Exploration of Musculoskeletal Diseases

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# Work-related musculoskeletal disorders among surgeons: a bibliometric analysis from 1982 to 2024

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**Academic Editor:** Fernando Pérez-Ruiz, Cruces University Hospital, Spain
**Received:** April 10, 2024 **Accepted:** May 28, 2024 **Published:** July 30, 2024

**Cite this article:** Gorce P, Jacquier-Bret J. Work-related musculoskeletal disorders among surgeons: a bibliometric analysis from 1982 to 2024. Explor Musculoskeletal Dis. 2024;2:317–35. https://doi.org/10.37349/emd.2024.00059

## Abstract

Surgeons are exposed to a high prevalence of work-related musculoskeletal disorders (WMSDs). The scientific issues surrounding this problem are generating a growing body of work. The aim of this study is to obtain quantitative and visual information from articles about WMSDs and surgeons through bibliometric analysis. The keywords "surgeon" and "work-related musculoskeletal disorders" were searched in the PubMed/Medline database until March 2024. Data extraction and visualization were performed using VOSviewer version 1.6.20. and Microsoft Excel on the overall distribution of publications by year, sources, articles, authors and keywords. A total of 173 English-language publications were extracted between 1982 and 2024. The number of publications has increased over the years. A significant increase was observed from 2016. America is the leader with 82/173 publications (47.4%) and 3,276 citations. Work [impact factor (IF): 2.3] is the first top source which has 7 articles followed by Surgical Endoscopy (IF: 3.1) with 5 publications. Journal of Occupational Rehabilitation (IF: 3.3) is the top journal with 681 citations for 2 publications. Hallbeck MS, Yu D, and Vijendern A are the most productive authors with 23 publications. The analysis showed that the United States and the UK are the two most productive countries (journals, authors, citations). The most frequently used keywords were "ergonomics", "musculoskeletal disorders", "work-related musculoskeletal disorders", and "surgeons". Bibliometric analysis has shown that the prevalence of WMSDs in surgeons is a topic showing significant growth, particularly since 2016, dominated by American researchers. A synthesis of the WMSD prevalence by body area has been made based on the most cited articles. This field has evolved considerably. From a rather subjective analysis of prevalence based on questionnaires, work has moved towards a more ergonomic assessment using objective evaluation tools.

## Keywords

Ergonomics, prevalence, surgery, musculoskeletal disorders, pain, injury, occupational safety, operating room

## Introduction

Musculoskeletal disorders are very common in the world of occupational health [1]. They affect the skeletal muscles, nerves, tendons, ligaments, joints, cartilage, or vertebral discs which occur slowly over time due to repetitive wear and tear or microtrauma. The overall prevalence of work-related musculoskeletal disorders (WMSDs) is very high among healthcare professionals [2–6]: between 87.2% and 93% among dentists [7, 8], between 90% and 92% for midwives [9, 10], between 56.8% to 92.5% for nurses [11, 12], 58% among osteopaths [13], and between 47.6% and 96% among physiotherapists [14, 15]. Among surgeons, this problem has become increasingly acute over the last 15 years. Their overall prevalence has been estimated at over 80% [16, 17]. This high rate is explained by the fact that a surgeon works for long periods in a static position that is often awkward, with repetitive movements that require a high level of precision [18–20]. These WMSDs expose surgeons to numerous pathologies such as spinal degeneration [21], rotator cuff pathology [22], or carpal tunnel [23].

Numerous studies have investigated prevalence by body area in open surgery. Neck, lower back and upper limb are the most exposed areas. Various authors have reported prevalence of between 46.6% and 66.6% for the neck [24, 25], between 39.0% and 71.7% for the lower back [26, 27], between 25.8% and 61.5% for the shoulder [17, 28], and between 31.3% and 38.3% for the wrist [25, 29].

Progressively, minimally invasive surgery has been developed with the use of increasingly sophisticated technological equipment. This change in surgical practice is associated with high levels of strain [30] and has an effect on the risk of WMSDs, particularly in the shoulder, wrist and thumb [31]. Some authors have reported prevalence rates by area in the context of assisted surgery. Franasiak et al. [32] and Adams et al. [33] reported a prevalence ranging from 58.8% to 72.9% for the neck, Wohlauer et al. [26] and Szeto et al. [16] from 44.2% to 68.1% for the lower back, Wauben et al. [34] and Tjiam et al. [35] from 51.2% to 77.0% for the shoulder, and Liberman et al. [36] and Adams et al. [33] from 44.2% to 60.9% for the wrist. These areas are also highly exposed to WMSDs among other healthcare professionals, as highlighted by Jacquier-Bret and Gorce [2]. Neck and lower back have often been studied and considered by numerous studies to be the areas with the highest prevalence among dentists (68.5% [8] and 60.1% [37]), midwives (45.3% and 71.4% [9]), nurses (50.1% [38]; 65.7% [39]), physiotherapists (47.6% [40] and 69.8% [41] respectively for these two body areas). The high prevalence observed for surgeons' shoulders and extremities are also found among dentists (shoulder: 60.0% [8], elbow: 25.4% [37], wrist: 69.5% [8]). Lower prevalence rates were reported for lower limbs in surgeons (18.5% and 15.2% for knee and ankle by meta-analysis [31] and 10.1% for hip [24]). These values are lower than those reported for nurses by Asghari et al. [11] (60.5% and 55.8% respectively for knee and ankle) and Choobineh et al. [42] (29.3% for hip).

Bibliometric analysis measures the development of a scientific field, and has been used frequently in the medical field [43, 44]. It is based on the evaluation of one or more databases to explore and analyze a large number of scientific data to study their development and evolution. To our knowledge, no bibliometric study on WMSDs among surgeons has been conducted.

This research aims to obtain quantitative and visual information from articles about this domain. The bibliometric analysis was performed on PubMed/Medline-indexed publications. The analysis of this research was based on a performance analysis, an analysis of sources and articles, and an analysis of the intellectual structure of authorship that maps keywords and relationships between authors.

## Materials and methods

The literature search was carried out using PubMed/Medline in one day (March 25, 2024) to avoid deviations and take into account the rapid evolution of the literature. Two keywords were used to identify articles: "surgeon*" (wildcard character for singular and plural keyword) AND "work-related musculoskeletal disorders". Only English-language articles and journals were selected. No date limit was imposed.

Search results were exported from PubMed/Medline into Comma Separated Value (CSV) files in Microsoft® Excel. Various data relating to journals (IF: impact factor, h-index, SJR: Scimago Journal Rank, Q: quartile ranking of a journal in a specific field, ISSN: International Standard Serial Number, Np: number of publication on the field), articles (keywords, GCS: global citation score) and authors (h-index) were then added. These data were extracted independently by two editors. Discrepancies were resolved by consensus after re-examination of the article.

VOSviewer software version 1.6.20 (Leiden University, Leiden, the Netherlands) was used for the bibliometric analysis. Co-authorship and co-occurrence analysis were performed with VOSviewer in this study. The analyses of publication frequency by year, number of article citations by country, analysis of the Source (Np and GCS), of authors, and of highly cited articles have been conducted with Microsoft® Excel.

