Original article

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Trends and topics in occupational diseases over the last 60 years from PubMed

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Objectives The purpose of this study was to provide an analysis of scientific production on occupational diseases (OD) during the period 1945–2015 in order to describe publication trends on that topic and identify the major diseases as well as the predominant actors (journals, countries) involved in this field.

Methods A PubMed search was carried out to extract articles related to occupational diseases during the period 1 January 1945 to 31 December 2015 using a specific query. Data were downloaded from PubMed in Extensible Markup Language (XML) and processed through a dedicated parser.

Results A total of 160 025 articles were retrieved from 7127 journals. One third of these articles were published in 39 journals: the core journals according to Bradford's law. Following exponential growth, OD publications reached a plateau in 2007. The overall dynamics of the OD field are heterogeneous with differences between subfields: psychological diseases emerged in the 1990s while "traditional" OD are less studied nowadays. Despite a sharp decrease in the proportion of publications, the most productive country remains the USA with 14.5% of the OD publications over the period but Scandinavian countries are, proportionally, the most active in research and publication on OD.

Conclusions The proportion of publications on OD is decreasing in Medline, except for specific subfields of OD. This is discrepant with the global burden of occupational diseases.

Key terms bibliometrics; biomedical research; biomedical trend; publication.

The idea that some diseases could result from occupational exposure emerged in antiquity, mostly for slave labor in mining operations, and grew slowly thereafter, as demonstrated by some famous textbooks, by Paracelsus or Ramazzini for example.

Scientific journals began in the 17th century with the French *Journal des Savants* and the British *Philosophical Transactions of the Royal Society* (1). The journals complemented scientific meetings, which had until then been the main way of communicating science. General medical journals began appearing at the end of the 18th century, and some articles were published from time to time on occupational diseases (OD) (2, 3). Specialist medical journals emerged at the beginning of the 20th century, and occupational medicine followed that trend with the creation of *La Medicina del Lavoro* in 1925, the *Archives des Maladies Professionnelles* in 1938 or the *British Journal of Industrial Medicine* in 1944. The literature in the field of OD has developed since then, in a huge number of journals, and in the 1990s more than half of articles were published in journals dealing with general practice or medical specialties other than occupational health (4). However, despite strong preventive policies, OD still frequently occur and are responsible for a great deal of suffering and economic damage in countries all over the world (5–11).

Despite the importance of occupational factors in the etiology of many diseases, the literature remains quite poor in that field, compared to other medical specialties. In that respect, it has been estimated that among

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the articles published in the *Lancet*, the *New England Journal of Medicine* (NEJM), the *Journal of the American Medical Association* (JAMA) and the British Medical Journal (BMJ) in 1997, 2002 and 2007, only 0.48% featured occupational medicine as the main topic (12).

Bibliometry is, according to Lewison & Devey (13), to scientific papers what epidemiology is to patients. Using the metadata of scientific publications (authors, references, keywords etc.), it allows measurement of the "output" of individuals/research teams, institutions, and countries, identification of national and international networks, description of historical development, and mapping of new fields of development in science and technology. From an historical perspective, bibliometric studies have been conducted in many fields, such as dermatology, acupuncture, physical medicine and rehabilitation or pediatrics (14–16). However, nothing has been done to our knowledge on OD. The purpose of this study was to provide an analysis of scientific production during the period 1 January 1945 to 31 December 2015 in order to identify the major topics and diseases, as well as the predominant actors (journals, countries) involved in the field of OD.

Methods

Bibliographic search

The search for papers to be included in this study was carried out in September 2017, using the MEDLINE database (www.ncbi.nlm.nih.gov/pubmed). MEDLINE was chosen because it is widely used in medicine, it has a good coverage for high quality studies and every reference in MEDLINE is indexed using MeSH thesaurus (17, 18).

In order to identify the relevant articles for OD, we searched the MEDLINE database with two MeSH terms: occupational diseases OR occupational exposure.

The choice of the two MeSH terms was made after assessing the precision and recall of the search string ("Occupational Diseases"[Mesh]) OR "Occupational Exposure"[Mesh]). We examined all (N=866) the articles published in the three major reviews in occupational health (*Scandinavian Journal of Work, Environment and Health*; *Occupational and Environmental Medicine* and the *American Journal of Industrial Medicine*) in 1990 and 2015, and compared those identified by the search string and those which were not identified. The recall of the search string for articles dealing with OD was 91.9% and the precision was 96.0%.

