , vol. 23, no. 10, pp. 1163-1167	64	2	3.56
39	Louw, J.A. 1990, "Spinal Tuberculosis with Neurological Deficit - Treatment with Anterior Vascularized Rib Grafts, Posterior Osteotomies and Fusion," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 72, no. 4, pp. 686-693	62	1	2.38
40	Tuli, S.M. 1995, "Severe Kyphotic Deformity in Tuberculosis of the Spine," <i>International Orthopaedics</i> , vol. 19, no. 5, pp. 327-331	59	2	2.68
41	Malaviya, A.N. & Kotwal, P.P. 2003, "Arthritis associated with tuberculosis," <i>Best Practice & Research in Clinical Rheumatology</i> , vol. 17, no. 2, pp. 319-343	58	11	4.46
42	Versfeld, G.A. & Solomon, A. 1982, "A Diagnostic-Approach to Tuberculosis of Bones and Joints," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 64, no. 4, pp. 446-449	56	1	1.60
43	Walker, G.F. 1968, "Failure of early recognition of skeletal tuberculosis," <i>British medical journal</i> , vol. 1, no. 5593, pp. 682-3	56	0	1.14
44	Abernathy, R.S., Dutt, A.K., Stead, W.W. & Moers, D.J. 1983, "Short-Course Chemotherapy for Tuberculosis in Children," <i>Paediatrics</i> , vol. 72, no. 6, pp. 801-806	55	6	3.79
45	Forssbohm, M., Zwahlen, M., Loddenkemper, R. & Rieder, H.L. 2008, "Demographic characteristics of patients with extrapulmonary tuberculosis in Germany," <i>European Respiratory Journal</i> , vol. 31, no. 1, pp. 99-105	54	9	6.75
46	Parthasarathy, R., Sriram, K., Santha, T., Prabhakar, R., Somasundaram, P.R. & Sivasubramanian, S. 1999, "Short-course chemotherapy for tuberculosis of the spine - A comparison between ambulant treatment and radical surgery - Ten-year report," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 81B, no. 3, pp. 464-471	51	5	3.00
47	Pui, M.H., Mitha, A., Rae, W.I.D. & Corr, P. 2005, "Diffusion-weighted magnetic resonance imaging of spinal infection and malignancy," <i>Journal of Neuroimaging</i> , vol. 15, no. 2, pp. 164-170	51	4	4.64
48	Schulitz, K.P., Kothe, R., Leong, J.C.Y. & Wehling, P. 1997, "Growth changes of solidly fused kyphotic bloc after surgery for tuberculosis - Comparison of four procedures," <i>Spine</i> , vol. 22, no. 10, pp. 1150-1155	51	4	2.68
49	Teo, H.E.L. & Peh, W.C.G. 2004, "Skeletal tuberculosis in children," <i>Pediatric radiology</i> , vol. 34, no. 11, pp. 853-860	51	5	3.92
50	Halsey, J.P., Reeback, J.S. & Barnes, C.G. 1982, "A Decade of Skeletal Tuberculosis," <i>Annals of the Rheumatic Diseases</i> , vol. 41, no. 1, pp. 7-10	50	0	1.47
51	Stroebel, A.B., Daniel, T.M., Lau, J.H.K., Leong, J.C.Y. & Richardson, H. 1982, "Serologic Diagnosis of Bone and Joint Tuberculosis by an Enzyme-Linked Immunosorbent-Assay," <i>Journal of Infectious Diseases</i> , vol. 146, no. 2, pp. 280-283	50	1	1.43
52	Bottiger, M., Romanus, V., Deverdier, C. & Boman, G. 1982, "Osteitis and Other Complications Caused by Generalized Bcg-Itis - Experiences in Sweden," <i>Acta Paediatrica Scandinavica</i> , vol. 71, no. 3, pp. 471-478	49	0	1.44