# Results

## Performance analysis

### Publication frequency by year

A total of 173 scientific publications written in English with the keywords "surgeon*" and "work-related musculoskeletal disorders" were found in the PubMed/MedLine database. The 173 studies comprised 17 reviews with or without meta-analysis and 156 original researches or pilot studies. The majority of original research studies were cross-sectional surveys that assess the prevalence of WMSDs using questionnaires. All works cover the period from 1982 to 2024. Figure 1 illustrates the publication rate by year over this period. A very low number of studies were carried out between 1982 and 2007 (one study per year, except for 2001 with 2 studies). Over the period 2008–2015, the number of studies increased slightly (between 2 and 5 studies per year; average 3.6 studies/year). Since 2016, this number has increased considerably, tripling in 8 years: 13 publications in 2016 and 41 in 2023 (+ 3 to 4 publications per year). Linear regressions performed with Excel show the overall tendency toward more articles being published, with correlation coefficients $r^2$ = 0.614 and $r^2$ = 0.863 for the period 2008–2015 and 2016–2023 respectively. These results reflect the growing interest in the study of WMSDs among surgeons, especially with the rapid increase in recent years.

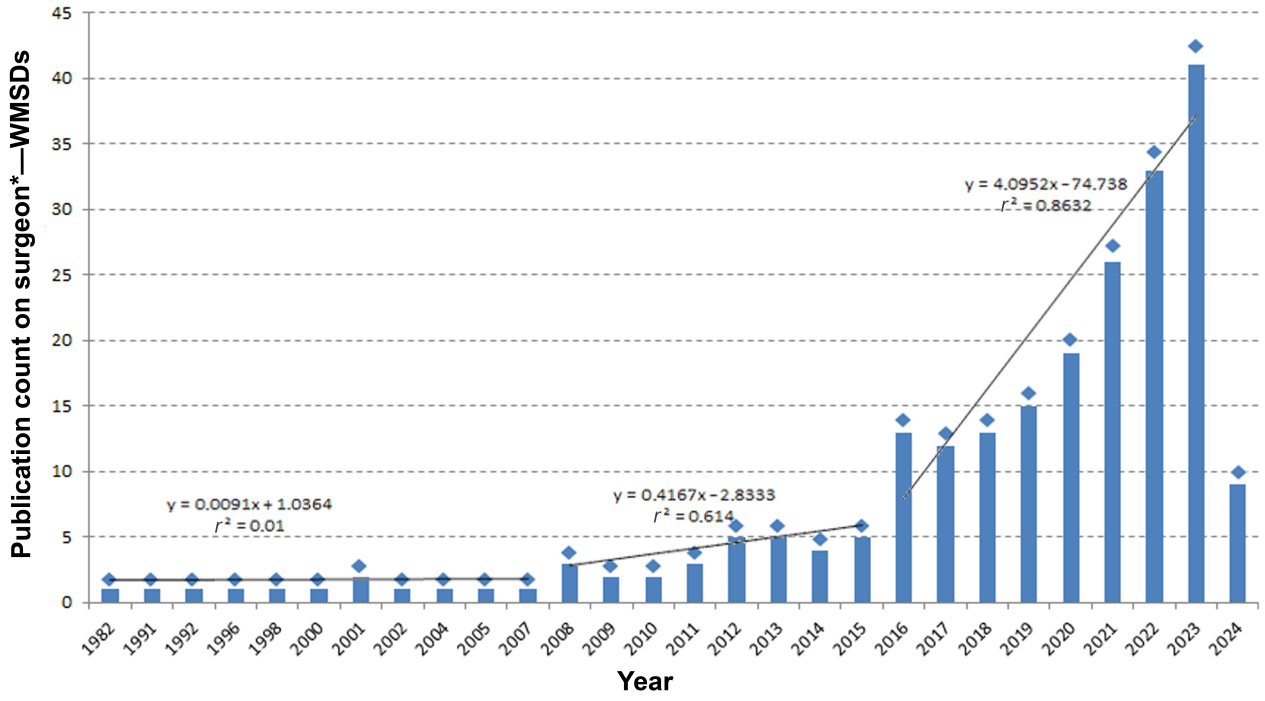


**Figure 1.** The number of publications by year from 1982 to date

### Number of article citations by country

Citation analysis was conducted considering a minimum of 1 article and one citation per country with no limit of countries in one article. Table 1 shows the top 16 countries/regions for all articles. America is the clear leader in this field, with 82 publications out of the 173 selected, i.e. 47.4% of publications and 3,276 citations. The UK, Canada, India, and Saudi Arabia rank in the next 4 places, with eight times fewer publications (between 9 and 13). There is nevertheless a wide disparity in citations. The UK has 697 citations with 13 publications (7.5%), while India and Canada have only 467 and 386 citations respectively with 10 publications each (5.8%). Saudi Arabia is much less cited, with just 181 citations for 9 publications (5.2%). The other 11 countries have fewer publications (7 and under) with few citations. Italy and Sweden have a good citation rate (182 and 177 citations respectively), equivalent to that of Saudi Arabia despite their low number of works (5 and 3 respectively).

**Table 1.** The top sixteen countries/regions with the highest productivity

| Rank | Country | Region | Np[$] | % | GCS[#] |
|---|---|---|---|---|---|
| 1 | United States | America | 82 | 47.4% | 3,276 |
| 2 | UK | Europe | 13 | 7.5% | 697 |
| 3 | Canada | America | 10 | 5.8% | 386 |
| 3 | India | Asia | 10 | 5.8% | 467 |
| 5 | Saudi Arabia | Asia | 9 | 5.2% | 181 |
| 6 | France | Europe | 7 | 4.0% | 98 |
| 7 | Germany | Europe | 6 | 3.5% | 96 |
| 8 | Italy | Europe | 5 | 2.9% | 182 |
| 9 | Australia | Oceania | 3 | 1.7% | 27 |
| 9 | Greece | Europe | 3 | 1.7% | 36 |
| 9 | Sweden | Europe | 3 | 1.7% | 177 |
| 12 | Brazil | America | 2 | 1.2% | 86 |
| 12 | Ireland | Europe | 2 | 1.2% | 22 |
| 12 | Japan | Asia | 2 | 1.2% | 8 |
| 12 | Netherland | Europe | 2 | 1.2% | 63 |
| 12 | Spain | Europe | 2 | 1.2% | 76 |

[$] Np: number of publication on the field; [#] GCS: global citation score

## Analysis of the source

### Source analysis based on the number of documents

Source analysis based on the number of documents or articles using Excel. The results show that 110 PubMed/MedLine-indexed sources have published the 173 identified articles. In Table 2 presenting the 18 top-ranking sources (due to the number of journals with 3 publications), it can be seen that Work (IF: 2.3) is the first top source which has 7 articles followed by Surgical Endoscopy (IF: 3.1) with 5 publications. Clinical Orthopaedics (IF: 4.2) and Related Research (IF: 3.8) come next, each with 4 publications. The next 14 journals in the ranking each have 3 publications. Just over a third of publications appeared in the top 18 academic journals (62/35.8%). The IFs of the top 18 journals range from 1.4 to 4.3 and h-indexes from 55 to 225, except for Annals of Surgery (IF: 9.4; h-index: 335) and Annals of the Rheumatic Diseases (IF: 27.4; h-index: 272), which have much higher impacts and h-indexes. In this top 18, the two countries with the highest number of journals are the United States and United Kingdom, with 10 and 5 journals respectively, widely outranking the other countries.