There was only a minor difference between 1990 and 2015, the recall being 91.5% and 92.2% in 1990 and 2015, respectively, and the precision being 95.9% and 96.1% in 1990 and 2015, respectively.

The search was not restricted to major MeSH headings and the explode function was activated. We restricted the publication date to all articles published between 1944 and December 2015.

Therefore, the following PubMed query for OD was created: ("Occupational Diseases"[MeSH] OR "Occupational Exposure"[MeSH] AND ("1945/01/01"[PDat]: "2015/12/31"[PDat]))

Data were downloaded from PubMed in extensible markup language (XML) and were processed through a dedicated parser. The following metadata, extracted from PubMed, were integrated in a dedicated database: journal, Major MeSH terms, first author's affiliation, publication type, language and year of publication. PubMed was also searched for all the articles published in the same period of time, in order to make comparisons in the trends of publications.

The country in which the work was performed is not available in PubMed. This information was therefore extracted from the first author's affiliation. A specific algorithm in several steps was developed from: (i) the e-mail address country code top-level domain based on ISO 3166-1 (eg, "it" refers to Italy) (ii) each address field, a comparison was performed with a dedicated geographical database enriched by the Google map API (geocode).

Due to the high number of missing data concerning the first authors' affiliation in PubMed before the 1990s, we restricted the analysis on countries to the last 21 years (1995–2015).

Country ranks for scientific publication were adjusted for population size (number of articles published divided by population size) and gross domestic product (GDP) per capita (number of articles published divided by GDP per capita). The data on population size and GDP per capita were computed from the World Population Review (worldpopulationreview.com) and the World Bank (data.worldbank.org/indicator), respectively. Country ranks for scientific publications were also adjusted for their overall contribution to research, to assess the weight of work on OD among their scientific production. We computed an activity index indicator as follows: [(Number of publications of the country on OD / overall number of publications on OD in PubMed) / (number of publications of the country in PubMed / overall number of publications in PubMed)].

The annual growth rates of publications were computed as follows: (number of publications in year n – number of publications in year n-1)/(number of publications in year n-1).

The analysis of the topics of the articles was performed by computing the major MeSH terms used to index the articles, in the C (diseases) and F categories (psychiatry and psychology) of the MeSH.

Results

A total of 160 025 articles were retrieved from PubMed among 7127 different journals over the period 1 January 1945 to 31 December 2015. The number of articles per year increased from 5 articles in 1944 to 4466 in 2015. Most of the articles (N=81 141; 50.7%) were published between 1995 and 2015.

The annual growth rate of publications on OD was on average 4.1% per year. However, the increase was observed mostly in the 1950s and 60s, and the annual growth rate was only 1.8% and 1.7% in the last two decades, respectively. When compared to the annual growth rate of the total number of articles indexed in Medline, we observed that the rate of publications on OD followed the overall rate of Medline until the late 1990s, when the overall number of articles in PubMed increased exponentially (figure 1). In 1986, studies on occupational diseases represented 0.887% of all articles in PubMed, but only 0.357% in 2015.

Journals

Publications were retrieved from 7127 journals spanning 41 languages. The exact number of unique journals was in fact lower since many journals changed their name during that period. According to Bradford's law, the population of journals may be divided in three groups: a small group of core journals that contains one third of articles, a larger group of journals that accounts for another third, and a much larger group of journals that picks up the last third (19). Therefore, we divided the journals into three categories. The first category included 39 journals (0.6%) that had published one third (N=54 030) of the total number of articles we identified (table 1). Ten of these journals were not specialized in occupational medicine and had broad (eg, JAMA, BMJ) as well as specialized (eg, Chest, Contact Dermatitis) medical themes.

Language

Although the articles were published in 41 different languages, 68.8% of the articles (N=110 080) were in English, 8% (N=13 510) in Spanish and 5% (N=8528) in German. In PubMed overall, the proportions were 82.3%, 1.2% and 3.2%, respectively.

The articles on OD in Russian and German decreased from the early 1990s to 2015, from 427 and 253 per year to 143 and 55, respectively.

