Publication Trends in Osteoporosis Treatment: A 20-Year Bibliometric Analysis

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Background: Osteoporosis prevalence continues to escalate with the growth of the older adult population. In this study, we aimed to investigate the profile of osteoporosis treatment-related research articles published in the past 20 years using bibliometric analysis.

Methods: We analyzed all osteoporosis treatment-related articles published between 2001 and 2020 in the Web of Science (WoS) database using bibliometric methods. In the Title search section in WoS, we searched the documents using “osteoporosis treatment”-related keywords. We used the VOSviewer software to construct the bibliometric maps of keyword co-occurrences.

Results: Our search yielded 29,738 publications, 21,556 (72.5%) were original articles and 4,529 (15.2%) were review articles and review articles (4,529). We noticed a steady increase in the publication numbers from 2001 to 2020. The overall scientific publication number in WoS increased 3.5-fold, with the five most productive countries being the USA, China, Germany, the United Kingdom, and Japan. The largest contributor was the University of California system. The most productive journals were Osteoporosis International (1,679, 6.4%), Bone (832, 3.2%), and the Journal of Bone and Mineral Research (727, 2.8%). We observed increasing trends in the appearance of denosumab and teriparatide during the last two decades. In our keyword co-occurrence analysis, we constructed four keyword clusters using VOSviewer.

Conclusions: In this study, we provided a gross overview of the visibility and productivity of research studies in osteoporosis treatment. Substantial changes have occurred in osteoporosis treatment over the last 20 years. The effector mechanism of anti-osteoporosis medications could be future hot spots in osteoporosis research. We believe that our study is a valuable guide for clinicians related to the global outputs of osteoporosis treatment.

Key Words: Bibliometrics · Osteoporosis · Publications · Therapeutics

INTRODUCTION

Osteoporosis is one of the most common bone diseases in humans, representing a major health problem. It has been estimated that more than 200 million people are suffering from osteoporosis, nowadays.[1] According to recent statistics from the International Osteoporosis Foundation, one in three women over the age of 50 years and one in five men will experience fragility fractures in their lifetime.[2-4] Since life expectancy is increasing and the risk for osteoporosis increases with age, it’s not surprising that osteoporosis and its devastating outcomes are increasing around the world. Because of the morbid consequences of osteoporo-
Publication Trends in Osteoporosis Treatment

We aimed at investigating the profile of osteoporosis treatment-related research articles published in the past 20 years using bibliometric analysis.

**Aims**

- We noticed a steady increase in the publication numbers from 2001 to 2020.
- The overall scientific publication number in WoS increased 3.5-fold, with the five most productive countries being the USA, China, Germany, the United Kingdom, and Japan.
- We observed increasing trends for the appearance of denosumab and teriparatide during the last two decades.

**Results**

**Methods**

1. Literature search

   We performed the literature review using the “osteoporosis treatment” keyword in the Title search section. All published articles on osteoporosis treatment with this search method were downloaded from the Web of Science (WoS) index using bibliometric methods. The WoS is known as one of the most suitable online databases for bibliometric analysis.\(8,9\) The database included SCIE, SSCI, ESCI, A&HCI, CPCI-S, CPCI-SSH, and CCR-EXPANDED. Terms used during the search were: Theme = ([osteoporosis treatment] OR [treatment, osteoporosis] OR [treatment for osteoporosis] OR [osteoporosis management] OR [osteoporosis medication]). In addition, drug classes frequently researched including bisphosphonates, selective estrogen receptor modulators (SERMs), denosumab, and teriparatide were also used as search terms. The search was conducted on November 2, 2021. Document retrieval was completed within one day to avoid bias caused by continuous database updates. To evaluate most recent trends and hot spots in osteoporosis research, the publication period was limited to 20 years from 2001 to 2020. Original and review articles were selected for further analyses because they accounted for the majority of...
document types that also included complete research ideas and results.[10] The exclusion criteria were as follows: editorials, letters, errata, meeting abstracts, conference papers, and duplicate printings. They were excluded because they may not contain adequate, enough information for systematic reviewers to appraise the design, methods, risk of bias, outcomes, and results of studies reported.[11,12] No language restriction was imposed in the search strategy. In our bibliometric analysis, there was no need to check for duplicate articles as all data were retrieved from one database.