**Table 2.** Top-ranking sources with at least 3 publications

| Rank | Sources | IF* | Np[$] | GCS[#] | ISSN[£] | h-index | SJR[&] | Q[§] | Country |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Work | 2.3 | 7 | 27 | 18759270, 10519815 | 58 | 0.51 | Q2 | Netherland |
| 2 | Surgical Endoscopy | 3.1 | 5 | 128 | 14322218, 09302794 | 166 | 1.12 | Q1 | United States |
| 3 | Clinical Orthopaedics and Related Research | 4.2 | 4 | 97 | 15281132, 0009921X | 225 | 1.19 | Q1 | United States |

**Table 2.** Top-ranking sources with at least 3 publications (*continued*)

| Rank | Sources | IF* | Np[$] | GCS[#] | ISSN[£] | h-index | SJR[&] | Q[§] | Country |
|---|---|---|---|---|---|---|---|---|---|
| 3 | Occupational Medicine | 3.8 | 4 | 137 | 09627480, 14718405 | 97 | 0.82 | Q2 | United Kingdom |
| 5 | The American Journal of Surgery | 2.4 | 3 | 63 | 00029610, 18791883 | 163 | 0.85 | Q1 | United States |
| 5 | Annals of the Rheumatic Diseases | 27.4 | 3 | 101 | 00034967, 14682060 | 272 | 6.49 | Q1 | United Kingdom |
| 5 | Annals of Surgery | 9.4 | 3 | 277 | 15281140, 00034932 | 335 | 2.95 | Q1 | United States |
| 5 | Applied Ergonomics | 2.6 | 3 | 278 | 18729126 | 119 | 0.922 | Q1 | United Kingdom |
| 5 | Dermatologic Surgery | 2.4 | 3 | 146 | 10760512, 15244725 | 134 | 0.56 | Q2 | United States |
| 5 | Ergonomics | 2.4 | 3 | 33 | 00140139, 13665847 | 124 | 0.76 | Q1 | United Kingdom |
| 5 | The Journal of Laryngology & Otology | 1.4 | 3 | 101 | 17485460, 00222151 | 72 | 0.57 | Q2 | United Kingdom |
| 5 | Journal of Reconstructive Microsurgery | 2.8 | 3 | 96 | 0743684X, 10988947 | 61 | 1.01 | Q1 | United States |
| 5 | Journal of Vascular Surgery | 4.3 | 3 | 94 | 10976809, 07415214 | 210 | 2.03 | Q1 | United States |
| 5 | Laryngoscope | 2.6 | 3 | 68 | 15314995, 0023852X | 168 | 1.1 | Q1 | United States |
| 5 | Orthopaedics & Traumatology: Surgery & Research | 2.5 | 3 | 46 | 18770568 | 69 | 1.08 | Q1 | France |
| 5 | Plastic and Reconstructive Surgery | 3.6 | 3 | 110 | 15294242, 00321052 | 198 | 1.35 | Q1 | United States |
| 5 | World Journal of Orthopedics | 1.9 | 3 | 16 | 22185836 | 55 | 0.53 | Q2 | China |
| 5 | World Neurosurgery | 2.1 | 3 | 56 | 18788769, 18788750 | 106 | 0.59 | Q2 | United States |

* IF: impact factor; [$] Np: number of publication on the field; [#] GCS: global citation score; [£] ISSN: International Standard Serial Number; [&] SJR: Scimago Journal Rank; [§] Q: quartile ranking of a journal in a specific field

## Source analysis based on the number of citations

Table 3 ranks the sources by number of citations. Journal of Occupational Rehabilitation (JOR; IF: 3.3) is the top journal with 681 citations (with 2 Np), twice as many as JAMA Surgery (365 citations, IF: 16.9), which ranks second. Applied Ergonomics (278 citations, IF: 2.6), Annals of Surgery (277 citations, IF: 9.4), and Journal of Occupational and Environmental Medicine (233 citations, IF: 3.2) occupy the next three places with a number of citations between 200 and 300. The remaining journals have fewer than 200 citations. Among the journals in this ranking, 9 are in the United States and 3 in the United Kingdom.

**Table 3.** Top 15 ranked sources with the most citations

| Rank | Sources | IF* | GCS[#] | Np[$] | ISSN[£] | h-index | SJR[&] | Q[§] | Country |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Journal of Occupational Rehabilitation | 3.3 | 681 | 2 | 15733688, 10530487 | 79 | 0.89 | Q1 | United States |
| 2 | JAMA Surgery | 16.9 | 365 | 1 | 21686262, 21686254 | 193 | 3.62 | Q1 | United States |
| 3 | Applied Ergonomics | 2.6 | 278 | 3 | 18729126 | 119 | 0.922 | Q1 | United Kingdom |
| 4 | Annals of Surgery | 9.4 | 277 | 3 | 15281140, 00034932 | 335 | 2.95 | Q1 | United States |
| 5 | Journal of Occupational and Environmental Medicine | 3.2 | 233 | 1 | 10762752 | 121 | 0.74 | Q2 | United States |
| 6 | Neurosurgery | 4.8 | 198 | 1 | 15244040, 0148396X | 215 | 1.22 | Q1 | United States |
| 7 | Female Pelvic Medicine & Reconstructive Surgery Match | 2.1 | 188 | 1 | 21544212, 21518378 | 32 | 0.65 | Q2 | United States |
| 8 | Arthroscopy | 4.7 | 151 | 1 | 07498063, 15263231 | 180 | 2.01 | Q1 | United Kingdom |
| 9 | Annals of Medical and Health Science - Research | - | 148 | 1 | 21419248, 22779205 | 67 | 0 | Q | Nigeria |
| 10 | Dermatologic Surgery | 2.4 | 146 | 3 | 10760512, 15244725 | 134 | 0.56 | Q2 | United States |
| 11 | Occupational Medicine | 3.8 | 137 | 4 | 09627480, 14718405 | 97 | 0.82 | Q2 | United Kingdom |
| 12 | Surgical Endoscopy | 3.1 | 128 | 5 | 14322218, 09302794 | 166 | 1.12 | Q1 | United States |
| 13 | Surgical laparoscopy, endoscopy & percutaneous techniques | 1 | 121 | 1 | 15304515, 15344908 | 66 | 0.4 | Q2 | United States |
| 14 | Indian Journal of Dental Research | 1 | 114 | 1 | 19983603, 09709290 | 50 | 0.26 | Q3 | India |
| 15 | Clinical, Cosmetic and Investigational Dentistry | 2 | 112 | 1 | 11791357 | 27 | 0.47 | Q2 | New Zealand |

* IF: impact factor; [#] GCS: global citation score; [$] Np: number of publication on the field; [£] ISSN: International Standard Serial Number; [&] SJR: Scimago Journal Rank; [§] Q: quartile ranking of a journal in a specific field; -: not provided

## Analysis of authors

Table 4 shows the thirteen most productive authors (due to the large number of authors with 3 publications). They published 65 papers, i.e. 37.6% of all published work. Hallbeck MS (h-index 35) of the Department of Health Sciences Research, Mayo Clinic, USA, takes first place with 10 publications on surgeons and WMSDs, followed by Yu D (7 publications, h-index 20), School of Industrial Engineering, Purdue University, USA, and Vijendern A (6 publications, h-index 14) of the ENT Department, Lister Hospital, UK. Alqahtani SM (h-index 6) and Alzahrani MM (h-index 17), both from the Department of Orthopaedics, Imam Abdulrahman Bin Faisal University, Saudi Arabia come next with 5 publications each. The other authors in the ranking have published 4 works each. The authors in this ranking are mainly from North America and 3 European countries.