Countries from which publications originated

Our retrieved articles represented publications originating from 149 countries between 1944 and 2015, but the affiliation was not available for 51% of them mostly for the older articles. Over the period ranging from 1995 to 2015, we were able to identify the country of origin for 79% of the articles. Among the 17 countries that contributed most to the total amount of publications, the top three contributors of OD-related publications were the United States (USA) (21%), the United Kingdom (UK) (4%) and Italy (3%) (table 2).

When adjusted to the size of the population, Finland, Sweden and Denmark took the lead in terms of scientific production, and when adjusted to GDP per capita, the ranking changed to place India, China and Brazil in the top 3, respectively (table 2).

In order to assess the weight of research of OD in each country, we compared the contribution of each country in terms of publications of OD to their contri-

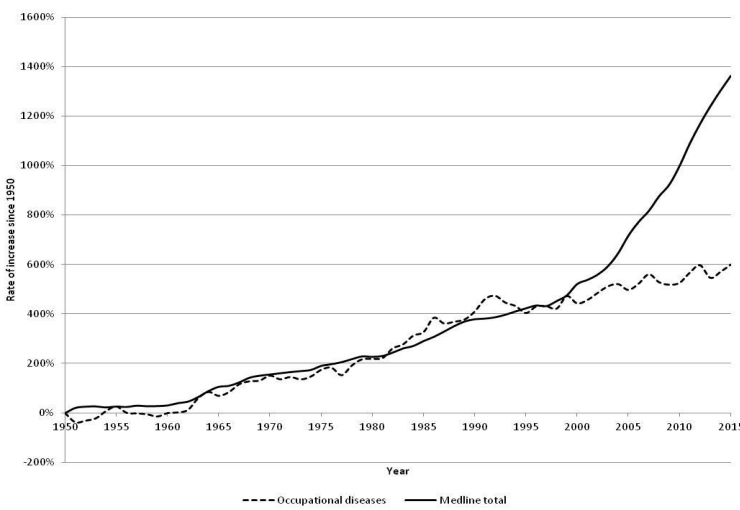

Figure 1. Rate of increase of the number of publications indexed in PubMed on occupational diseases and on publications overall, with 1950 as the reference.

Table 1. Top journals that published one third of the total number of articles on occupational diseases.

Journal's name	Number of articles published (% of total)	First (and last year [a]) of indexation in Medline	Mean number of articles published annually
Meditsina Truda i Promyshlennaia Ekologiia	5492 (3.43%)	1957	94.7
Occupational & Environmental Medicine	4331 (2.71%)	1944	61.0
Journal of Occupational & Environmental Medicine	3593 (2.25%)	1959	64.2
American Journal of Industrial Medicine	3514 (2.20%)	1980	100.4
Gigiena i Sanitaria	2634 (1.65%)	1936	33.3
Journal of Occupational & Environmental Hygiene	2621 (1.64%)	1958	46.0
Contact Dermatitis	2573 (1.61%)	1975	64.3
International Archives of Occupational and Environmental Health	2226 (1.39%)	1930	26.2
La Medicina del Lavoro	2126 (1.33%)	1925	23.6
Annals of Work Exposures & Health	1770 (1.11%)	1958	31.1
Scandinavian Journal of Work, Environment & Health	1755 (1.10%)	1975	43.9
Occupational Medicine	1728 (1.08%)	1951	27.0
Occupational Health & Safety	1541 (0.96%)	1949	23.3
Archives of Environmental & Occupational Health	1488 (0.93%)	1919	15.5
Medycyna Pracy	1484 (0.93%)	1948	22.1
Giornale Italiano di Medicina del Lavoro ed Ergonomia	1378 (0.86%)	1979	38.3
Chinese Journal of Industrial Hygiene & Occupational Diseases	1251 (0.78%)	1983	39.1
Lancet	1169 (0.73%)	1823	6.1
Radiation Protection Dosimetry	1098 (0.69%)	1981	32.3
BMJ (Clinical research ed.)	1061 (0.66%)	1857	6.7
Environmental Health Perspectives	993 (0.62%)	1972	23.1
Health Physics	985 (0.62%)	1958	17.3
Likars'ka Sprava	981 (0.61%)	1918	10.1
Archives des Maladies Professionnelles et de l'Environnement	891 (0.56%)	1946-1992	19.4
American Journal of Respiratory & Critical Care Medicine	885 (0.55%)	1917	9.0
Industrial Health	791 (0.49%)	1963	15.2
Chest	790 (0.49%)	1935	9.9
Zeitschrift für die Gesamte Hygiene und Ihre Grenzgebiete	751 (0.47%)	1955-1991	20.9
Journal of the American Medical Association	700 (0.44%)	1883	5.3
Ugeskrift for Laeger	628 (0.39%)	1839	3.6
Clinics in Occupational & Environmental Medicine	571 (0.36%)	1986-2006	28.6
Work	537 (0.34%)	1990	21.5
American Journal of Epidemiology	533 (0.33%)	1921	5.7
Annals of the New York Academy of Sciences	527 (0.33%)	1877	3.8
The Medical Journal of Australia	519 (0.32%)	1914	5.1
Mutation Research	498 (0.31%)	1964	9.8
Environmental Research	494 (0.31%)	1967	10.3
International Journal of Occupational & Environmental Health	487 (0.30%)	1995	24.4
Ergonomics	484 (0.30%)	1957	8.3

