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An analysis of factors contributing to PubMed's growth

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ABSTRACT

We studied the factors (recent and older journals, publication types, electronic or print form, open or subscription access, funding, affiliation, language and home country of publisher) that contributed to the growth of literature in Biomedical and Life Sciences as reflected in PubMed in the period 2004–2013. Only records indexed as journal articles were studied. 7364,633 journal articles were added in PubMed between 2004 and 2013 (48.9% increase from 2003). Recently launched journals showed the greater increase in published articles, but older journals contributed the greater number of articles. The observed growth was mainly attributed to articles to which no other PubMed publication type was assigned. Articles available in both print and electronic form increased substantially (61.1%). Both open (80.8%) and subscription access (54.7%) articles increased significantly. Funding from non-US government sources also contributed significantly (74.5%). Asian (114%) and European (34.9%) first author affiliation increased at a higher rate than American publications (7.9%). English remained the predominant language of publications. USA- and England-based organizations published a gradually increasing body of literature. Open access, non-US government funding and Asian origin of the first author were the factors contributing to literature growth as depicted in PubMed. A better assignment of publication types is required.

1. Introduction

PubMed, maintained by the United States National Library of Medicine (NLM) of the National Institute of Health (NIH), is an open access search engine that provides records on Biomedical and Life Sciences. It was launched in January 1996 and made freely available online one and a half year later. Since then, it has become one of the most commonly used search tools for retrieving scientific data in Biomedical and Life Sciences. An almost continuous increase in the performed searches has been observed. From 244 million in 2000 (the first year for which data is available), searches almost tripled in 2004, when 677 million searches were performed in PubMed/MEDLINE; this figure rocketed to 2.7 billion in 2014 (NLM).

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The increase in the number of searches was accompanied by a continuous increase in the number of records (i.e. the articles, abstracts and books included in the database) added in PubMed, as did those of other databases (Larsen & von Ins, 2010). A more dramatic increase in their numbers has occurred since 2004, when the number of records was approximately 15 million. By the first half of 2014 approximately 9.9 million more records have been added in Pubmed (a 66% increase from 2004), as evident from PubMed identification number (PMID) (http://www.nlm.nih.gov/bsd/licensee/baselinestats.html). This increase could be attributed to the increase in the number of researchers or an increase in their productivity. An analysis of several databases showed that despite the increase in literature, the productivity of scientists decreased, as shown by the number of papers per unique author (Larsen & von Ins, 2010). An analysis of PubMed records for the period 1978–2001 concluded that the growth of medical literature should be attributed to clinical research, while a shift away from basic science was observed (Druss & Marcus, 2005). Simultaneously, an increase in new journal titles (the term used in PubMed for journals) was observed (3173 more titles in 2013 – new or due to title changes – compared to 2003) (http://www.nlm.nih.gov/bsd/licensee/baselinestats.html), which might denote an increased demand for articles or a limited space in the available journals for the generated research.

There have been numerous bibliometric studies regarding specific diseases, organs or systems (Michalopoulos & Falagas, 2005; Vergidis, Karavasiou, Paraschakis, Bliziotis, & Falagas, 2005; Li, Pan, & Ye, 2013; Stockmann et al., 2014; Sun et al., 2014; Boudry & Mouriaux, 2015; Escobedo et al., 2015), according to the country or continent of origin (Schoonbaert, 2009; Farhat et al., 2013; Sun et al., 2013; Fodor et al., 2014; Man et al., 2014; Kozak, Bornmann, & Leydesdorff, 2015; Uuskula et al., 2015), in the fields of medicine, surgery, laboratory medicine, nursing or veterinary medicine that evaluated literature trends (Rahman & Fukui, 2003; van Eck, Waltman, van Raan, Klautz, & Peul, 2007; Li, Wan, Lu, Li, & Li, 2010; Ahmed Ali et al., 2013; Baldi et al., 2014). A few studies also compared trends between specific countries or continents (Durando, Sticchi, Sasso, & Gasparini, 2007; Uthman & Uthman, 2007), or compared accessibility (open or subscription access) in specific fields (Kurata, Morioka, Yokoi, & Matsubayashi, 2013). The impact of articles in the literature has been also evaluated (van Eck, Waltman, van Raan, Klautz, & Peul, 2013). However, to our knowledge, the factors contributing to the overall growth of PubMed records during the period 2004–2013 have not been studied. In this analysis, we sought to study the contribution of newer and older journals, publication types (as defined in the PubMed database) (http://www.nlm.nih.gov/mesh/pubtypes.html), electronic or print availability, open or subscription access, funding, author affiliation, language and home country of publisher to the growth of literature archived in PubMed from 2004 to 2013.