2. Data extraction

All literature retrieval and data extraction were performed independently by 2 authors and the differences were fully discussed until they reach an agreement. The records extracted were analyzed for citation characteristics, including languages, publication years, authors, institutions, countries, journals, impact factors, articles, and growth rate (GR). GR was calculated using the following formula: \( GR = \frac{(\text{Frequency of Current Year} - \text{Frequency of Last Year})}{\text{Frequency of Last Year}} \times 100.\) [13] In addition, total citations, average citations, and h-index were extracted from the WoS database. The h-index is an author-level metric that tries to measure both the productivity and citation impact of the publications of an author; an author has h-index if his (or her) number of papers have at least h citations.[14] Thus, the h-index reflects both the number of publications and the number of citations per publication. Particularly, h-index can be extended to describe publications of a country, a journal, or an organization.[15] VOSviewer, a Java software, was used to create maps from bibliographic data and to visualize the intrinsic meaning of the maps in the present study.

3. Statistical analysis

The data were analyzed quantitatively and qualitatively by Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA). We performed a quantitative description of time distribution, country of origin, institution, number of studies by author, and frequency of citation by country through the bibliometric approach. Linear regression analysis was conducted to calculate the estimated number of publications in the following years. Wilcoxon signed-rank test was used to compare any significant differences between the groups in terms of continuous variables. SPSS (version 22.0; SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Statistical analysis was performed by an independent statistician, blinded to group allocations. The level of significance was set at \( P \)-values less than or equal to 0.05.

RESULTS

1. Literature review and studies included

The literature search revealed 29,738 publications on osteoporosis treatment published between 2001 and 2020.
Of all these publications, 21,556 (72.5%) were articles, 4,529 (15.2%) were review articles, 2,789 (9.4%) were meeting abstracts, 764 (2.6%) were proceedings papers, 45 (0.2%) were book chapters, and 55 (0.2%) were others (retracted publications, and early access) (Fig. 1).

Bibliometric analyses were performed on 26,085 (original articles and review articles) out of 29,738 publications. The 24,604 (94.3%) were identified from SCIE, 1,350 (5.2%) were identified from ESCI and 1,263 (4.8%) were identified from SSCI and 917 (3.5%) were identified from others. Twenty-seven languages of publication were identified in the 26,085 articles. The 3 predominant languages were English (N=24,751, 94.9%), German (N=608, 2.3%), and Spanish (N=193, 0.7%). All other languages including French, Turkish, Russian, Portuguese, Polish, Czech, Italian, Japanese, Korean, Hungarian, and Chinese amounted to less than 2%.

We also counted the number of published papers according to the following medication classes: bisphosphonate, denosumab, SERM, and teriparatide. Multiple naming of different drugs within one paper was classified into each medication class.

### 2. Development of publications

The 640 articles were published in 2001, increasing to 2,222 in 2020. The mean number of articles published over the period is 1,304.3 per year. Figure 2A shows that the number of articles increased steadily during the past two decades. The overall number of scientific publications in WoS increased 3.5 times. The largest growth in publications since 2001 was between 2004 and 2005, from 717 to 910 publications, an annual GR of 26.9%. The year 2020 (2,222 papers) was the peak of the number of literatures. Of the 26,085 articles...
cles, 17,084 (65.5%) were published in the last decade, compared with 9,001 (34.5%) in the decade prior. The average GR of the literature regarding osteoporosis treatment was 6.65% over the last 20 years. Using the cumulative number of publications, we calculated the linear adjustment and found $y = 80.7586x - 161061$ with $r^2 = 0.974$ (Fig. 2B). According to the calculated curve model, it is estimated that the number of publications will reach 2,475 by 2025.

