Citation Classics in Occupational Medicine Journals

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Abstract

Objectives. The number of citations an article receives after its publication reflects its impact on the scientific community, but also the impact of the institutions or countries in the field studied. Garfield in 1987 introduced the concept of "Citation classics" for the best-cited articles. An analysis of top-cited articles coming from journals of occupational medicine (*e.g.* OEM, SJWEH) has not yet been reported. The purpose of this study was to assess whether or not such citation classics exist in this field and to analyse their characteristics.

Methods. The most frequently cited articles published in the five major journals in occupational medicine were identified using the database of the Science Citation Index Expanded. The data were obtained by searching one year and one journal at a time. All the articles cited more than 100 times were collected and analyzed.

Results. Among the 15 553 articles published by the journals since 1949, only 85 articles had been cited more than 100 times. The oldest was published in 1950 and the latest in 1997. The United Kingdom contributed 28% of citation classics and the US or Sweden 19%. The most cited article had been cited 979 times. The main topics of articles were metabolism, occupational neoplasm and work related musculoskeletal disorders.

Conclusions. Since the 80's, Scandinavia and USA have taken the leadership in the publication of citation classic papers. Nevertheless, according to the level of citations, the influence of literature published in occupational medicine journals remains limited.

Introduction

The number of citations an article receives after its publication reflects its impact on the scientific community, but also the impact of the authors, a specific institution or even a country in the field studied. Although citation statistics have been frequently criticized, the analysis of citation rates may allow for the identification of advances in a specialty and may provide a historical perspective of its scientific progress. Garfield in 1987 listed the "top 100" best-cited articles ever published in JAMA (1) and named them "Citation classics". Since then, there were a few recent attempts to identify and analyze those citation classics for various specialities, *i.e.* dermatology (2), critical care medicine (3), physical medicine (4) or general surgery (5), as well as for specific journals (6-8).

However, the analysis of top-cited articles originating from occupational medicine periodicals has not yet been reported. The purpose of the present study was therefore to assess whether or not citation classics exist in occupational medicine journals and to determine the characteristics, *i.e.* ranking (number of citations), year of publication, publishing journal, type of article, institution of origin, country, state, and topic of the most frequently cited articles published in prominent occupational medicine journals.

Methods

The five major journals in occupational medicine, according to their Impact Factor (Journal Citation Report, 2004) and to a previous study (9) were analysed (Table 1). The most frequently cited articles in these journals were identified using the database of the Science Citation Index Expanded (SCI-EXPANDED, 1945 to present). The SCI-EXPANDED is a multidisciplinary database powered by the ISI and the Web of SCIENCE with searchable author abstracts covering the journal literature of the sciences; it indexes more than 6,000 major journals across 164 scientific disciplines. Since the Cited Reference Search option of the Web of SCIENCE returns a site-configured maximum number of results, which is limited to 500, the data were obtained by searching one year and one journal at a time.

All the articles cited more than 100 times were collected and analyzed.

The papers were not weighted by age in the analysis and the raw numbers of citations were used.

Two strategies were applied to analyse the subjects of each of these articles. The first one was to describe by one word, *e.g.* "metabolism", "cancer" or "work-related musculoskeletal disorders" (WRMSD) the main subject covered by each article. The second strategy was to collect all the keywords used to index each article in Medline. They were analyzed using two tools. The first one is a medico-scientific data mining web service developed by the Institute for Medical Statistics and Epidemiology of the Technical University of Munich and named Meva (MEDLINE Evaluator) (http://www.med-ai.com/meva/index.html). This Medline postprocessor condenses the list of a Medline retrieval outcome into a structured result, showing a graphical representation of counts and relations of the MEDLINE fields by using frequency distributions, contingency tables and detailed sorted lists. The second one is a MEDLINE categorization algorithm (MCA), based on semantic links existing between

Medical Subject Headings (MeSH) terms and metaterms on the one hand and between MeSH subheadings and metaterms on the other hand. These links are used to automatically infer a list of metaterms from any MeSH term/subheading indexing (10).

Results

Among the 15 553 articles published by the journals studied since 1949, 85 articles (0.55%) have been cited more than 100 times (Table 1).

The number of citation classics papers among all published papers varied widely between studied journals, ranging from 0 to 1.02%. For this indicator, Occupational and Environmental Medicine (OEM) and the British Journal of Industrial Medicine (BJIM) were considered as a single journal since the BJIM became OEM in 1994.