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Rank	Paper	Total	2014	Density
53	Hsu, L.C.S. & Leong, J.C.Y. 1984, "Tuberculosis of the Lower Cervical-Spine (C2 to C7) - a Report on 40 Cases," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 66, no. 1, pp. 1-5	49	1	1.75
54	Janssens, J.P. & Dehaller, R. 1990, "Spinal Tuberculosis in a Developed Country - a Review of 26 Cases with Special Emphasis on Abscesses and Neurologic Complications," <i>Clinical Orthopaedics and related research</i> , no. 257, pp. 67-75	49	0	1.88
55	Biddulph, J. 1990, "Short Course Chemotherapy for Childhood Tuberculosis," <i>Pediatric Infectious Disease Journal</i> , vol. 9, no. 11, pp. 794-801	47	1	1.81
56	Grammatico, L., Baron, S., Rusch, E., Lepage, B., Surer, N., Desenclos, J.C. & Besnier, J.M. 2008, "Epidemiology of vertebral osteomyelitis (VO) in France: analysis of hospital-discharge data 2002-2003," <i>Epidemiology and Infection</i> , vol. 136, no. 5, pp. 653-660	47	8	5.88
57	Bergdahl, S., Fellander, M. & Robertson, B. 1976, "Bcg Osteomyelitis - Experience in Stockholm Region Over Years 1961-1974," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 58, no. 2, pp. 212-216	46	0	1.15
58	Hodgson, A.R., Skinsnes, O.K. & Leong, C.Y. 1967, "The pathogenesis of Pott's paraplegia," <i>The Journal of bone and joint surgery. American volume</i> , vol. 49, no. 6, pp. 1147-56	46	0	0.94
59	Maltezou, H.C., Spyridis, P. & Kafetzis, D.A. 2000, "Extra-pulmonary tuberculosis in children," <i>Archives of Disease in Childhood</i> , vol. 83, no. 4, pp. 342-346	46	7	2.88
60	Gasbarrini, A.L., Bertoldi, E., Mazzetti, M., Fini, L., Terzi, S., Gonella, F., Mirabile, L., Barbanti Brodano, G., Furno, A., Gasbarrini, A. & Boriani, S. 2005, "Clinical features, diagnostic and therapeutic approaches to haematogenous vertebral osteomyelitis," <i>European review for medical and pharmacological sciences</i> , vol. 9, no. 1, pp. 53-66	45	6	4.09
61	Martini, M., Adjrak, A. & Boudjemaa, A. 1986, "Tuberculous Osteomyelitis - a Review of 125 Cases," <i>International Orthopaedics</i> , vol. 10, no. 3, pp. 201-207	45	1	1.50
62	Darbyshire, J. 1993, "Controlled Trial of Short-Course Regimens of Chemotherapy in the Ambulatory Treatment of Spinal Tuberculosis - Results at 3 Years of a Study in Korea," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 75, no. 2, pp. 240-248	44	1	1.91
63	Laberge, J.M. & Brantzawadzki, M. 1984, "Evaluation of Potts Disease with Computed-Tomography," <i>Neuroradiology</i> , vol. 26, no. 6, pp. 429-434	43	0	1.34
64	Snider, D.E. 1975, "Extrapulmonary Tuberculosis in Oklahoma, 1965 to 1973," <i>American Review of Respiratory Disease</i> , vol. 111, no. 5, pp. 641-646	43	0	1.02