**Table 4.** The top 6 authors with the most publications

| Rank | Author | Affiliation | Country | Np[$] | GCS[#] | h-index |
|---|---|---|---|---|---|---|
| 1 | Hallbeck MS | Mayo Clinic, Department of Health Sciences Research | United States | 10 | 557 | 35 |
| 2 | Yu D | School of Industrial Engineering, Purdue University, West Lafayette, Indiana | United States | 7 | 395 | 20 |
| 3 | Vijendren A | ENT Department, Lister Hospital, East and North Herts NHS Trust, Stevenage | United Kingdom | 6 | 242 | 14 |
| 4 | Alqahtani SM | Department of Orthopaedics, Imam Abdulrahman Bin Faisal University, Dammam | Saudi Arabia | 5 | 147 | 6 |
| 4 | Alzahrani MM | Department of Orthopaedics, Imam Abdulrahman Bin Faisal University, Dammam | Saudi Arabia | 5 | 147 | 17 |
| 6 | Demetriades AK | Department of Clinical Neurosciences, Royal Infirmary of Edinburgh, Edinburgh | United Kingdom | 4 | 80 | 30 |
| 6 | Lowndes BR | Mayo Clinic, Department of Health Sciences Research | United States | 4 | 379 | 11 |
| 6 | Meling TR | Department of Neurosurgery, The National Hospital, Rigshospitalet, Copenhagen | Denmark | 4 | 80 | 41 |
| 6 | Ricci JA | Division of Plastic Surgery, Montefiore Medical Center, Albert Einstein College of Medicine, Bronx, New York | United States | 4 | 42 | 28 |
| 6 | Rieger MA | Institute of Occupational and Social Medicine and Health Services Research, University Hospital of Tübingen, Tübingen | Germany | 4 | 40 | 30 |
| 6 | Seibt R | Institute of Occupational and Social Medicine and Health Services Research, University Hospital of Tübingen, Tübingen | Germany | 4 | 40 | 11 |
| 6 | Steinhilber B | Institute of Occupational and Social Medicine and Health Services Research, University Hospital of Tübingen, Tübingen | Germany | 4 | 40 | 11 |
| 6 | Yung M | Department of ENT, Ipswich Hospital | United Kingdom | 4 | 218 | 36 |

[$] Np: number of publication on the field; [#] GCS: global citation score

Three of the top authors with the most publications also appeared in the top 10 authors with the most citations (Table 5). Hallbeck MS remains in first place with 557 citations (10 publications). Yu D and Lowndes BR ranked 8th and 9th respectively with 395 and 379 publications. Four co-authors, Lee BT, Ruan QZ, Singhal D, Tran BN, from Division of Plastic Surgery and Reconstructive Surgery, Department of Surgery, Beth Israel, Israel, and Epstein S from Harvard T. H. Chan School of Public Health, Boston, United States, occupy second place with 455 citations for 3 publications. Dennerlein JT from Bouvé College of Health Sciences, Northeastern University, Boston, United States, has the highest h-index (53) and ranks 7th with 405 citations. All the authors in the top 10 are from the United States.

**Table 5.** The top 10 authors with the most citations

| Rank | Author | Affiliation | Country | GCS[#] | Np[$] | h-index |
|---|---|---|---|---|---|---|
| 1 | Hallbeck MS | Mayo Clinic, Department of Health Sciences Research | United States | 557 | 10 | 35 |
| 2 | Lee BT | Division of Plastic Surgery and Reconstructive Surgery, Department of Surgery, Beth Israel | United States | 455 | 3 | 48 |
| 2 | Ruan QZ | Division of Plastic Surgery and Reconstructive Surgery, Department of Surgery, Beth Israel | United States | 455 | 3 | - |

**Table 5.** The top 10 authors with the most citations (*continued*)

| Rank | Author | Affiliation | Country | GCS[#] | Np[$] | h-index |
|---|---|---|---|---|---|---|
| 2 | Singhal D | Division of Plastic Surgery and Reconstructive Surgery, Department of Surgery, Beth Israel | United States | 455 | 3 | - |
| 2 | Tran BN | Division of Plastic Surgery and Reconstructive Surgery, Department of Surgery, Beth Israel | United States | 455 | 3 | 12 |
| 2 | Epstein S | Harvard T. H. Chan School of Public Health, Boston, Massachusetts | United States | 455 | 3 | 12 |
| 7 | Dennerlein JT | Bouvé College of Health Sciences, Northeastern University, Boston, Massachusetts | United States | 405 | 2 | 53 |
| 8 | Yu D | School of Industrial Engineering, Purdue University, West Lafayette, Indiana | United States | 395 | 7 | 20 |
| 9 | Lowndes BR | Mayo Clinic, Department of Health Sciences Research | United States | 379 | 4 | 11 |
| 10 | Sparer EH | Harvard T. H. Chan School of Public Health, Boston, Massachusetts | United States | 365 | 1 | 11 |

[#] GCS: global citation score; [$] Np: number of publication on the field; -: not provided

## Analysis of highly cited articles

Table 6 listed the top 15 most cited articles sorted by the total number of citations. These articles covered 30 years, i.e. between 1991 and 2019. The first three articles total more than 300 citations. The first was published in JAMA Surgery (IF: 16.9, 365 citations), which focuses on technical and technological innovations in surgery and their impact on the health and prevention of musculoskeletal disorders among surgeons. The next two were published in the JOR (IF: 3.3, 360 and 321 citations respectively), whose main theme is the study of work rehabilitation, helping to advance scientific understanding of the promotion of work ability and the prevention of work disability. Rosenman's article in the Journal of Occupational and Environmental Medicine (IF: 3.2) ranks 4th with 233 citations. The other articles in this top 15 have fewer than 200 citations, with a wide disparity between journals (IF between 1 and 9.4, h-index between 27 and 335, quartile ranking between Q1 and Q3). Among these 15 articles, 8 quantified the prevalence of WMSD by body area among surgeons. Table 7 summarizes the prevalence. Two of the most cited articles in the top 3, by Epstein et al. [20] and Szeto et al. [16], reported prevalence for four body areas (neck, back, shoulder and upper extremities). Other studies provided extended results with more areas: 8 areas for the Stomberg et al. [45] study and 9 areas for the Batham and Yasobant [46] and Rambabu and Suneetha [47] studies. Neck and shoulder were the most studied areas, with prevalence ranging from 11.0% to 88.2% and from 8.0% to 57.8% respectively, followed by upper and lower back.

**Table 6.** The top 15 highest cited articles

| Rank | Article | Year | GCS[#] | IF* | h-index | Q[§] |
|---|---|---|---|---|---|---|
| 1 | Epstein S, Sparer EH, Tran BN, Ruan QZ, Dennerlein JT, Singhal D, et al. Prevalence of Work-Related Musculoskeletal Disorders Among Surgeons and Interventionalists: A Systematic Review and Meta-analysis. JAMA Surg. 2018;153:e174947. | 2018 | 365 | 16.9 | 193 | Q1 |
| 2 | Pascarelli EF, Hsu YP. Understanding work-related upper extremity disorders: clinical findings in 485 computer users, musicians, and others. J Occup Rehabil. 2001;11:1–21. | 2001 | 360 | 3.3 | 79 | Q1 |
| 3 | Szeto GPY, Ho P, Ting ACW, Poon JTC, Cheng SWK, Tsang RCC. Work-related musculoskeletal symptoms in surgeons. J Occup Rehabil. 2009;19:175–84. | 2009 | 321 | 3.3 | 79 | Q1 |
| 4 | Rosenman KD, Gardiner JC, Wang J, Biddle J, Hogan A, Reilly MJ, et al. Why most workers with occupational repetitive trauma do not file for workers' compensation. J Occup Environ Med. 2000;42:25–34. | 2000 | 233 | 3.2 | 121 | Q2 |
| 5 | Abramovitz JN, Neff SR. Lumbar disc surgery: results of the Prospective Lumbar Discectomy Study of the Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons. Neurosurgery. 1991;29:301–7; discussion 307–8. | 1991 | 198 | 4.8 | 215 | Q1 |
| 6 | Catanzarite T, Tan-Kim J, Whitcomb EL, Menefee S. Ergonomics in Surgery: A Review. Female Pelvic Med Reconstr Surg. 2018;24:1–12. | 2018 | 188 | 2.1 | 32 | Q2 |
| 7 | Park AE, Zahiri HR, Hallbeck MS, Augenstein V, Sutton E, Yu D, et al. Intraoperative "Micro Breaks" With Targeted Stretching Enhance Surgeon Physical Function and Mental Focus: A Multicenter Cohort Study. Ann Surg. 2017;265:340–6. | 2017 | 183 | 9.4 | 335 | Q1 |