The oldest citation classic paper was published in 1950 (102 citations) and the latest in 1997 (122 citations). Although the most cited article had been cited 979 times, 68% of citation classic papers had been cited between 100 to 150 times. The "top twenty" of papers, with their number of citations, is presented in table 2.

The articles covered a wide range of diseases and chemicals. Among the 1371 MeSH descriptors used to index those articles, the most frequently used in categories C (diseases) and D (drugs and chemicals) are displayed in table 3, together with their corresponding MeSH tree number. A total of 190 and 112 descriptors were used, respectively for categories C and D. The most common keywords for diseases were neoplasms, particularly thoracic neoplasms or mesotheliomas, followed by nervous system diseases, mainly peripheral nervous system diseases, respiratory tract diseases and musculosqueletal diseases. Among the chemicals, hydrocarbons, metals and asbestos were the most frequently cited.

The methods used in the articles were studied using the MCA. It demonstrated that epidemiology was the most frequent qualifier used in the Medline indexation of the papers, followed by toxicology, statistics and physiology, in decreasing order.

Overall, 14 articles dealt with metabolism of xenobiotics (16.5%) and 3 (3.5%) with toxicological properties of xenobiotics. Some trends exist concerning these topics. Whereas

between 2 and 5 citation classics dealing with fundamental toxicology or metabolism studies were published during each decade, citation classics concerning solvents appeared only during the 70's and 80's and those concerning WRMSD emerged in the 80's (3 papers) and increased significantly in the 90's (10 papers out of the 21 citation classics identified during this decade). In total, thirteen articles (15.3%) were review articles.

The 85 top-cited articles originated from 13 countries, with The United Kingdom contributing 26 (31%) articles, followed by Sweden and the United States (US) with 16 articles each (Table 4).

Only 53% of articles originated from English speaking countries (Figure 1).

When evaluating at the affiliation of the corresponding authors of papers, the Catholic University of Louvain and the University of Michigan were the most important providers of citation classics, with 4 citation classics for each (Figure 1). It is significant to note that 8 citation classics (nearly 10%) originated from the private sector, although from 8 different teams.

A total of 270 authors contributed to these citation classic papers, some of them more than once. Axelson and Jongeneelen were the only authors to have written 3 citation classics, as first author, and Axelson the only person to have co-authored 5 citation classics.

Discussion

The term *citation classics* was first introduced by Eugene Garfield in 1987, in a study to identify the 100 most cited JAMA articles (1). In that study, the least cited article received 158 citations. Since then, some authors have studied the citation classics in various specialities or among papers published by specific journals(2-8,11-15). Although the least cited article in the Garfield's study received 158 citations (1), the threshold used for according the status of citation classic to a paper as been set to "100 times cited" in many studies,

concerning various medical or surgical specialties (2,3,5,14,15) and we therefore adopted the same threshold.

This bibliometric review of citation classics in occupational medicine journals illustrates how this scientific field has evolved during the past 50 years and the importance of this field compared to other specialties.

Such a bibliometric study has the potential to identify most of the true landmark papers published in the journal studied, some of the most important contributions published in the 50's or 60's may have been overlooked. Yet, as time passes, even true-classics are gradually being cited less often because their substance has been absorbed by the current knowledge, a phenomenon called "obliteration by incorporation" (1). Thus, the absolute number of citations an article has accumulated cannot be used as a sole measurement of its "importance." As Garfield (1) noted, the landmark article by Sabin and colleagues from 1960 (16) on the use of oral poliomyelitis virus vaccine received only 90 citations up to 1987. In fact, the true intellectual milestones may often be found in the reference lists of the top-cited papers (8).

It has been demonstrated that occupational medicine is a wide specialty which covers many different fields and that articles dealing with it are therefore published in a multitude of journals (9). Therefore, studying only the citation rate of papers published in occupational medicine journals is an underestimation of the number of citations classics in this field. In fact, in their study on the top cited articles in critical care medicine, Baltussen and Kindler compared the citation rate of the articles originating from critical care journals to those concerning critical care but published in a noncritical care journal (3). The mean numbers of citations of the top 45 articles published in critical care journals and the top 45 articles published in a noncritical care journal, mainly the most important general medical journals, were 440 and 810, respectively (3). Nevertheless, the purpose of our study was to study the

impact of occupational health journals, and not of occupational health literature on the whole, which would have needed another methodology.