1.1. PubMed compared to other databases

PubMed is not the only search tool provided by the US NLM. MEDLINE is the U.S. NLM principal bibliographic database. It covers articles published from 1946 to the present primarily in scholarly journals; some older material is also included. It currently includes 21 million publications. The selection of publications to be included in MEDLINE depends on their relevance to Biomedical and Life Sciences. Following assignment of MeSH terms, according to the NLM controlled vocabulary, these records can be included in the MEDLINE database. MEDLINE is the primary component of PubMed. PubMed contains over 23 million records, including the MEDLINE database plus the following types of publications: (a) records for articles before they go through quality control and are indexed with MeSH terms (in-process publications) or converted to out-of-scope status; (b) references to articles that are out-of-scope (e.g., covering issues irrelevant to Health or Life Sciences) from certain MEDLINE journals, primarily general science and general chemistry journals; (c) records that precede the article's final publication in a MEDLINE indexed journal ("Ahead of Print"); (d) records that precede the date that a journal was selected for MEDLINE indexing; e) records that have not yet been updated with current MeSH and converted to MEDLINE status (OLD MEDLINE, publications before 1966); (f) publications to some additional life sciences journals that submit full texts to PubMed Central and receive a qualitative review by NLM; (g) records to author manuscripts of articles published by NIH-funded researchers; and (h) records for the majority of books, and in some cases each chapter of the book, available on the U.S. National Center for Biotechnology Information bookshelf http://www.nlm.nih.gov/bsd/pmresources.html; http://www.nlm.nih.gov/pubs/factsheets/dif_med_pub.html)

In this study we evaluated literature growth in Biomedical and Life Sciences according to the records included in the PubMed database. However, PubMed is not the only available database. Scopus and Web of Science, and in the era of World Wide Web, Google scholar are among the most popular and highly accessed databases for scientific data retrieval. These four databases have their own characteristics that may account for discrepancies in article retrieval during a "key words" search (Falagas, Pitsouni, Malietzis, & Pappas, 2008). All 4 databases offer numerous search facilities and outcome display options. They also offer links to or coverage of similar databases. The major advantage of Google Scholar and PubMed is their free access to articles' abstracts. With PubMed Central open access to key articles, for which subscription is typically required, is available. With Google Scholar a free full text of the article can be retrieved from various web sites, legally or not, even if the journal itself does not offer free access at the moment. The keyword search with PubMed, Scopus and Google Scholar offers optimal update frequency and includes online early articles not available in the Web of Science. Scopus covers a wider journal range (i.e. more scientific fields besides biomedical and life sciences) than PubMed. PubMed however covers more journals in biomedical sciences than Scopus. Google Scholar can retrieve even the most obscure information as long as this is available in the web (Falagas et al., 2008). The search algorithms in PubMed appear to be more specific but include explosion of relevant MeSH terms. Although Scopus allows search on the PubMed's MeSH terms, it won't explode. Scopus, Web of Science and Google Scholar don't have a thesaurus (subject index) of their own, as PubMed does (www.adelaide.edu.au/library/guide/med/wd.html). Scopus, Web of Science, and Google scholar, in contrast to PubMed, provide the number of citations as an index of article importance (Bakkalbasi, Bauer, Glover, & Wang, 2006; Falagas et al., 2008; Kulkarni, Aziz, Shams, & Busse, 2009).

2. Methods

2.1. Data retrieval

We used two mechanisms to retrieve data: PubMed search engine and PubMed/Medline baseline statistics. Searches in PubMed were done using the "Search Field Descriptions and Tags" (http://www.ncbi.nlm.nih.gov/books/NBK3827/). We started by using common search terms regarding time periods, start publication year of journal titles, publication types, language, affiliations, funding, access to full article (open or subscription), and electronic or print publications. As we were becoming more familiar to PubMed's services, policy, mechanisms, functions, and classifications, the methodology of this study evolved and modulated to become more specific and detailed. Contact with the PubMed help Desk and the NLM Customer Service Desk was established for further credibility. All searches were performed for the period 2004–2013 (ten years). Searches were performed in June 2014 by two authors (GT and AP) and verified in meetings with KZV.