**Table 6.** The top 15 highest cited articles (*continued*)

| Rank | Article | Year | GCS[#] | IF* | h-index | Q[§] |
|---|---|---|---|---|---|---|
| 8 | Hallbeck MS, Lowndes BR, Bingener J, Abdelrahman AM, Yu D, Bartley A, et al. The impact of intraoperative microbreaks with exercises on surgeons: A multi-center cohort study. Appl Ergon. 2017;60:334–41. | 2017 | 166 | 2.6 | 119 | Q1 |
| 9 | Ryu RK. Arthroscopic subacromial decompression: a clinical review. Arthroscopy. 1992;8:141–7. | 1992 | 151 | 4.7 | 180 | Q1 |
| 10 | Rambabu T, Suneetha K. Prevalence of work related musculoskeletal disorders among physicians, surgeons and dentists: a comparative study. Ann Med Health Sci Res. 2014;4:578–82. | 2014 | 148 | - | 67 | - |
| 11 | Stomberg MW, Tronstad SE, Hedberg K, Bengtsson J, Jonsson P, Johansen L, et al. Work-related musculoskeletal disorders when performing laparoscopic surgery. Surg Laparosc Endosc Percutan Tech. 2010;20:49–53. | 2010 | 121 | 1 | 66 | Q2 |
| 12 | Batham C, Yasobant S. A risk assessment study on work-related musculoskeletal disorders among dentists in Bhopal, India. Indian J Dent Res. 2016;27:236–41. | 2016 | 114 | 1 | 50 | Q3 |
| 13 | Meisha DE, Alsharqawi NS, Samarah AA, Al-Ghamdi MY. Prevalence of work-related musculoskeletal disorders and ergonomic practice among dentists in Jeddah, Saudi Arabia. Clin Cosmet Investig Dent. 2019;11:171–9. | 2019 | 112 | 2 | 27 | Q2 |
| 14 | Capone AC, Parikh PM, Gatti ME, Davidson BJ, Davison SP. Occupational injury in plastic surgeons. Plast Reconstr Surg. 2010;125:1555–61. | 2010 | 107 | 3.6 | 198 | Q1 |
| 15 | Cavanagh J, Brake M, Kearns D, Hong P. Work environment discomfort and injury: an ergonomic survey study of the American Society of Pediatric Otolaryngology members. Am J Otolaryngol. 2012;33:441–6. | 2012 | 95 | 2.5 | 66 | Q1 |

[#] GCS: global citation score; * IF: impact factor; [§] Q: quartile ranking of a journal in a specific field; -: not provided

## Analysis of co-authorship between authors

Co-authorship analysis focused on interactions between authors. Using data tables in Excel and VOSviewer, the network visualization of co-authorship was constructed for the 809 authors listed with a threshold for each author having at least 2 articles and zero citations. The co-authorship analysis provided 109 authors divided into 19 clusters (Figure 2). The three largest author clusters shown in Figure 2 have an extensive network and comprise 16, 13 and 11 authors respectively. Cluster 1 (16 authors, red) comprises the following authors: Bhatt DI, Buch MH, Charles-Schoeman C, Connell CA, Dougados M, Giles JT, Koch GG, Kwok K, Menon S, Rivas JL, Szekanecz Z, Vranic I, Wang C, Wu J, Yndestad A, Ytterberg SR. Among the 13 authors of cluster 2 (green) who publish together, four of them, Hallerbach MS, Lowndes BR, Bingener J, and Park AE, also collaborate with cluster 7 (6 authors, orange) through Yu D. Hallerbach MS also collaborates with cluster 5 (9 authors, purple) through Howarth AI, Lemaine V, Noland SS, Meltzer AJ, and Money SR. Cluster 3 (blue) includes 11 authors: Capone AC, Dennerlein JT, Epstein S, Greige N, Lee BT, Nash D, Ricci JA, Ruan QZ, Sinhgal D, Tran BN, and Wang F.

## Analysis of the intellectual structure: author's keywords

The aim of the author's keyword analysis is to find the correlation between the keywords and the subject of the article, so that readers can easily identify the different dimensions of the research theme "surgeons" and "work-related musculoskeletal disorders". The co-occurrence analysis of the author's keywords with VOSviewer counted 378 different keywords with a minimum number of occurrences of 1. Figure 3 shows the network visualization map (A, top panel) and overlay visualization map (B, bottom panel) of author keywords. In Figure 3A, the 378 keywords have been divided into 39 clusters of 1 to 21 keywords. The most frequently used keyword is "ergonomics" in cluster 9, with 63 occurrences and 154 links. The next two most-cited keywords refer to musculoskeletal disorders with "musculoskeletal disorders" (cluster 23, 91 links) and "work-related musculoskeletal disorders" (cluster 21, 77 links) with 28 and 27 occurrences respectively. "Surgeons" ranks 4th with 19 occurrences. The next most frequently used keywords are "operating room" (cluster 25, 11 occurrences, 31 links), "surgical ergonomics" (cluster 3, 10 occurrences, 39 links), "musculoskeletal pain" (cluster 4, 10 occurrences, 34 links), "posture" (cluster 9, 9 occurrences, 28 links), and "surgery" (cluster 11, 9 occurrences, 31 links).

**Table 7.** Overview of the 8 articles reporting the WMSD prevalence by body area among surgeons, extracted from the 15 most cited articles

| Authors | Study characteristics | | | | Body area | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Neck | Back | Upper back | Mid back | Lower back | Shoulder | Elbow | Wrist | Hand/Fingers | Thumb | Hip | Knee | Ankle/Foot |
| Batham and Yasobant (2016) | **N-participants** | 93 dentists | **Age (year)** | 27.7 ± 3.1 | 88.2% | - | 17.2% | - | 86.0% | 34.4% | 5.4% | - | 54.8% | - | 0.0% | 2.1% | 19.3% |
| | **Country** | India | **Practice (year)** | 5.5 ± 3.0 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 37.0/63.0 | **Case load (per week)** | 54.4 ± 8.3 h | | | | | | | | | | | | | |
| Capone et al. (2010) | **N-participants** | 325 surgeons | **Age (year)** | 48.1 | - | - | 26.8% | 9.2% | 24.0% | 17.9% | 29.8% | 24.7% | - | 12.6% | - | - | - |
| | **Country** | United States | **Practice (year)** | 12.9 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 87.1/12.9 | **Case load (per week)** | NR | | | | | | | | | | | | | |
| Cavanagh et al. (2012) | **N-participants** | 100 ORL | **Age (year)** | 52.96 ± 8.0.3 | 59.7% | 56.5% | - | - | - | - | - | 19.4% | - | - | - | - | - |
| | **Country** | United States | **Practice (year)** | 21.17 ± 9.32 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 85.0/15.0 | **Case load (per week)** | NR | | | | | | | | | | | | | |
| Epstein et al. (2018) | **N-participants** | 7981 surgeons | **Age (year)** | 48 | 60.0% | 49.0% | - | - | - | 52.0% | - | - | 35.0% | - | - | - | - |
| | **Country** | United States | **Practice (year)** | 12.6 | | | | | | | | | | | | | |
| | **Male/Female (%)** | NR | **Case load (per week)** | 12.9 h/8.3 cases | | | | | | | | | | | | | |
| Hallbeck et al. (2017) | **N-participants** | 56 surgeons | **Age (year)** | 47.1 ± 9.4 | 75.0% | - | 61.0% | - | 69.0% | 51.0% | - | - | 31.0% | - | - | 26.0% | 26.0% |
| | **Country** | United States | **Practice (year)** | 11.6 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 67.9/32.1 | **Case load (per week)** | NR | | | | | | | | | | | | | |
| Rambabu and Suneetha (2014) | **N-participants** | 37 surgeons | **Age (year)** | 30−60 | 11.0% | - | 5.0% | - | 20.0% | 8.0% | 5.0% | - | 8.0% | - | 12.0% | 16.0% | 15.0% |
| | **Country** | India | **Practice (year)** | > 5 | | | | | | | | | | | | | |
| | **Male/Female (%)** | NR | **Case load (per week)** | > 50 h | | | | | | | | | | | | | |