In our study, the number of articles cited more than 100 times was 85, which is lower or comparable to the numbers of citation classic reported in the literature. For example, among the papers published in 65 general surgical journal's between 1945 and 1995, 1500 had been cited more than 100 times, and 100 more than 278 times (5). The mean number of citation of the top 100 was 405 (range 278 – 1013). Absolute numbers of classic papers have also been reported for otolaryngology-head and neck surgery journals (80 papers between 1900 and 1999) (12), for clinical dermatologic journals (129 papers between 1945 and 1990) (2), for critical care journals (418 papers between 1945 and 2003) (3), for The Journal of Trauma (80 papers between 1961 and 2004) or for the British Journal of Clinical Pharmacology (70 papers between 1974 and 2003) (11).

Although a rate of citation classics based on the total number of articles published in these studies would allow more reliable comparison between our results and studies previously published in the literature, this information is rarely available, except for three studies. The citation classic's rate of 0.55% in our study was lower than those reported for the British Journal of Clinical Pharmacology (1,1%, $p<0.001$) (11), for critical care medicine journals (0.84%, $p<0.001$) (3), and for The Journal of Trauma (0.63%, $p=0.39$) (14).

Therefore, the number of citation classics in occupational medicine appears to be limited. This probably reflects the low level of influence of occupational medicine journals, which is also indicated by the low level of the impact factor of the five major periodicals in this field, always lower or equal than 2. While studying the influence of occupational medicine on general medicine, McCunney and Harzbecker have shown that occupational medical journals (hence articles) were nearly 50 times more likely to cite the general medical literature than the opposite (17).

All our 85 citations classics were about etiological studies or occupational exposure. None of them concerned occupational health intervention. Nevertheless, as recently pointed out by Ruotsalainen, there is a relative paucity of clinically relevant and methodologically well-conducted occupational health intervention studies in occupational health literature (18). Despite the recent overall improvement of the number and quality of such studies, the fact that no such studies has had time to become a citation classic is therefore not surprising. Browsing through the most cited articles we observe that among the many true-landmark contributions there are articles dealing with topics that were "hot", or popular, at one time and then ceased to be so. The topics covered by the citation classics originating from occupational medicine journals reveals the dominance of basic science, *i.e.* of studies on metabolism or toxicological properties of industrial compounds, and of traditional risks in occupational medicine, *e.g.* cancers, effects of asbestos, solvents or metals. The number of papers dealing with WRMSD is underestimated by the analysis of MeSH descriptors since these disorders include a group of conditions that involve the nerves, tendons, muscles, and supporting structures such as intervertebral discs, and can thus be indexed under nervous system diseases or musculosqueletal disorders in Medline. Overall, 13 (15.3%) of the 85 citation classics had WRMSD as their main subject. Nevertheless, musculosquelettal disorders have gained a growing importance in the 90's, with 10 out of 21 citations classics published during this decade concerning this topic. The place of new risks such as psychological disorders or effects of shiftwork remains low, but is emerging, as reflected by the second rank of the paper written by Bongers and colleagues (Table 2). As reported by Terajima and Aneman, this reflects the fact that these topics emerged recently and that it takes some time to achieve "classical" status, even in the era of the internet (19). Furthermore, this latency is also influenced by the low (17) immediacy index (*i.e.* the average number of times that an article published in a specific year within a specific journal is cited over the course of

that same year) and the long cited half-life (*i.e.* the number of years, going back from the current year, that account for 50% of the total citations received by the cited journal in the current year) of occupational and environmental health literature. Yet, in 2002, the cited half-life of OEM was 4.8 years, and the cited half life of other periodicals in this field, such as Journal of Occupational and Environmental Medicine or of the Scandinavian Journal of Work Environment and Health were, respectively, 8.2 and 8.4 years (Journal of Citation Reports. 2002:113-114).

Although it has been claimed that with increasing age each paper has more time to be cited (8), our analysis shows that 59 % of citation classics were published after 1980. The development of bibliographic databases, particularly PubMed, and their availability on the Internet since the nineties is probably the main factor that may explain this trend.