3. Distribution of the countries and active authors

Authors from a total of 133 countries contributed to the 26,085 published articles. The distribution of the top productive world countries is demonstrated in Table 1. The USA has the largest number of publications. The top productive countries were the USA, China, Germany, United Kingdom, and Japan. The top three countries accounted for 49.5% of all articles. Publications from the USA had the highest h-index (234; citations per article = 49.87), followed by those from the United Kingdom (h-index = 144; citations per article = 53.98) and those from Canada (h-index = 120; citations per article = 53.78).

The top five active authors who had the highest number of publications on this topic were Reginster JY (259), Cooper C (220), Kanis JA (210), Eastell R (154), and Lewiecki EM (142).

4. Highly contributive institutions

The top five institutions that had the highest number of publications on this topic were University of California System (906, 3.5%), Harvard University (676, 2.6%), Institut National de la Santé et de la Recherche Médicale (521, 2.0%), University of Sheffield (486, 1.8%), and University of California San Francisco (447, 1.7%). Although there is no doubt that USA currently has the most powerful impact on the field with respect to both productivity and contribution (three of the top five institutions are in USA), European institutions have also played an outstanding role. Institutions from Asia, South America, and Africa were not among the top 10. Table 2 demonstrates the top ten institutions contributing to publications on osteoporosis treatment.

### Table 2. Top 10 institutions contributing to publications on osteoporosis treatment

<table>
<thead>
<tr>
<th>Rank</th>
<th>Institution</th>
<th>Number of publications</th>
<th>Percentage of total (%)</th>
<th>Total citations</th>
<th>H-index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University of California System</td>
<td>906</td>
<td>3.5</td>
<td>70,755</td>
<td>123</td>
</tr>
<tr>
<td>2</td>
<td>Harvard University</td>
<td>676</td>
<td>2.6</td>
<td>53,613</td>
<td>105</td>
</tr>
<tr>
<td>3</td>
<td>Institut National de la Santé et de la Recherche Medicale</td>
<td>521</td>
<td>2.0</td>
<td>33,397</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>University of Sheffield</td>
<td>486</td>
<td>1.8</td>
<td>37,167</td>
<td>94</td>
</tr>
<tr>
<td>5</td>
<td>University of California San Francisco</td>
<td>447</td>
<td>1.7</td>
<td>41,796</td>
<td>93</td>
</tr>
<tr>
<td>6</td>
<td>US Department of Veterans Affairs</td>
<td>408</td>
<td>1.6</td>
<td>24,522</td>
<td>81</td>
</tr>
<tr>
<td>7</td>
<td>Veterans Health Administration</td>
<td>397</td>
<td>1.5</td>
<td>24,364</td>
<td>81</td>
</tr>
<tr>
<td>8</td>
<td>Assistance Publique-Hopitaux de Paris</td>
<td>385</td>
<td>1.5</td>
<td>22,370</td>
<td>77</td>
</tr>
<tr>
<td>9</td>
<td>Columbia University</td>
<td>385</td>
<td>1.5</td>
<td>20,440</td>
<td>86</td>
</tr>
<tr>
<td>10</td>
<td>University of Toronto</td>
<td>376</td>
<td>1.4</td>
<td>18,741</td>
<td>68</td>
</tr>
</tbody>
</table>