**Table 7.** Overview of the 8 articles reporting the WMSD prevalence by body area among surgeons, extracted from the 15 most cited articles (*continued*)

| Authors | Study characteristics | | | | Body area | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Neck | Back | Upper back | Mid back | Lower back | Shoulder | Elbow | Wrist | Hand/Fingers | Thumb | Hip | Knee | Ankle/Foot |
| | **N-participants** | 61 dentists | **Age (year)** | 30−60 | 30.0% | - | 12.0% | - | 24.0% | 18.0% | 4.0% | - | 22.0% | - | 0.0% | 5.0% | 10.0% |
| | **Country** | India | **Practice (year)** | > 5 | | | | | | | | | | | | | |
| | **Male/Female (%)** | NR | **Case load (per week)** | > 50 h | | | | | | | | | | | | | |
| Stomberg et al. (2010) | **N-participants** | 101 gyneco | **Age (year)** | 48.2 ± 10.2 | 50.0% | - | 24.0% | - | 55.0% | 51.0% | 6.0% | 14.0% | 17.0% | - | - | 27.0% | - |
| | **Country** | Sweden | **Practice (year)** | 14.5 ± 10.4 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 36.6/63.4 | **Case load (per week)** | 1.9 h | | | | | | | | | | | | | |
| | **N-participants** | 103 surgeons | **Age (year)** | 43.3 ± 9.1 | 44.0% | - | 22.5% | - | 44.0% | 38.0% | 7.0% | 10.0% | 30.0% | - | - | 27.0% | - |
| | **Country** | Sweden | **Practice (year)** | 8.7 ± 5.1 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 82.2/17.8 | **Case load (per week)** | 3 h | | | | | | | | | | | | | |
| Szeto et al. (2009) | **N-participants** | 135 surgeons | **Age (year)** | 35.3 | 82.9% | - | 52.6% | - | 68.1% | 57.8% | - | - | - | - | - | - | - |
| | **Country** | Chine | **Practice (year)** | 10.0 ± 7.3 | | | | | | | | | | | | | |
| | **Male/Female (%)** | 82.2/17.8 | **Case load (per week)** | NR | | | | | | | | | | | | | |

NR: not recorded; ORL: otolaryngologists; Gyneco: gynecologists; -: not provided

In Figure 3B, VOSviewer has separated the colors of all keywords into categories according to their average publication year (APY). The oldest keywords (2014) were “work-related injury”, (cluster 13, APY: 2013.67), “injury” (cluster 6, APY: 2014.75), and “microsurgery” (cluster 16, APY: 2014.60). The three most cited keywords appeared in 2020: “ergonomics” (cluster 9, APY: 2020.57), “musculoskeletal disorders” (cluster 23, APY: 2020.11), “work-related musculoskeletal disorders” (cluster 21, APY: 2020.56).

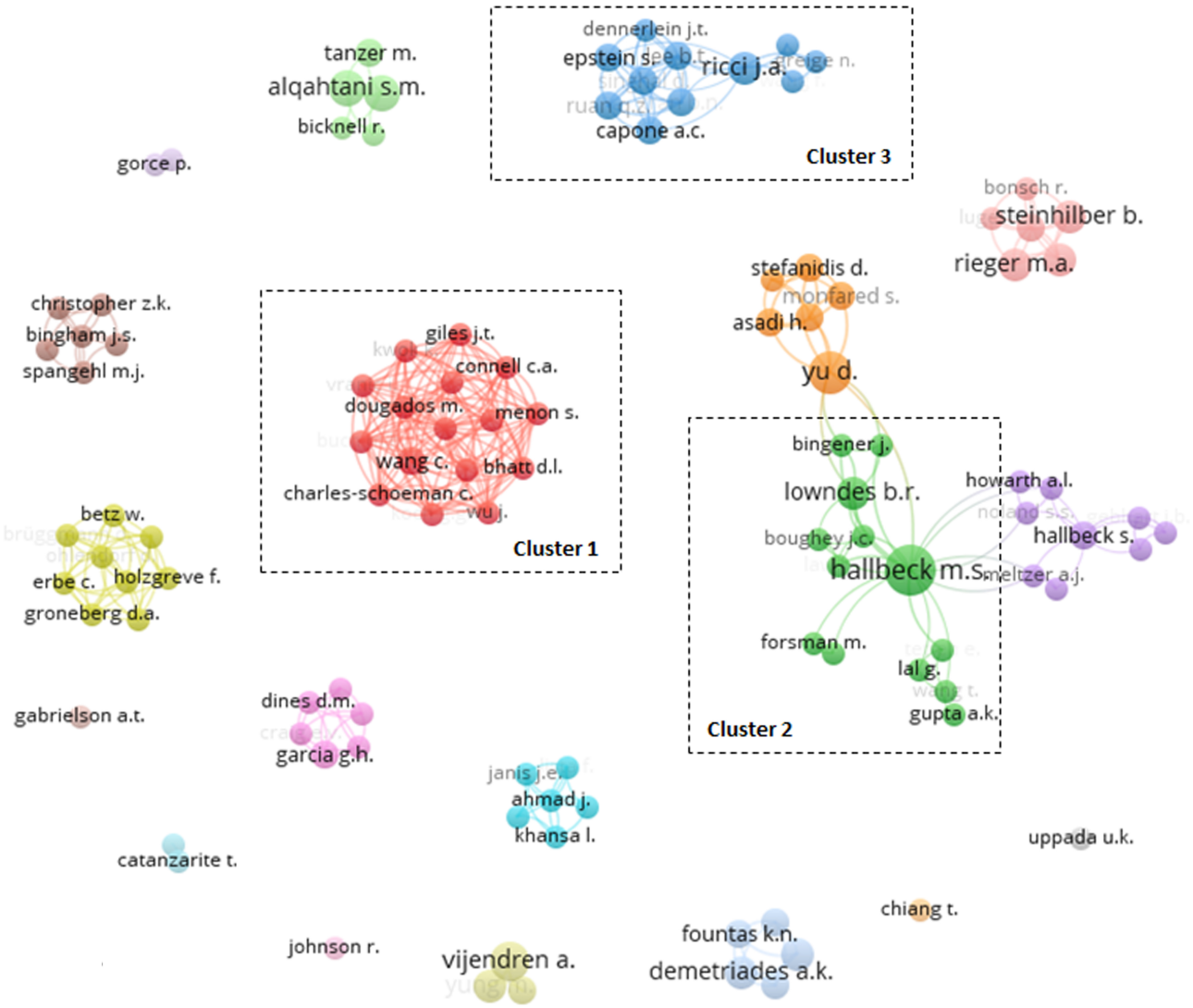


**Figure 2.** Co-authorship network visualization. The three dotted rectangles illustrate the three largest author clusters. All linked nodes of the same color constitute a cluster different from the others

## Discussion

This bibliometric analysis is the first research on WMSDs among surgeons. The aim was to undertake research mains points and trends in using PubMed/Medline database, VOSviewer, and Microsoft Excel [48]. The analysis includes the identification and analysis of articles, authors, keywords and sources based on the number of citations [49]. Results are presented as descriptive analysis and mapping with VOSviewer. These data allow the impact measurement of published articles within the scientific community.