[a] No final year is mentioned when the journal is still indexed in Medline.

Table 2. Scientific production on occupational diseases (OD) per country, according to their population, GNP per capita and scientific production overall.

Country	N [a]	N/ number of articles published	N/ population in millions	N / GNP per capita [b]	Activity index [c]
Australia	1567	1.93%	65.3	27.7	0.88
Brazil	927	1.14%	4.5	105.3	0.90
Canada	2507	3.09%	69.8	57.9	1.04
China	2251	2.77%	1.6	277.9	0.49
Denmark	1048	1.29%	183.9	19.8	1.74
Finland	1198	1.48%	217.8	28.3	2.64
France	1964	2.42%	30.5	53.8	0.78
Germany	2543	3.13%	31.5	61.7	0.71
India	770	0.95%	0.6	481.3	0.49
Italy	2788	3.44%	46.6	92.9	1.10
Japan	2155	2.66%	17	62.5	0.49
Poland	931	1.15%	24.1	73.9	1.74
Spain	1212	1.49%	26.3	47.2	0.76
Sweden	2006	2.47%	204.7	39.6	1.97
The Netherlands	1701	2.10%	100.7	38.4	1.10
UK	3632	4.48%	56.1	82.7	0.91
USA	16 899	20.83%	52.5	300.7	0.86

[a] Number of articles published on OD for the country between 1995 and 2015

[b] GNP per capita is in thousands of US dollars.

[c] [Number of publications of the country on OD / (overall number of publications on OD in PubMed) / (number of publication of the country in PubMed / overall number of publications in PubMed)]

bution to articles in PubMed in the same period of time (activity index) (table 2). As regards their level of publication, the countries which gave a higher than average importance to OD were Finland, Sweden and Denmark, followed by Italy, the Netherlands and Canada. Conversely, India China and Japan gave far less importance to OD (50%) than to other medical subjects.

We observed a steady increase in the number of publications on OD over the last 20 years (1995–2015) for 14 out of the 17 countries. For Japan, the number of publications remained stable (from 104 in 1995 to 112 in 2015). For the UK, it decreased between 2005 and 2014, before increasing again in 2015 (221, 162 and 238 publications respectively). The most dramatic evolution was for the USA with an increase between 1995 and 2002 (from 645 to 969 publications), followed by a plateau and a sharp decrease between 2011 and 2014 (from 891 to 412 publications).

Publication types

Case reports and reviews were almost the only publication types for the first 40 years and meta-analysis, randomized control studies and systematic reviews appeared at the end of the 1980s and have displayed a steady increase since then (figure 2). However, the numbers remain low and, from 1995–2015, the proportion of meta-analysis and systematic reviews published annually increased from 0.34% and 0.99% to 1.37% and 3.65%, respectively. Over the period of the study, only

206 practice guidelines were published, 41% of them in the last decade.