### Table 3. Top 10 active journals on osteoporosis treatment

<table>
<thead>
<tr>
<th>Rank</th>
<th>Journal</th>
<th>Number of publications</th>
<th>Percentage of total (%)</th>
<th>Total citations</th>
<th>Impact factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osteoporosis International</td>
<td>1,679</td>
<td>6.4</td>
<td>65,039</td>
<td>4.507</td>
</tr>
<tr>
<td>2</td>
<td>Bone</td>
<td>832</td>
<td>3.2</td>
<td>34,061</td>
<td>4.147</td>
</tr>
<tr>
<td>3</td>
<td>Journal of Bone and Mineral Research</td>
<td>727</td>
<td>2.8</td>
<td>50,427</td>
<td>6.741</td>
</tr>
<tr>
<td>4</td>
<td>Calcified Tissue International</td>
<td>362</td>
<td>1.4</td>
<td>10,948</td>
<td>3.860</td>
</tr>
<tr>
<td>5</td>
<td>Journal of Bone and Mineral Metabolism</td>
<td>331</td>
<td>1.3</td>
<td>6,185</td>
<td>2.626</td>
</tr>
<tr>
<td>6</td>
<td>The Journal of Clinical Endocrinology and Metabolism</td>
<td>312</td>
<td>1.2</td>
<td>31,344</td>
<td>5.958</td>
</tr>
<tr>
<td>7</td>
<td>Archives of Osteoporosis</td>
<td>281</td>
<td>1.1</td>
<td>3,836</td>
<td>2.017</td>
</tr>
<tr>
<td>8</td>
<td>Plos One</td>
<td>238</td>
<td>0.9</td>
<td>5,042</td>
<td>3.240</td>
</tr>
<tr>
<td>9</td>
<td>Journal of Clinical Densitometry</td>
<td>216</td>
<td>0.8</td>
<td>4,133</td>
<td>2.617</td>
</tr>
<tr>
<td>10</td>
<td>Current Osteoporosis Reports</td>
<td>207</td>
<td>0.8</td>
<td>3,512</td>
<td>4.690</td>
</tr>
</tbody>
</table>
Table 4. Top 10 most cited articles from 2001 to 2020

<table>
<thead>
<tr>
<th>Rank</th>
<th>Title</th>
<th>Year</th>
<th>Journal</th>
<th>Total citations</th>
<th>Average citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Evaluation, treatment, and prevention of vitamin D deficiency: an endocrine society Clinical practice guideline</td>
<td>2011</td>
<td>The Journal of Clinical Endocrinology and Metabolism</td>
<td>4,728</td>
<td>429.82</td>
</tr>
<tr>
<td>2</td>
<td>Clinician’s guide to prevention and treatment of osteoporosis</td>
<td>2014</td>
<td>Osteoporosis International</td>
<td>1,424</td>
<td>178</td>
</tr>
<tr>
<td>3</td>
<td>Osteoporosis: now and the future</td>
<td>2011</td>
<td>Lancet</td>
<td>1,298</td>
<td>118</td>
</tr>
<tr>
<td>4</td>
<td>WNT signaling in bone homeostasis and disease: from human mutations to treatments</td>
<td>2013</td>
<td>Nature Medicine</td>
<td>1,109</td>
<td>123.22</td>
</tr>
<tr>
<td>5</td>
<td>Osteoporosis in the European Union: medical management, epidemiology and economic burden</td>
<td>2013</td>
<td>Archives of Osteoporosis</td>
<td>941</td>
<td>104.56</td>
</tr>
<tr>
<td>6</td>
<td>Lack of exercise is a major cause of chronic diseases</td>
<td>2012</td>
<td>Comprehensive Physiology</td>
<td>927</td>
<td>92.70</td>
</tr>
<tr>
<td>7</td>
<td>European guidance for the diagnosis and management of osteoporosis in postmenopausal women</td>
<td>2013</td>
<td>Osteoporosis International</td>
<td>852</td>
<td>94.67</td>
</tr>
<tr>
<td>8</td>
<td>Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases</td>
<td>2015</td>
<td>Scandinavian Journal of Medicine &amp; Science in Sports</td>
<td>801</td>
<td>114.43</td>
</tr>
<tr>
<td>9</td>
<td>Genome-wide meta-analysis identifies 56 bone mineral density loci and reveals 14 loci associated with risk of fracture</td>
<td>2012</td>
<td>Nature Genetics</td>
<td>766</td>
<td>76.60</td>
</tr>
<tr>
<td>10</td>
<td>The Achilles’ heel of senescent cells: from transcriptome to senolytic drugs</td>
<td>2015</td>
<td>Aging Cell</td>
<td>736</td>
<td>105.14</td>
</tr>
</tbody>
</table>