65	Santos, A.L. & Roberts, C.A. 2001, "A picture of tuberculosis in young Portuguese people in the early 20th century: A multidisciplinary study of the skeletal and historical evidence," <i>American Journal of Physical Anthropology</i> , vol. 115, no. 1, pp. 38-49	42	4	2.80
66	Behari, S., Nayak, S.R., Bhargava, V., Banerji, D., Chhabra, D.K. & Jain, V.K. 2003, "Craniocervical tuberculosis: Protocol of surgical management," <i>Neurosurgery</i> , vol. 52, no. 1, pp. 72-80	42	2	3.23
67	Liao, C.H., Chou, C.H., Lai, C.C., Huang, Y.T., Tan, C.K., Hsu, H.L. & Hsueh, P.R. 2009, "Diagnostic performance of an enzyme-linked immunospot assay for interferon-gamma in extrapulmonary tuberculosis varies between different sites of disease," <i>Journal of Infection</i> , vol. 59, no. 6, pp. 402-408	42	2	6.00
68	Nicholson, R.A. 1974, "Twenty years of bone and joint tuberculosis in Bradford. A comparison of the disease in the indigenous and Asian populations," <i>The Journal of bone and joint surgery. British volume</i> , vol. 56-B, no. 4, pp. 760-5	42	0	1.00
69	Garg, R.K. & Somvanshi, D.S. 2011, "Spinal tuberculosis: A review," <i>Journal of Spinal Cord Medicine</i> , vol. 34, no. 5, pp. 440-454	41	12	8.20
70	Pattison, P.R.M. 1986, "Potts Paraplegia - an Account of the Treatment of 89 Consecutive Patients," <i>Paraplegia</i> , vol. 24, no. 2, pp. 77-91	41	0	1.37
71	Pun, W.K., Chow, S.P., Luk, K.D.K., Cheng, C.L., Hsu, L.C.S. & Leong, J.C.Y. 1990, "Tuberculosis of the Lumbosacral Junction - Long-Term Follow-Up of 26 Cases," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 72, no. 4, pp. 675-678	41	0	1.58
72	Jain, A.K., Dhammi, I.K., Prashad, B., Sinha, S. & Mishra, P. 2008, "Simultaneous anterior decompression and posterior instrumentation of the tuberculous spine using an anterolateral extrapleural approach," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 90B, no. 11, pp. 1477-1481	40	5	5.00
73	Laheri, V.J., Badhe, N.P. & Dewnany, G.T. 2001, "Single stage decompression, anterior interbody fusion and posterior instrumentation for tuberculous kyphosis of the dorso-lumbar spine," <i>Spinal Cord</i> , vol. 39, no. 8, pp. 429-436	40	3	2.67
74	Martin, N.S. 1970, "Tuberculosis of the spine. A study of the results of treatment during the last twenty-five years," <i>The Journal of bone and joint surgery. British volume</i> , vol. 52, no. 4, pp. 613-28	40	0	0.87
75	Hellinger, W.C., Smilack, J.D., Greider, J.L., Alvarez, S., Trigg, S.D., Brewer, N.S. & Edson, R.S. 1995, "Localized Soft-Tissue Infections with Mycobacterium-Avium Mycobacterium-Intracellulare Complex in Immunocompetent Patients - Granulomatous Tenosynovitis of the Hand Or Wrist," <i>Clinical Infectious Diseases</i> , vol. 21, no. 1, pp. 65-69	39	1	1.86
76	Omari, B., Robertson, J.M., Nelson, R.J. & Chiu, L.C. 1989, "Potts Disease - a Resurgent Challenge to the Thoracic Surgeon," <i>Chest</i> , vol. 95, no. 1, pp. 145-150	38	1	1.41