The results of the bibliometric analysis showed that the field of WMSD in surgeons began in 1982. Until 2008, the number of publications was very low. An initial increase in publications was observed until 2015 (increase coefficient = 0.4, $r^2$ = 0.614). From 2016, the number of publications has risen considerably, with 3 to 4 additional publications per year (increase coefficient = 4.1, $r^2$ = 0.863) and a total of 41 publications in 2023. This reflects the growing interest among surgeons in analyzing WMSDs as part of their practice, especially in recent years [20, 31]. The numerous studies carried out on healthcare professionals have shown a high prevalence of WMSDs. Surgeons are among the most exposed professionals. They operate in awkward static postures that are maintained for long periods [50]. Their actions require great precision, which generates stress and mental fatigue in addition to the physical load. The main aim of recent research is to reduce the risks to which surgeons are exposed by improving their working conditions. In this context, the increase in the number of publications may be associated with a growing awareness of this issue, which is spreading to all surgical specialties: gynecology [27], orthopedics [51], vascular surgery [26], plastic surgery [25], etc.

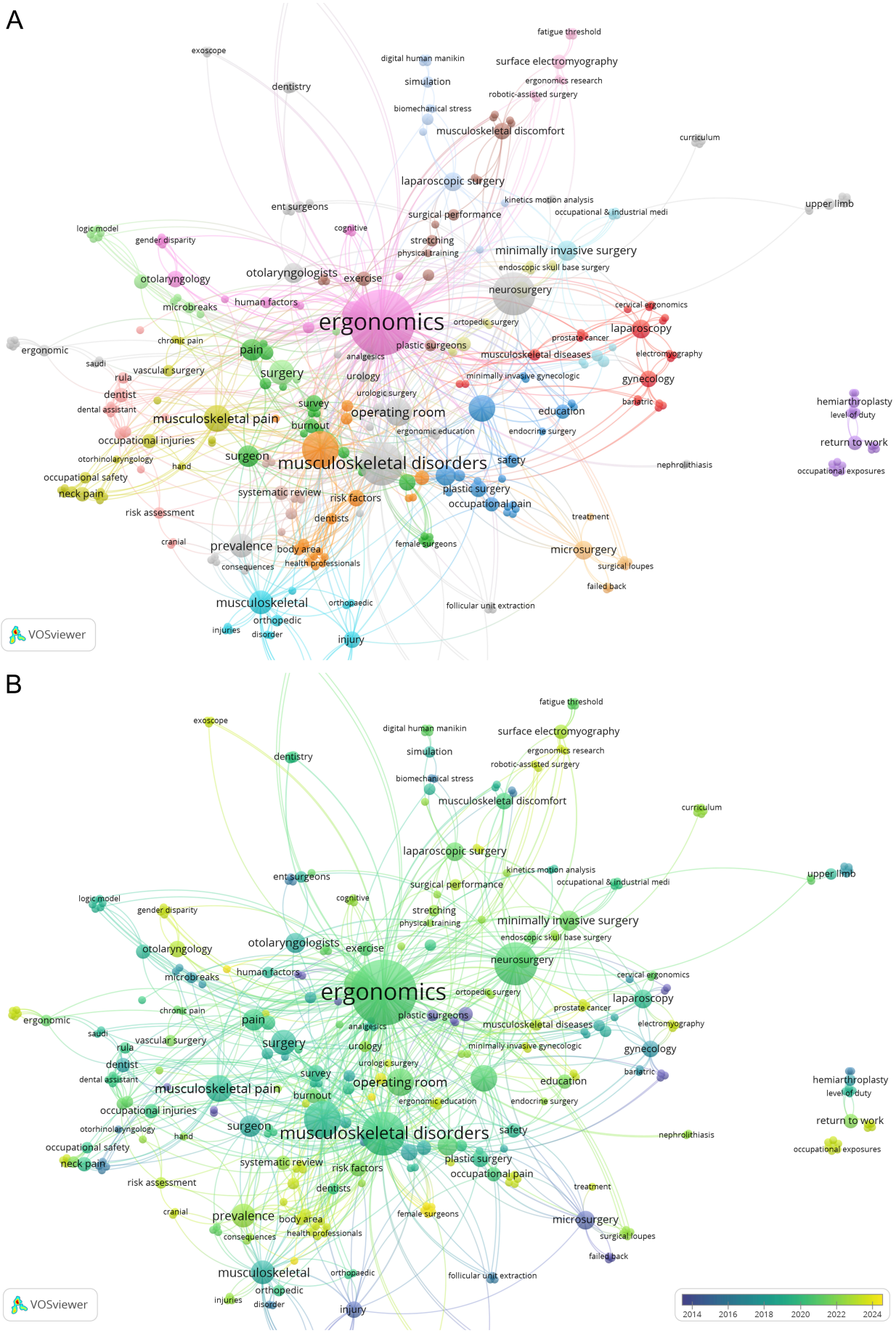


**Figure 3.** Networks of author keywords from 1982 to 2024. (A) Network visualization map. Nodes of the same color linked together constitute a cluster; (B) overlay visualization map. The color of the 378 circles ranges from blue, which indexes articles with publication years around 2014, to yellow for 2018 to the latest year 2024

Global trends in musculoskeletal disorders in surgeons show that the United States is the leader with 82 publications (Table 1), well ahead of the United Kingdom (13 publications), followed by Canada and India with 10 publications. The United States also largely leads in terms of citations (GCS = 3,276), indicating a very prolific country in this field. United Kingdom retains second place with 697 citations. India ranks third ahead of Canada, with more citations (467 vs. 386 respectively) for the same number of publications.

Based on the source ranking (Table 2), Work is the journal with the most publications in the field, with 7, ahead of Surgical Endoscopy (Np = 5). Surgical Endoscopy nevertheless has a higher number of citations, h-index, SJR and Q-index than Work. Clinical Orthopaedics and Related Research and Occupational Medicine ranked third with 4 publications. Annals of the Ruheumatic Diseases, ranked 5th with 3 publications, is the journal with the best statistics in the ranking: an IF of 27.4, an h-index of 272, an SJR of 6.49 and a Q1 in Medicine, Biochemistry, Genetics and Molecular Biology, Immunology and Microbiology. It is also worth noting that Applied Ergonomics and Annal of Surgery are the two most cited sources (GCS = 278 and GCS = 277) even though they only rank 5th. Finally, the top 4 journals with the most publications (Table 2) do not appear in the ranking of sources by number of citations (Table 3). JOR is the source with the highest number of citations (GCS = 681) followed by JAMA Surgery (GCS = 365) despite the very low number of publications (2 and 1 respectively). These two journals have a quartile ranking of Q1 in Medicine, but JAMA Surgery has better statistics, with an IF of 16.9 (vs. 3.3 for JOR), an h-index of 193 (vs. 79 for JOR) and an SJR of 3.62 (vs. 0.89 for JOR).