Fig. 3. Distribution of yearly publications on each anti-osteoporosis medication (A) bisphosphonate, (B) selective estrogen receptor modulators (SERMs), (C) denosumab, and (D) teriparatide.
5. Active research areas and active journals

According to the analysis of WoS databases, the top 5 research areas that had the highest number of publications were Endocrinology Metabolism (6,834, 26.2%), Pharmacology Pharmacy (2,521, 9.7%), Orthopedics (2,428, 9.3%),

Fig. 4. (A) Mapping on co-occurrence of keywords regarding osteoporosis treatment. The size of a point represents the frequency of the keywords. The line between two points represents that both keywords occurred in one paper. (B) Visualization of time when a keyword appeared. Keywords in blue appeared earlier than that in yellow.
Medicine General Internal (2,139, 8.2%), and Medicine Research Experimental (1,738, 6.7%). The top ten journals that had the highest number of publications related to osteoporosis treatment and the total number of citations are demonstrated in Table 3. The top three journals that had the highest number of publications were Osteoporosis International (1,679, 6.4%), Bone (832, 3.2%), and Journal of Bone and Mineral Research (727, 2.8%), accounting for 12.4% of all published literature relating to the field. The New England Journal of Medicine, which had the highest 2020 impact factor (91.245) among all of these journals, published 36 articles.

6. Citation analysis
Table 4 demonstrates the top-cited ten articles that were analyzed bibliometrically according to the total number of citations in the 2001 to 2020 period. The last column of Table 4 demonstrates the average number of citations of the articles per year. The highest number of citations of a single article belonged to Holick MF of the Boston University (4,728 citations), which was published in the Journal of Clinical Endocrinology & Metabolism. According to our analysis of the WoS index, all highly cited articles (151) regarding osteoporosis treatment have been cited 46,916 times since 2001 (46,671 times without self-citations). The cited frequency per article was 310.7 times.

7. Drug classes
In terms of drug classes, the anti-osteoporosis medication most frequently researched were bisphosphonate (9,997), followed by SERM (3,801), denosumab (2,820), and teriparatide (2,051). The increase in number of publications on each drug was consistent and stable in general, but the number of publications regarding SERM has fluctuated slightly over the past 20 years. Figure 3 shows that the relative supremacy of the bisphosphonate and SERM has declined over the last 5 years. On the contrary, increasing trends have been observed for denosumab and teriparatide during the last two decades (Fig. 3). The increase in publications on denosumab jumped significantly between 2016 and 2017 (GR = 26%). There was a statistically significant difference in the rate of increase of all publications on denosumab and teriparatide compared to all publications on osteoporosis treatment over the study period ($P = 0.001$ and $P = 0.019$, respectively). All articles about currently licensed romosozumab were published between 2013 and 2020.

8. Hotspots of papers on osteoporosis treatment
Figure 4A demonstrates the keywords analysis of publications regarding osteoporosis treatment by VOSviewer. Due to the large number of keywords, the minimum number of occurrences of a keyword was set as 100. Of the 18,038 keywords, 163 met the threshold and were chosen for analyzing. The keywords were classified into four clusters. Red points (cluster 1) which consist of 57 items are mainly about osteoporosis and bone. Green points (cluster 2) which consist of 51 items are mainly about hip fracture. Blue points (cluster 3) which consist of 31 items are mainly about bone mineral density (BMD) and postmenopausal women. Yellow points (cluster 4) which consist of 24 items are mainly about bisphosphonates and alendronate. An overlap visual rainbow diagram (Fig. 4B) is drawn based on the approximate year in which the keyword appears, and the color varies with the timeline. Blue and purple nodes appear earlier than yellow nodes, meaning that Keywords in yellow are hot keywords. As can be seen from the figure, most of the studies before 2014 focused on cluster 3 and 4. Current trend keywords used in recent years were RANKL, osteoclast, osteoblast, differentiation, expression, mesenchymal stem cells, and denosumab.