Contd...

Table 1: Contd....

Rank	Paper	Total	2014	Density
77	Dhillon, M.S. & Nagi, O.N. 2002, "Tuberculosis of the foot and ankle," <i>Clinical Orthopaedics and Related Research</i> , no. 398, pp. 107-113	37	2	2.64
78	Mackay, A., Alcorn, M.J., Macleod, I.M., Stack, B.H.R., Macleod, T., Laidlaw, M., Millar, J.S. & White, R.G. 1980, "Fatal Disseminated Bcg Infection in an 18-Year-Old Boy," <i>Lancet</i> , vol. 2, no. 8208, pp. 1332-1334	37	0	1.03
79	Naimurrahman 1980, "Atypical Forms of Spinal Tuberculosis," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 62, no. 2, pp. 162-165	37	2	1.03
80	Nemir, R.L. & Krasinski, K. 1988, "Tuberculosis in Children and Adolescents in the 1980s," <i>Pediatric Infectious Disease Journal</i> , vol. 7, no. 6, pp. 375-379	37	0	1.32
81	Peltola, H., Salmi, I., Vahvanen, V. & Ahlqvist, J. 1984, "Bcg Vaccination as a Cause of Osteomyelitis and Subcutaneous Abscess," <i>Archives of Disease in Childhood</i> , vol. 59, no. 2, pp. 157-161	37	2	1.16
82	Rasool, M.N., Govender, S. & Naidoo, K.S. 1994, "Cystic Tuberculosis of Bone in Children," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 76B, no. 1, pp. 113-117	37	2	1.68
83	Armbrust, W., Kamphuis, S.S.M., Wolfs, T.W.F., Fiselier, T.J.W., Nikkels, P.G., Kuis, W. & Wulffraat, N.M. 2004, "Tuberculosis in a nine-year-old girl treated with infliximab for systemic juvenile idiopathic arthritis," <i>Rheumatology</i> , vol. 43, no. 4, pp. 527-529	36	0	3.00
84	Moon, M.S., Kim, I., Woo, Y.K. & Park, Y.O. 1987, "Conservative Treatment of Tuberculosis of the Thoracic and Lumbar Spine in Adults and Children," <i>International Orthopaedics</i> , vol. 11, no. 4, pp. 315-322	36	0	1.24
85	Rajasekaran, S., Vijay, K. & Shetty, A.P. 2010, "Single-stage closing-opening wedge osteotomy of spine to correct severe post-tubercular kyphotic deformities of the spine: a 3-year follow-up of 17 patients," <i>European Spine Journal</i> , vol. 19, no. 4, pp. 583-592	36	8	6.00
86	Andronikou, S., Jadwat, S. & Douis, H. 2002, "Patterns of disease on MRI in 53 children with tuberculous spondylitis and the role of gadolinium," <i>Pediatric Radiology</i> , vol. 32, no. 11, pp. 798-805	35	2	2.50
87	Govender, S. & Parbhoo, A.H. 1999, "Support of the anterior column with allografts in tuberculosis of the spine," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 81B, no. 1, pp. 106-109	35	0	2.06
88	Moon, M.S., Ha, K.Y., Sun, D.H., Moon, J.L., Moon, Y.W. & Chung, J.H. 1996, "Pott's paraplegia - 67 cases," <i>Clinical Orthopaedics and Related Research</i> , no. 323, pp. 122-128	35	1	1.75
89	Robins, R.H. 1967, "Tuberculosis of the wrist and hand," <i>The British journal of surgery</i> , vol. 54, no. 3, pp. 211-8	35	0	0.71
90	Kumar, K. & Saxena, M.B.L. 1988, "Multifocal Osteoarticular Tuberculosis," <i>International Orthopaedics</i> , vol. 12, no. 2, pp. 135-138	34	2	1.21
91	Deeks, S.L., Clark, M., Scheifele, D.W., Law, B.J., Dawar, M., Ahmadipour, N., Walop, W., Ellis, C.E. & King, A. 2005, "Serious adverse events associated with Bacille Calmette-Guerin vaccine in Canada," <i>Pediatric Infectious Disease Journal</i> , vol. 24, no. 6, pp. 538-541	32	2	2.91
92	Fountain, S.S., Hsu, L.C.S., Yau, A.C.M.C. & Hodgson, A.R. 1975, "Progressive Kyphosis Following Solid Anterior Spine Fusion in Children with Tuberculosis of Spine - Long-Term Study," <i>Journal of Bone and Joint Surgery-American Volume</i> , vol. 57, no. 8, pp. 1104-1107	32	0	0.78
93	Jain, A.K., Kumar, S. & Tuli, S.M. 1999, "Tuberculosis of spine (C1 to D4)," <i>Spinal Cord</i> , vol. 37, no. 5, pp. 362-369	32	1	1.88
94	Bell, D. & Cockshott, W.P. 1971, "Tuberculosis of the vertebral pedicles," <i>Radiology</i> , vol. 99, no. 1, pp. 43-8	31	0	0.69
95	Kalra, K.P., Dhar, S.B., Shetty, G. & Dhariwal, Q. 2006, "Pedicle subtraction osteotomy for rigid post-tuberculous kyphosis," <i>Journal of Bone and Joint Surgery-British Volume</i> , vol. 88B, no. 7, pp. 925-927	31	3	3.10
96	Kelly, P.J. & Karlson, A.G. 1969, "Musculoskeletal tuberculosis," <i>Mayo Clinic Proceedings</i> , vol. 44, no. 2, pp. 73-80	31	0	0.66
97	Krishnan, A., Patkar, D., Patankar, T., Shah, J., Prasad, S., Bunting, T., Castillo, M. & Mukherji, S.K. 2001, "Craniovertebral junction tuberculosis: A review of 29 cases," <i>Journal of Computer Assisted Tomography</i> , vol. 25, no. 2, pp. 171-176	30	1	2.00
98	Morris, B.S., Varma, R., Garg, A., Awasthi, M. & Maheshwari, M. 2002, "Multifocal musculoskeletal tuberculosis in children: appearances on computed tomography," <i>Skeletal Radiology</i> , vol. 31, no. 1, pp. 1-8	30	0	2.14
99	Rezai, M.S., Khotaei, G., Mamishi, S., Kheirkhah, M. & Parvaneh, N. 2008, "Disseminated Bacillus CalmetteGuerin Infection after BCG Vaccination," <i>Journal of Tropical Pediatrics</i> , vol. 54, no. 6, pp. 413-416	30	3	3.75
100	Southwood, T.R., Hancock, E.J., Petty, R.E., Malleson, P.N. & Thiessen, P.N. 1988, "Tuberculous Rheumatism (Poncets Disease) in a Child," <i>Arthritis and Rheumatism</i> , vol. 31, no. 10, pp. 1311-1313	30	0	1.03