Papers originated from 13 different countries, with a very high proportion of non-English speaking countries. Not surprisingly, during the years when the only international journal covering occupational medicine was the British Journal of Industrial Medicine, nearly all of the articles originated from The United Kingdom. Nevertheless, since the 70's, the Scandinavian countries, and notably Sweden and to a lesser extent Finland, have published a growing amount of citation classics paper, exceeding those originating from the US. This trend is very different of the one observed by other studies made on citation classics in other specialties which usually identify the US as the most contributing country (1,3,5,19).

Considering that most occupational health research is published outside occupational health journals (9), our study clearly does not provide an exhaustive view of the trends in that field. Nevertheless, it gives an opportunity to assess the influence of occupational periodicals, which appears to be limited.

Further studies on the real impact of occupational medicine papers on the whole, including those published in non occupational medicine journals, would therefore be warranted.

Conclusion

To our knowledge, this study is the first reported attempt to identify citation classics in occupational medicine journals. These results confirm the low influence of occupational health journals on the whole, except for a very few number of papers which has brought new insights concerning epidemiological evidence on toxic effects of metals, asbestos or solvents, which revealed metabolism of common workplace pollutants or proposed a comprehensive approach of the occupational aetiology of some occupational diseases, such as WRMSD. Among the possible causes, we can mention that very few occupational medicine journals provide free access to their content via Internet, except OEM for papers older than one year. It is difficult to know if our observations can be generalized to occupational health literature on the whole and a study on citation classics for occupational medicine papers published in general medical journals would therefore be interesting.

The method used in this study provides useful insights concerning the institutes and countries who are leaders in terms of research and thereof publication in occupational medicine journals and displayed the influence of Scandinavian and Benelux countries.

Furthermore, identifying the most important papers in our field is not only of historical interest, but is also most relevant in terms of education since these papers which have influenced occupational medicine should be included in the curriculum for occupational health students, among other landmark papers on occupational medicine published in prominent general medicine journals.

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Contributions

JFG was responsible for the design of the study. He collected and analysed the data.

KT, SD and JW participated to the analysis of the data and to the discussion.

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Table 1: Number of papers published and of Citation classic's paper during the period

Journal	Publication period	Articles published during the period	Impact Factor (2004)	Nb of paper cited more than 100 times	% of citation classics among published papers
Am J Ind Med	1980 -	4275	1.542	9	0.21
Occup Environ Med	1949 -	4789	1.916	43	0.90
Int Arch Occ Env Health	1976 -	2333	1.388	6	0.26
J Occup Environ Med	1971 -	1505	1.472	0	0
Scand J Work Env Health	1975 -	2651	1.816	27	1.02
Total		15553		85	0.56

Table 2: most cited 20 articles

Article	Times cited	Rank
Wagner JC, Sleggs CA, Marchand P. Diffuse pleural mesothelioma and asbestos exposure in the North Western Cape Province Br J Ind Med. 1960;17:260-71.	979	1
Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. Scand J Work Environ Health. 1993;19(5):297-312.	374	2
Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. Am J Ind Med. 1987;11(3):343-58.	315	3
Barry PS. A comparison of concentrations of lead in human tissues. Br J Ind Med. 1975;32(2):119-39.	304	4
Barnes JM, Magee PN. Some toxic properties of dimethylnitrosamine. Br J Ind Med. 1954;11(3):167-74.	291	5
Clark DG, McElligott TF, Hurst EW. The toxicity of paraquat. Br J Ind Med. 1966;23(2):126-32.	256	6
Hagberg M, Wegman DH. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. Br J Ind Med. 1987;44(9):602-10.	253	7
Newhouse ML, Thompson H. Mesothelioma of pleura and peritoneum following exposure to asbestos in the London area Br J Ind Med. 1965;22(4):261-9.	252	8
Silverstein BA, Fine LJ, Armstrong TJ. Hand wrist cumulative trauma disorders in industry. Br J Ind Med. 1986;43(11):779-84.	249	9
Fullerton PM, Barnes JM. Peripheral neuropathy in rats produced by acrylamide. Br J Ind Med. 1966;23(3):210-21.	238	10
Sato A, Nakajima T. Partition coefficients of some aromatic hydrocarbons and ketones in water, blood and oil Br J Ind Med. 1979;36(3):231-4.	238	11
McDonald JC, Liddell FD, Gibbs GW, Eyssen GE, McDonald AD. Dust exposure and mortality in chrysotile mining, 1910-75. Br J Ind Med. 1980;37(1):11-24.	231	12
Eriksson M, Hardell L, Berg NO, Moller T, Axelson O. Soft-tissue sarcomas and exposure to chemical substances: a case-referent study Br	228	13