DISCUSSION
Substantial changes have occurred over the last two decades in the pharmacological management of osteoporosis. The aim of our study was to investigate the profile of research articles on osteoporosis treatment published from 2001 to 2020 and our bibliometric analysis of research articles indicates an exponential growth in published evidence, with an average annual GR of 6.65%. In addition, we analyzed the changing patterns of most commonly prescribed medications (bisphosphonate, SERM, denosumab, and teriparatide) specifically, and have discovered the direction of rapid development that may become future trends and hot spots to attract scientists and researchers.

In recent years, a large volume of literature has become available to clinicians prescribing anti-osteoporosis medication. According to our study, over the past two decades,
the number of articles about osteoporosis treatment has shown an increasing trend in general. This may be due to the rapid increase in the number of patients with osteoporosis parallel to the aging of the population, and the continuous penetration of the concept of “fracture prevention” has prompted an increasing number of physicians, surgeons, and patients to have an interest in osteoporosis treatment. This in turn stimulates the research and development of alternate therapies by academic institutes as well as pharmaceutical companies for inventing novel osteoporosis treatment strategies with high potency and low complication compared to conventional modalities. Given the situation of aging populations in most developed and developing countries, the number of high-quality research on osteoporosis treatment is expected to increase in the coming years.[16] Therefore, we can predict that the trend in the next 5 years or even 10 years will have an even more significant growth.

The increase in the number of novel studies can be an indicator of rapid development in the country’s level of education, service delivery, and shift from a production-based economy to a knowledge-based economy.[17] The USA is responsible for the greatest number of citations and is by far the most productive country, suggesting that there were both quantity and quality in their publications about osteoporosis treatment research. This is mainly attributed to the USA having the most advanced medical research level along with the strongest economic strength. China also has had many published articles related to osteoporosis treatment in recent years. China ranked second in the total number of publications, but seventh in citation frequency and tenth in h-index. This suggested that the quality of articles from China still required improvements. The results of our study might be helpful for all those involved in worldwide osteoporosis treatment research. Fellows and researchers choosing an institution for advanced work may be interested in such an analysis. In addition, policymakers and governments can ascertain the most effective countries and institutions in the world in this field, and our study may assist them to predict the future directions of osteoporosis research and to target resources so that further developments can be supported.

According to our study, Osteoporosis International, Bone, and Journal of Bone and Mineral Research are the top 3 productive journals on osteoporosis treatment, suggesting that there will be more novel studies on this issue to be published in these journals. Given its reliable content, we can expect future breakthroughs in this field to be published there, and authors interested in osteoporosis treatment should pay more attention to these journals. We believe that our analysis can help researchers and practitioners better understand osteoporosis research worldwide and be useful, for instance, in choosing appropriate journals for publication and collaborations. Journals can determine where they stand in relation to other journals in publishing articles regarding osteoporosis treatment. Impact factors have been extensively used to evaluate the quality of a journal.[18] In our study, we presented the top 10 journals with the highest number of articles and their impact factors, but further analysis and discussion are required. Journals with high impact factors occasionally publish low-quality articles, and doubts about the importance of impact factors may remain.[19]