Work is an open access interdisciplinary journal ranked Q2 since 1990 with the subject Prevention, Assessment & Rehabilitation covering the entire scope of the occupation of work. Due to its large topic about occupation of work, authors find it easier to propose new work around WMSDs, which could explain its top ranking by number of publications. On the other hand, the journals with the highest number of citations have a high IF (above 3), including two with scores of 9 or more. This implies very high quality work, which is more likely to be cited by researchers in the field. Applied Ergonomics, however, has a lower IF (IF = 2.6), but is well established in the field of ergonomics, having been in existence since 1969. Consequently, this bibliometric analysis shows that particular related parameters such as IFs, h-index, topic, quality (Q and SJR), open access status, can play an essential role in the reading and citation rate of an article [52].

The table of top 10 rankings by author (Table 5) shows that Halleck MS, Mayo Clinic, Department of Health Sciences Research, United States, is the researcher with the most publications (Np = 10) and citations (GCS = 557) in the field, with an h-index of 35. However, Dennerlein JT, an American colleague, ranked 7th (Np = 2 and GCS = 405), has the highest h-index with 53. In the top 15 most-cited articles (Table 6), Epstein S holds first place with an article entitled Prevalence of Work-Related Musculoskeletal Disorders Among Surgeons and Interventionalists: A Systematic Review and Meta-analysis published in JAMA Surgery (IF: 16.9, h-index: 193, SJR: 3.62, Q1) with 365 citations. Based on 30 works, the authors reported the pathologies to which surgeons are most exposed, as well as the prevalence of WMSD for four body areas: 60% for the neck, 49% for the back, 52% for shoulder, and 35% for hand/fingers (Table 7). Szeto GPY, ranked 3rd with an article published in JOR (IF: 3.3, h-index: 79, SJR: 0.98, Q1, 321 citations), also proposed a prevalence of WMSD for four body zones (neck: 82.9%, upper back: 52.6%, lower back 68.1%, and shoulder: 57.8%) using a survey. Six other studies in the top 15 most-cited articles also reported prevalence by body area. Table 7 showed that in the 15 most cited articles, the neck and shoulder were the two most studied areas with a prevalence between 11% [47] and 88% [46] and between 8% [47] and 57.8% [16] respectively, followed by upper back, lower back and hand/finger. Some areas, notably the elbow and wrist, which are important for upper limb activity in surgery, have been much less studied, as has the prevalence of lower limb WMSDs.

Figure 2 shows the co-authorship networks extracted from the VOSviewer analysis. The three largest clusters have been represented: cluster 1 groups together American and European authors; the other two clusters are essentially composed of Americans. This analysis completes and reinforces the dominant position of Americans in this field.

Figure 3 presented the co-occurrence analysis of keywords throughout a network performed with VOSviewer. It enables analysis of the links between the different issues relating to WMSDs among surgeons, and thus establishes the different research directions. Of the 378 keywords identified, the most frequently used was "ergonomics", with 63 occurrences and 154 links. The next three keywords are directly related: "musculoskeletal disorders" (28 occurrences, 91 links), "work-related musculoskeletal disorders" (27 occurrences, 77 links), and "surgeons" (19 occurrences, 59 links). Two main lines of research can be identified from the various clusters analysis: (1) an ergonomic line of research in which WMSD risks are defined on the basis of assessment tools and measurement methods (electromyomyography, posture, motion analysis, ergonomic tools) [53–55]; (2) a medical-oriented research axis based on surveys to assess the prevalence of WMSDs in specific activity settings (operating room, laparoscopy, microsurgery, ...) [56–58]. Chronologically, the most frequently used keyword at the origin of the field was "injury" (APY: 2014.75). Work focused on the health status of surgeons, most often based on surveys [23, 59]. In 2020, the keywords "ergonomics", "musculoskeletal disorders" and "work-related musculoskeletal disorders" made their appearance in the field. As a result, the treatment of WMSDs is no longer based solely on questionnaires, but also on experimental data. The aim is now to quantitatively assess the level of WMSD risk and propose recommendations for reducing surgeons' exposure to WMSDs by modifying work practices and the work environment [60–63].

The study of WMSDs in surgeons is important because they are highly exposed to WMSDs due to the wide variety of static positions they may have (sitting, standing) as part of their practice. As a result of this constant exposure, surgeons present high prevalence of WMSDs in the neck (41% to 60.0%), lower back (37.7% to 49.0%), shoulders (27.3% to 52%) and upper extremities (20.1% to 35%), as shown by recent systematic reviews and meta-analyses [20, 31]. These prevalence are due to prolonged muscle contraction in asymmetrical postures involving flexion and rotation [64]. Added to this is the psychological burden, which is significant due to the high degree of technicality and precision required [54].

This bibliometric analysis research has enabled us to provide a quantitative and illustrated description, by country, source, author, citation and keyword, of research addressing the issue of WMSDs in surgeons. However, there are a few limitations. First, the search was carried out only in the PubMed/Medline database, which could lead to the omission of some works corresponding to the topic and thus limit the scope of the present work. Ideally, a complete analysis should include all published works and therefore consider all available databases. However, two major difficulties arise. On one hand, because of the independence of the databases, the number, nature and format of the data provided by each database are different, which would require significant homogenization in order to be able to use classic bibliometric analysis tools (Vosviewer, CiteSpace, etc.). On the other hand, with the development of online journals, the number of databases is increasing, with some of them requiring a fee-based subscription for access. However, the choice of the PubMed/Medline database remains relevant, since it is the database in which most of the work on WMSDs can be found. In addition, several criteria relating to bibliometric analysis have been added (IF, global citations score, journal rank and quartile rank in the field) to enrich the information extracted from the database and make the work presented more qualitative. Secondly, the search was limited to publications written in English, which could lead to the omission of some relevant work written in another language. In addition, some articles or journals do not have all the data required for analysis, such as keywords, affiliations, topics, IF, SJR or Q. Moreover, due to the fact that VOSviewer does not analyze the full text article, some information may not have been taken into account. Finally, it is important to bear in mind that a recent article of very high quality may be excluded from some rankings due to a low GCS.

## Conclusions

This analysis of bibliometrics shows that the overall trend is toward more and more articles being published on WMSDs among surgeons, especially since 2016. This topic is dynamic, with American research in a leadership position. Research in the field has evolved from a situation where the main focus was on

assessing the prevalence of WMSDs in specific activity settings, to a more ergonomic assessment of WMSD risks based on assessment and measurement tools. The latest work tends to show that the combination of subjective and objective data could be relevant for future work.

## Abbreviations

APY: average publication year

GCS: global citation score

IF: impact factor

ISSN: International Standard Serial Number

JOR: Journal of Occupational Rehabilitation

SJR: Scimago Journal Rank

WMSDs: work-related musculoskeletal disorders

## Declarations

### Author contributions

PG: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing—original draft, Writing—review & editing, Visualization, Supervision, Project administration, Funding acquisition. JJB: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing—original draft, Writing—review & editing, Visualization.

### Conflicts of interest

Philippe Gorce is the Editorial Board Member and Guest Editor of Exploration of Musculoskeletal Diseases, but he had no involvement in the decision-making or the review process of this manuscript. Another author declares that there is no conflicts of interest.

### Ethical approval

Not applicable.

### Consent to participate

Not applicable.

### Consent to publication

Not applicable.

### Availability of data and materials

The datasets for this manuscript are not publicly available because the authors prefer to communicate directly with researchers interested in the same issues rather than open access whose use is not controlled. Requests for accessing the datasets should be directed to jacquier@univ-tln.fr.

### Funding

This work was supported by the Erbio Association [EBC012024]. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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