Main health conditions addressed

Overall, 693 179 major MeSH terms were used to index the 160 025 articles, with 12 332 different terms. The average number of major MeSH terms per article was 4.3. The analysis of the number of articles linked to one of the C (diseases) or F categories (psychiatry and psychology) of the MeSH identified 219 730 articles; some articles were linked to two or more branches of the MeSH (for example an article on respiratory tract neoplasms is linked to respiratory tract diseases and neoplasm). The top two categories were respiratory tract diseases and psychiatry and psychology, accounting for one third of the articles, overall (table 3).

The analysis of the trends of the different topics revealed very different patterns. The evolution of the top eight topics is presented in figure 3.

Respiratory tract occupational diseases were the most addressed until 1991, when psychiatric and psychological diseases took the lead, in terms of research, and have risen dramatically since then. The number of publications on "traditional" OD reached a plateau or decreased from the late 1980s.

The only category that increased constantly, despite psychiatric diseases, was nervous system diseases.

Immune system diseases and infectious diseases reached maximum level in the 1990s and then decreased. This phenomenon concerning infectious diseases is related mostly to publications on tuberculosis in the mid-1960s and the onset of hepatitis B followed by HIV as an occupational risk in the 1980s.

Table 3. Frequency of the disease categories (MeSH) of the articles published 1945–2015.

MeSH category	Number of publications	Proportion [a]
Respiratory tract Diseases	39 079	17.8%
Psychiatry and psychology	37 308	17.0%
Nervous system diseases	18 550	8.4%
Immune system diseases	18 494	8.4%
Neoplasms	17 099	7.8%
Virus diseases, bacterial infections and mycoses and parasitic diseases	16 676	7.6%
Skin and connective tissue diseases	13 867	6.3%
Wounds and injuries	12 247	5.6%
Musculoskeletal diseases	7158	3.3%
Digestive system diseases	6484	3.0%
Cardiovascular diseases	6333	2.9%
Otorhinolaryngologic diseases	5660	2.6%
Female urogenital diseases and pregnancy complications	4538	2.1%
Male urogenital diseases	3488	1.6%
Hemic and lymphatic diseases	3459	1.6%
Eye diseases	2742	1.2%
Nutritional and metabolic diseases	2204	1.0%
Congenital, hereditary and neonatal diseases and abnormalities	1971	0.9%
Stomatognathic diseases	1333	0.6%
Endocrine system diseases	1040	0.5%

[a] Proportion: number of publications on that topic over the total number of publications on occupational diseases over the period.

Discussion

Our study has demonstrated a steady increase since 1945 in the number of publications on OD in the biomedical literature indexed in Medline, which followed the increase in the Medline database overall until the mid-1990s but which then stabilized. Studies on OD were scattered in a high number of different journals, most of them being nonspecifically occupational medicine journals, and originated from a large number of countries. There was no relation between the number of publications per country and their number of inhabitants or their GNP per capita, and some countries, mostly in Scandinavia, concentrated their efforts on OD as compared to other fields of research. The main health conditions addressed in publications have evolved over the years and "traditional" OD were overtaken by psychiatric and psychological diseases in the 1990s.

Limitations

As with other publication analyses, some study limitations are unavoidable. Exclusion of articles that were most recently published, not indexed by NLM, or not included in PubMed, make it impossible to trace all sources and to have an overview of the total number of publications worldwide. However, we performed the search in September 2017 for articles published until December 2015 to reduce as much as possible the impact of the indexation lag in Medline. The choice of the ending year was driven by the National Library of Medicine (NLM) latency in indexing, the goal being to analyze only fully indexed years.

In addition, although MEDLINE is the most authoritative international biomedical literature database, the number of medical journals from various countries is still limited. Other databases are also available for bibliometric studies, such as Web of Science, Scopus, Embase, PsychNet, and CINAHL. Nevertheless, we demonstrated in a previous study that most, if not all, of the good quality literature was published in Medline (18). Therefore, it is probable that including other databases would not have added significant improvement to our study or provided different results.