Currently, a large volume of literature has become available to clinicians prescribing various anti-osteoporosis medications. According to the present study, bisphosphonates were the most studied drugs for osteoporosis treatment. However, fewer articles have been published on bisphosphonates over the last few years. This is not surprising as bisphosphonates had been a hot research topic between 2010 and 2015. The plateauing and subsequent decline in the use of bisphosphonates is noted from 2015 to 2020, which follows reports of safety concerns in popular media despite consensus reports documenting their safety in the scientific literature.[20] On the contrary, many of the publications regarding denosumab have shaped the current research and clinical landscape. Several factors may have contributed to the switch from traditional bisphosphonates to denosumab in the outpatient management of osteoporosis. Hadji et al. [21] recently demonstrated that the 2-year persistence of denosumab was 39.8%, which was 1.5 to 2 times higher than that for bisphosphonates. Patient preference for 6-monthly denosumab injections versus intravenous bisphosphonates or daily oral tablets was not surprising in relation to the more acceptable, simple route of administration (subcutaneously) and the less frequent dosing regimen (6-month intervals).

Detailed analysis of co-occurrence keyword results will help us grasp the treatment of osteoporosis for the future of the research hotspot. Cluster 1 is “osteoporosis and the
mechanism of anti-osteoporosis medications”. To improve effectiveness and reduce adverse effects, many studies on drugs’ mechanisms of action such as osteoclast inhibition and osteoblast growth promotion have been conducted. Cluster 2 relates to the epidemiology, risk factors, and management of complications of postmenopausal osteoporosis. The worst complications of postmenopausal osteoporosis are fractures, especially hip and vertebral fractures. So the accurate assessment and prediction of the risk of fractures are particularly crucial. To avoid the devastating outcomes due to osteoporosis, prevention is better than treatment. Cluster 3 relates to “studies associated with BMD in the diagnosis of postmenopausal osteoporosis”. Assessment of BMD has provided a crucial determinant of fracture risk, and many guidelines have used BMD thresholds to determine whether treatments should be recommended. Many cross-sectional and prospective population studies indicate that the risk for fracture increases by a factor of 1.5 to 3.0 for each standard deviation decrease in BMD.[22] Cluster 4 relates to bisphosphonate therapy and various kinds of bisphosphonates. Bisphosphonates have been accepted for the treatment and prevention of postmenopausal osteoporosis as an anti-resorptive agent. However, the optimal duration of treatment is not yet known and long-term use has been associated with complications such as atypical femur fractures and osteonecrosis of the jaw. It is recommended that the need for bisphosphonate treatment should be reviewed every three to five years.[23,24] In visualized maps of co-occurrence of keywords, it can be noted that most of the yellow keywords are distributed in cluster 1. Based on Figure 4B, the analysis of bibliometrics showed that RANKL, osteoclast, osteoblast, differentiation, expression, mesenchymal stem cells, and denosumab may be the new research hotspot in this field in the present study. Current trends key words used in recent years were generally related to the mechanism of action of anti-osteoporosis medications. Therefore, more attention will perhaps be paid to it in the future.

There are some limitations to this study. First, our study is a bibliometric analysis of “osteoporosis treatment” or “osteoporosis management”. As osteoporosis treatment includes both pharmacologic and non-pharmacologic therapy, there is a possibility that the publications regarding non-pharmacologic therapy (e.g., exercise and dietary changes) that were not discussed in detail might be included in our bibliometric analysis. Second, the search terms used in our study may not have identified all the publications related to the subject of the study completely. In the title of some publications on medications for osteoporosis, other terms such as “change in BMD” and “fracture prevention” are often used instead of “osteoporosis treatment”. More enormous information and a gross overview may have been obtained if we didn’t focus on the treatment of osteoporosis.

In conclusion, there has been a consistent increase in the volume of published articles on osteoporosis treatment over the 20-year period, and the number of literature is expected to increase in the coming years. In recent years, publication trends in the drug treatment of osteoporosis have changed, and the mechanism of action of current anti-osteoporosis medications has been evaluated in detail. We believe that our study provides a gross overview of osteoporosis treatment and could be a valuable guide for researchers and clinicians.

DECLARATIONS

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Conflict of interest
No potential conflict of interest relevant to this article was reported.

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