J Ind Med. 1981;38(1):27-33.		
Elofsson SA, Gamberale F, Hindmarsh T, Iregren A, Isaksson A, Johnsson I, Knave B, Lydahl E, Mindus P, Persson HE, Philipson B, Steby M, Struwe G, Soderman E, Wennberg A, Widen L. Exposure to organic solvents. A cross-sectional epidemiologic investigation on occupationally exposed care and industrial spray painters with special reference to the nervous system. Scand J Work Environ Health. 1980;6(4):239-73.	225	14
Blair A, Malker H, Cantor KP, Burmeister L, Wiklund K. Cancer among farmers. A review. Scand J Work Environ Health. 1985;11(6):397-407.	219	15
Buchet JP, Lauwerys R, Roels H. Comparison of the urinary excretion of arsenic metabolites after a single oral dose of sodium arsenite, monomethylarsonate, or dimethylarsinate in man. Int Arch Occup Environ Health. 1981;48(1):71-9.	207	16
Lippmann M, Yeates DB, Albert RE. Deposition, retention, and clearance of inhaled particles. Br J Ind Med. 1980;37(4):337-62.	200	17
Donham K, Haglind P, Peterson Y, Rylander R, Belin L. Environmental and health studies of farm workers in Swedish swine confinement buildings Br J Ind Med. 1989;46(1):31-7.	191	18
Walpole AL, Williams MH, Roberts DC. The carcinogenic action of 4-aminodiphenyl and 3:2'-dimethyl-4-amino-diphenyl. Br J Ind Med. 1952;9(4):255-63.	187	19
Nicholson WJ, Perkel G, Selikoff IJ. Occupational exposure to asbestos: population at risk and projected mortality--1980-2030. Am J Ind Med. 1982;3(3):259-311.	181	20

Table 3: most frequent keywords used in Medline to index the 85 articles

MeSH tree number	Medical Subject Headings	Number of occurrence
C	**Diseases**	**190**
C04	Neoplasms :	37
C04.557.337	• Leukemia	3
C04.557.450.795	• Sarcoma	3
C04.557.470.035.510	• Mesothelioma	4
C04.588.894.797.520	• Lung Neoplasms	8
C04.588.894.797.640	• Pleural Neoplasms	2
C05	Musculoskeletal Diseases	11
C08	Respiratory Tract Diseases	13
C08.381.483.600.125	• Asbestosis	4
C10	Nervous System Diseases :	14
C10.668.829	• Peripheral Nervous System Diseases	6
C17.800	Skin Diseases	5
C20.543.480	Hypersensitivity, Immediate	7
C21.613.589	Lead Poisoning	4
C23.550.848	Stress	3
D	**Chemicals and Drugs**	**112**
D01.268.556.175	Chromium	1
D01.268.556.435	Lead	4
D01.268.556.484	Manganese	2
D01.268.912.035	Arsenic	3
D01.268.912.540	Manganese	1
D01.268.912.575	Nickel	1
D01.837.725.700.760.070	Asbestos	4
D02.455	Hydrocarbons :	20
D02.455.426.559.222	• Benzene	2
D02.455.426.559.389	• Benzene Derivatives	8
D02.455.526	• Hydrocarbons, Halogenated	4
D04.615	Polycyclic Hydrocarbons, Aromatic	6
D27	Chemical Actions and Uses :	26
D27.720.723.366	• Herbicides	3
D27.720.844	• Solvents	6

Table 4: Countries of origin of papers

	Decade during which papers were published					
Country	**50's**	**60's**	**70's**	**80's**	**90's**	**Total**
United Kingdom	7	8	6	4	1	26
Sweden			6	8	2	16
USA			1	9	6	16
Netherlands				2	3	5
Belgium				3	1	4
Finland			3		1	4
Canada					3	3
Denmark				2	1	3
Germany				1	1	2
Japan			2			2
Norway					2	2
Morocco	1					1
South Africa		1				1
Total	**8**	**9**	**18**	**29**	**21**	**85**

Figure 1: Main providers of citation classic papers