Most influential publications: Total citations (*n*), citations in 2014 (*n*), citation density (*n*/years)

author [Table 3]. Four publications were published by Moon, Jain, and Leong, all with at least one senior authorship.

Geographic origin

Of a total of 27 different countries identified [Table 4], the geographic origin with most published studies was India (*n* = 22), followed by the USA with 21% of included publications. Countries with <10 published articles were

Hong Kong (*n* = 9), England (*n* = 7), South Africa (*n* = 7), South Korea (*n* = 6), and Canada (*n* = 4). From most countries, only one article was published, except for Turkey, Sweden, Germany, and France, with each two articles.

Asia as a continent produced most publications (40%) with India in the first position (*n* = 22), Hong Kong

second ($n = 9$), and South Korea third ($n = 6$). Taiwan, Singapore, and China all published one. This was followed by North America with 25%, of which the USA brought up 21 and Canada four.

Europe produced 24% of all articles, with most from England ($n = 7$). All responsible for two publications were Turkey, Sweden, Germany, and France. Switzerland, Scotland, Portugal, The Netherlands, Italy, Ireland, Greece, Finland, and Belgium all published one each.

The continent of Africa only produced eight percent of all publications, seven of which from South Africa and one from Algeria. The Middle East published just two from Saudi Arabia and Iran. Papua New Guinea was the only country representing the continent of Oceania with just one publication.

Although there were no language restrictions recorded in our inclusion criteria, all studies included were published in English.

Study type

The majority of publications were identified as review articles (42%) when looking at study type [Figure 1]. In our selection, 32 studies were listed as therapeutic studies. In total, 19 studies were diagnostic studies, focusing on medical imaging and tests. Seven articles were prognostic studies.

Category, area of research

With respect to the area of research [Figure 2], almost half of all publications focused on the clinical course ($n = 48$). Clinical outcome was the focus of 22 studies; surgical technique was listed third with 14% and medical imaging with 11%, respectively. Only a limited number of publications focused on medical treatment ($n = 3$) or laboratory tests ($n = 2$).

Anatomy and patients

Half of the articles (53%) focused on TB of the spine. The latter half ($n = 47$) focused on different body parts or specific joints such as the knee, hip, and ankle.

Only 25% of all the included publications focused exclusively on children [Figure 3]. The majority of which ($n = 22$) provided specified ages of all included patients, whereas three studies did not. The remaining 75% focused on both adults and children, which was listed as one of our inclusion

criteria. Similarly, the majority specified for age of the included patients ($n = 46$) versus 29 studies which provided unspecified age groups.