Another limitation is that we relied on Medline MeSH terms. Articles included in Medline are manually indexed. This manual assignment of indexing terms and document qualifiers to each citation in the database is one of the key determinants of the system's performance

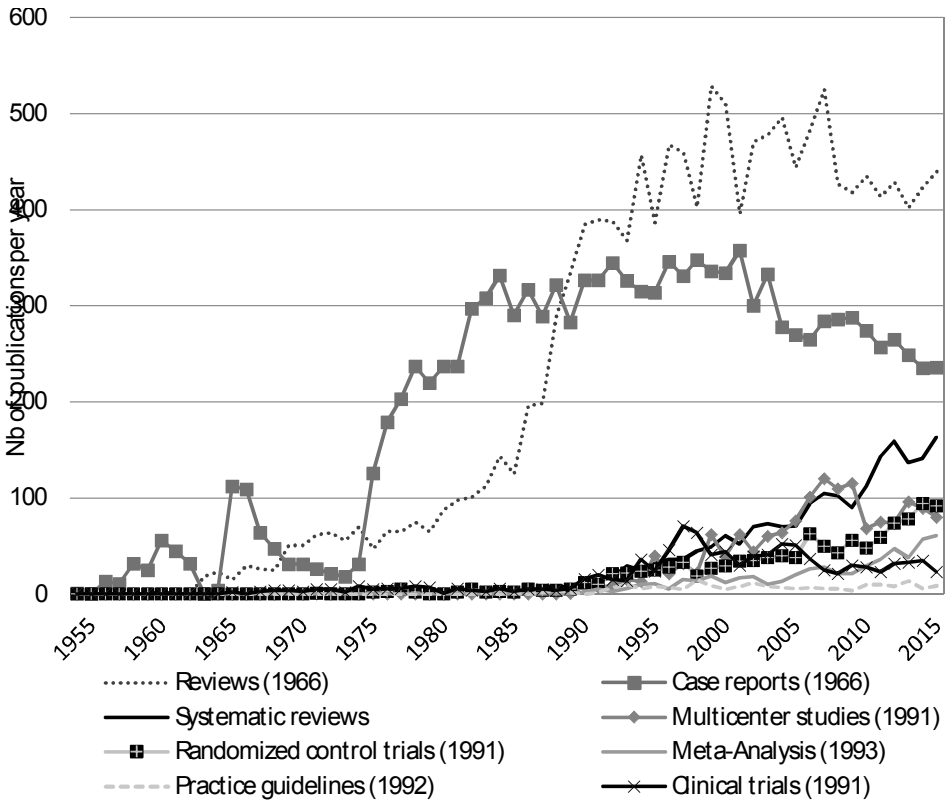

Figure 2. Number of publications per year according to the publication type (the year of creation of the publication type in Medline is mentioned between brackets).

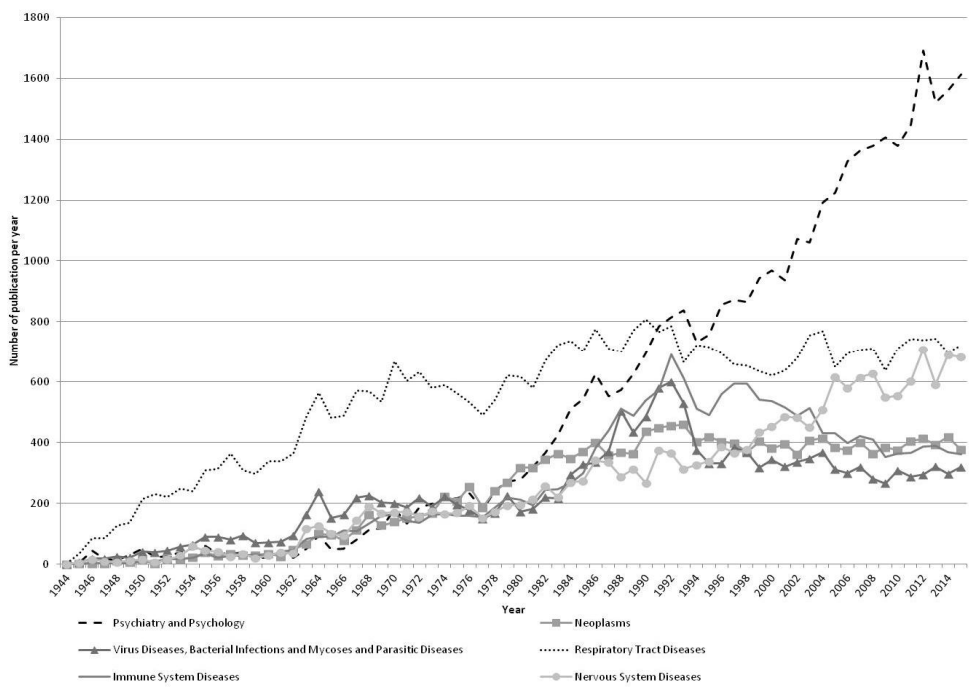

Figure 3. Trends of the different topics in the articles on occupational diseases, 1945–2015.