Quality

Forty-four articles were retrospective level IV studies [Figure 4]. Only two studies were level I studies, seven studies

Table 2: Scientific journals, ranked according to number of articles

Journal	Articles (n)
Journal of Bone and Joint Surgery-British Volume	23
Journal of Bone and Joint Surgery-American Volume	7
Spine	4
International Orthopaedics	4
Clinical Orthopaedics and Related Research	4
Pediatric Infectious Disease Journal	3
Spinal Cord	2
Radiology	2
Pediatrics	2
Pediatric Radiology	2
Medicine	2
Lancet	2
European Spine Journal	2
Clinical Infectious Diseases	2
Chest	2
Archives of Disease in Childhood	2
Annals of the Rheumatic Diseases	2

Table 3: Authorship

Name	Authorship		
	Total publications (n)	First author (n)	Senior author (n)
Rajasekaran, S.	6	6	2
Moon, M.S.	4	4	1
Jain, A.K.	4	3	2
Leong, (J.) C.Y.	4	0	4
Hsu, L.C.S.	2	2	0
Tuli, S.M.	2	1	2
Cremin, B.J.	2	0	2

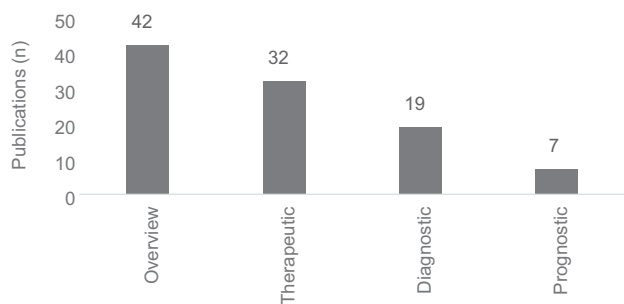


Figure 1: Study type of included publications

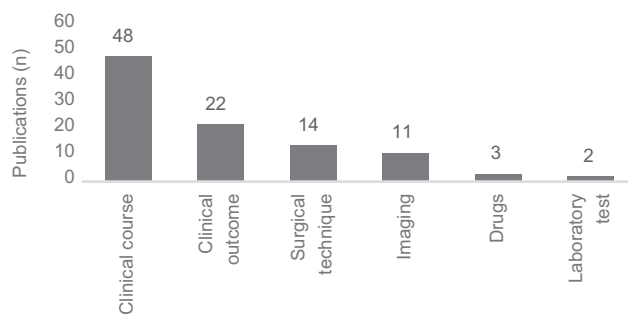


Figure 2: Area of research

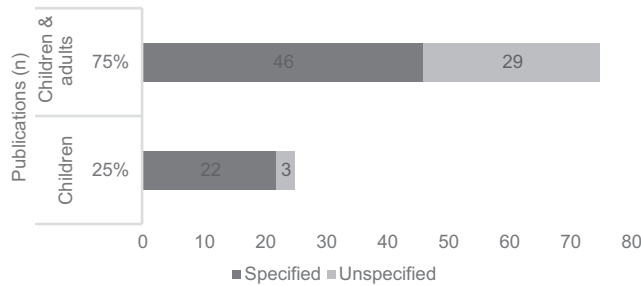


Figure 3: Patient groups

level II, 20% level III, and six studies level V. There were 14 publications that could not be assigned an LOE due to being a “basic” study type, providing a general overview and therefore do not go into detail with regard to our studied topic.

Top 10

Of the 10 most cited publications [Table 5], 50% originated from the United States ($n = 5$).

J Bone Joint Surg Am, *Medicine* and *Spine* all published two papers in this group.

These top 10 most influential articles were published on average 20.9 years (31–6), with an average citation rate of 245.1 (690–139) and an average citation density of 11,976 (31.41–5.15). The year of 2014 alone accounted for an average of 8.1 (28–0) citations.

The most cited publication was written by Bass *et al.* in 1994 and listed with 690 citations in total, a citation rate of 10 in the year 2014 and a citation density of 31.41 per year. This is the only article published in our selection by the *American Journal of Respiratory and Critical Care Medicine*. The second most cited article was a review article from 1984 of Alvarez and Mccabe with a total of 304 citations, focusing on extrapulmonary TB.

Listed as third is the *J Bone Joint Surg Am* article by Watts and Lifeso on TB of bones and joints published in 1996.

The author with most publications in the top 10 was Moon from South Korea with two publications.

DISCUSSION

Age – Oldest versus newest

Although our selection of articles has an average age of 23.11 years, most were published between the years of 2000 and 2010 ($n = 30$). The 1990s were the second most productive decade with 28 studies. This means that most high impact articles have been written in just 20 years around the turn of the century.

The most recently published article in our selection is from the year 2011. With a total citation number of 41, this merely 5-year-old article was cited 12 times in the year of 2014 alone, exceeding our top three publications. This publication focuses on spinal TB and is once more a review article. It is written by Garg and Somvanshi and originates from India.

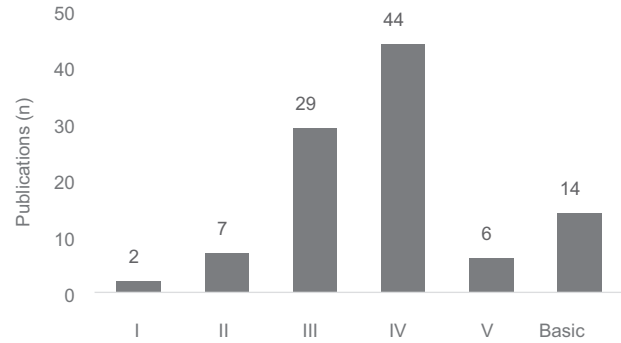


Figure 4: Level of evidence

Table 4: Geographic origin of publications

Country	Geographic origin publications (n)
India	22
USA	21
Hong Kong	9
England	7
South Africa	7
South Korea	6
Canada	4
Turkey	2
Sweden	2
Germany	2
France	2
Switzerland	1
Taiwan	1
Singapore	1
Scotland	1
Saudi Arabia	1
Portugal	1
Papua New Guinea	1
Netherlands	1
Italy	1
Ireland	1
Iran	1
Greece	1
Finland	1
China	1
Belgium	1
Algeria	1

The oldest articles included are almost 50 years, and although listed further down in this ranking, the number of citation was still above 30.

The most cited article in 2014 is another recent article from 2010, listed in the 13th place. It has the highest citation number of the preceding year with 30 total citations and a citation density of 18.17 citations per year, the third highest in our selection. It is titled *Spinal TB: A Fresh Look at an Old Disease* and has the potential to become one of the most influential publications in childhood musculoskeletal TB.

Table 5: Characteristics of our top 10 publications

	Top 10 publications
Top country	USA (n=5)
Top journal	JBJS Am (n=2), Medicine (n=2), Spine (n=2)
Top author	Moon, M.S. (n=2)
Top anatomy	General (n=7)
Top level of evidence	III (n=6)
Top study type	Retrospective (n=6)
Top study category	Basic (n=6)
Average citations	245.1 (690-139)
Average citations 2014	8.1 (28-0)
Average publication age (years)	20.9 (31-6)
Average citation density	11.976 (31, 41-5.15)

Journals

The *J Bone Joint Surg British* has so far published the highest number of articles in our selection ($n = 23$), followed by *J Bone and Joint Surg Am* ($n = 7$). Yet, the top articles in terms of citation have been published by American journals (*J Bone Joint Surg Am*, *Medicine and Spine*).

Most publications (49%) were found in journals focusing on orthopedics. Of these, 10 articles were published in journals focusing especially on spine. Interestingly, 13 publications could be found in 11 journals focusing on medical imaging or radiology. In total, only five journals could be identified as specialized in pediatrics, bringing up just ten publications ($n = 10$) in total, but seven ($n = 7$) ended up in the top 10.