because these terms, when accurately applied, ensure straightforward retrieval of articles of a specific type (20). Yet, as for any human activity, indexation errors in PubMed are possible and have been previously observed (20). This could have led to both false positive and false negative hits in our study.

We limited our search to two keywords (occupational diseases and occupational exposure) because they were the most relevant to the scope of our study. Doing that, we missed some articles dealing with OD but not indexed with these keywords. However, the high recall and precision of our search string, their stability between 1990–2015, and the large amount of literature we analyzed probably minimized this bias. Furthermore, the large number of publications analyzed gave us a wide enough overview of the trends of publication to draw reliable conclusions.

Trends

We observed a relative stagnation of the number of publications on OD, compared to the annual growth rate of the total number of articles indexed in Medline. We may wonder if this stagnation reflects that of OD or of the interest in OD?

Occupational factors represent an important part of the global burden of disease and were the topic of a recent review (21). To summarize, 1 086 000 deaths were estimated to occur globally due to occupational risks. These included 489,000 occupationally related cancer deaths with important causes being asbestos (180 000), diesel engine exhaust (120 000), silica (86 000) and second-hand smoke at work (96 000). Occupational exposure to asthmagens was estimated to cause 42 000 deaths, with particulate matter, gases and fumes causing 357 000 (mainly chronic obstructive pulmonary diseases) and workplace injuries causing 204 000 deaths (8). Furthermore, work-related morbidity and mortality not only results in suffering and hardship for the worker and his or her family, but also it adds to the overall cost to society through lost productivity and increased use of medical and welfare services. The cost to society has been estimated at 2–14% of the gross national product in different studies in different countries (22).

The stagnation of the number of publications on OD could therefore reflect the decrease in the interest in OD, more than the real impact of work on the global burden of disease. In fact, this stagnation seems to be mostly the consequence of the decrease in the number of publications originating from the USA. In other countries, the pattern is different and the number of publications is still increasing, but at a slow rate, except for China. When assessing the impact of economic development on the level of publications on OD, we observed that India, China and Brazil have the highest number of publications according to their GDP per capita. However, this probably reflects the rise in the overall number of publications and research in these countries rather than a growing interest on OD, since the contribution of these countries to publications on OD was lower than their contribution to articles in PubMed during the same period.

The most active countries in terms of research on OD were the Scandinavian countries (Sweden, Finland, Demark), and this confirms previous findings on research on return to work (23).

These findings probably also explain the trends observed on the main health conditions addressed in the publications on OD. The decline in "traditional" OD has been compensated by the dramatic increase in the number of publications in the psychiatry and psychology category. For example, there were more articles dealing with burnout (N=8083) than silicosis (N=6266) and the number of articles on burnout, as an occupational disease, rose from 3 in 1981 to 540 in 2015. This is also the perception of occupational health professionals and, in 2016, the participants to the International Occupational Medicine Society Collaborative Survey noted that increased job stress was a major factor across global regions, and the need to address mental health and other stress-related issues was on the rise (24).

Publication type

It is possible that we missed some systematic reviews since it is only a subheading and not a publication type, and is therefore hard to identify (20). However, although we observed an increase in the number of randomized controlled trials (RCT), meta-analysis and systematic reviews from the early 1990s, it remains low and gold standards in terms of evidence-based medicine are not frequent enough. We can hope that the publication of clinical trials and RCT will help to raise the overall number of meta-analyses published.

Research on OD has grown markedly in the past six decades, but with a lower growth rate than biomedical research overall. This probably reflects not the decline in OD but a decline in the interest of researchers on that topic, or at least on "traditional" OD, even though research on psychiatric and psychological OD is dramatically increasing. Thse findings provide a context for analyzing the strengths and gaps in the current state of OD research and for informing a comprehensive strategy for further advancing the field.

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