Geographic origin

TB remains a global health issue, especially in the developing countries.^[1,2] Although cases of TB are seen all around the world, the true burden of TB disease lies in the developing world, where this pathogen is still responsible for infecting around ten million people each year.^[1] South Africa is known to have the third highest incidence rate of TB worldwide, after India and China.^[10]

Most publications originated from India, which also is the country with the highest burden of TB in the world.^[10] With only one publication less, the USA-based research was also the main contribution to our selection of articles. Besides India, most research originated from first world countries indicating a major lack of indigenous research from countries of high disease burden.

This might be due not only to resource limitations but also to distance between medical centers and collaborators, especially in Africa.

For instance, India has many orthopedic centers with pediatric subspecialists, whereas these services are very scarce in African countries.

Study type

The “overview article” was the most frequently identified study type in the included publications. This shows the distinct characteristics of an infrequently studied topic. As

the treatment of musculoskeletal TB in children is still a highly complex component, therapeutic studies were listed as a second most identified study type, demonstrating the comprehensiveness of its therapy and outcome.

Quality

Overall, there was a low level of scientific evidence as most publications were based on retrospective, level IV studies, conducted over long periods of time. Especially in studies that focused exclusively on children, the LOE was low.

This might be due to the fact that this disease is rare in children or that countries with high TB burden are often resource restrained and do not have the infrastructure to conduct large prospective trials. Spinal TB is most frequently seen in musculoskeletal TB infection which might explain that this was also the most studied anatomical body part.

Anatomy and patients

According to our inclusion criteria, all included studies had to involve children, which did not mean to exclude adults. The majority of publications also included adults. It shows that highly influential publications in TB research, specifically focusing on children, are very rare.

Top 10

All top 10 publications were written and published in the decades before 2000, making it more likely to gain a higher number of citations mainly due to the age of the article.

These articles were still cited regularly in 2014 and stay relevant to the research field.

The publications with the highest citations in this group are review articles and might be used by many authors as a basis for their literature review.

Limitations

Bibliometric analyses have possible limitations.^[11,12] They are based on citation analysis which is time dependent. Therefore, it has to be taken into account that such a study only reflects the findings of one moment in time and provides a snapshot of most influential literature. Nonetheless, they remain to be the current gold standard with regard to establishing the scientific impact factor.

Yet, the citation number of an article is merely a display of the overall interest in that specific publication and does not reflect its quality *per se*. It only shows the recorded time in the cited references. This may even mean it was only cited by other papers to refute the research, to demonstrate its faulty methods, fraudulent data, or other limitations.

CONCLUSION

Although most publications originate from India, there is a lack of publications from other countries with a high burden of disease. Furthermore, the quality of studies is rather low, musculoskeletal TB is less frequently studied in children than in adults and spinal TB is mostly addressed. Therefore,

possibilities are initiated and opportunities are raised for high burden countries to share their opinion. Since they should be considered experts on the subject, their limited-resource experience is of a high level of importance and relevant to the rest of the affected third world countries.

Future studies should focus on prospective research and consist of larger patient populations to improve the LOE. Finally, musculoskeletal TB in childhood specifically should be addressed more often and include affected anatomical areas other than the spine.

Financial support and sponsorship

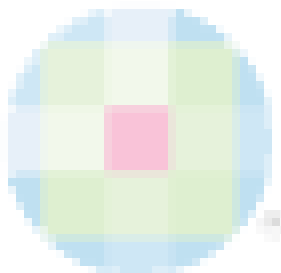
Nil.

Conflicts of interest

There are no conflicts of interest.

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APPENDIX

List I. Terms

1. Bone
2. Joint
3. Skeletal
4. Musculoskeletal
5. Osteoarticular
6. Orthopedic* OR orthopaedic*
7. Pott*
8. Osteomyelitis
9. Synovitis
10. Spondylitis
11. Arthritis OR arthritus
12. Vertebra*
13. Sacral
14. Spine OR spinal
15. Hip*
16. Knee*
17. Ankle*
18. Elbow*
19. Shoulder*
20. Foot OR feet
21. Hand*
22. Wrist*