PubMed utilizes several classification schemes, including medical subject headings (MeSH), subsets, publication status, date, and type of publications. For the purpose of this study and in order to avoid overlapping between subcategories two classification schemes were used: date and type of publication. PubMed utilizes several classifications regarding dates, including the date of publication (it can be searched using search field description [dp]), the date of print publication ([ppdat]), date of electronic publication ([epdat]), date of addition in PubMed database (entrez date, [edat]), and date of record creation ([crdt]) (http://www.ncbi.nlm.nih.gov/books/NBK3827/). Each date refers to the corresponding fiscal year. For indexing, this year is between mid November of one year and mid November of the following year. Although, publication date is the default PubMed search category, its use results in double entries or possible misclassification for every year due to incorporation of articles published electronically or in print in consecutive years. This causes a moderate increase in the total number of retrieved articles per year (Spreckelsen, Deserno, & Spitzer, 2010). Therefore, for the purpose of this study we used the print publication date for all searches regarding publication types and characteristics (e.g. language, affiliation, etc) as the default search category. The creation and entrez dates were used to calculate the number of new publications added in PubMed in this 10 year period.

PubMed also classifies the cited articles according to the type of publication. Publisher/suppliers who submit journal publication data to NLM are allowed to use only one of the following four publication types: letter, editorial, review, and journal article. If a publisher attempts to send something other than one of these choices or omits a publication type value, the default of journal article is substituted upon receipt at NLM (PubMed communication). NLM has three data creation methods for records included in the Data Creation and Maintenance System (DCMS): Extensible Markup Language (XML) submission, scanning from a print issue and direct creation. NLM makes the final decision of what publication types to apply to a DCMS record. Some of these decisions are made by their data creation staff; some are made by the indexers who do the MeSH subject indexing. Not all PubMed records are in the DCMS. The records in the publisher subset are in PubMed-only.

2.2. PubMed's publication types

After record creation, PubMed's staff assigns one or more publication types to it. One hundred and fifty three categories (publication characteristics/types) had been used in PubMed until June 2014 (http://www.ncbi.nlm.nih.gov/books/NBK3827/). Some of them were introduced in the later years, and therefore data for these categories are incomplete. We selected to study in depth 24 of them, which, according to our opinion, are more likely to be of interest for a physician or researcher: biography, case reports, clinical conference, clinical trial, comment, comparative study, controlled clinical trial, editorial, evaluation studies, government publications, guideline, historical article, in vitro, letter, meta-analysis, multicenter study, news, newspaper article, observational study, pragmatic clinical trial, randomized controlled trial, review, twin study, and validation studies. All aforementioned publication types were introduced in PubMed before 2004, besides pragmatic clinical trial and observational study which were introduced in 2013. The remaining publication types were studied as one. The publication type "publication formats[pt]" was excluded from every search since its inclusion retrieves all PubMed records. We also excluded "research support[pt]" from the publication types since this description provides no information regarding the study type or design.

"Journal article" is the predominant publication type in PubMed and the main publication type conferring new or confirmatory data to researchers or physicians. Therefore, the search was limited to them. We also used two different searches for each publication type: "publication type[pt]" and "journal article[pt] AND publication type[pt]", where "publication type[pt]" corresponds to each one of the 24 selected categories. If publication types were not classified as journal articles in PubMed (e.g. letter) and significant discrepancy (>10%) was found between the number of records retrieved from the two aforementioned searches, then these records were also included in the analysis for publication types. Additional MeSH terms were used for further searches only when a similar heading to a selected publication type (e.g. review, clinical trial etc) was found in the MeSH browser online searching (http://www.nlm.nih.gov/mesh/MBrowser.html). For example, the publication type (heading) "clinical trial" has a similar MeSH term called "clinical trial as topic", which is used for general design, methodology, economics, etc of clinical trials.

A significant overlap in journal articles was expected between some of these categories (for example between review and meta-analysis, letter and comment or editorial, comparative study and clinical trial, etc). In an effort to eliminate it, the number of articles included in the category with fewer records was deducted from the category with more records, acknowledging that this may underestimate the true number of articles included in the category with more records or overestimate the number of articles in the category with fewer records. The print publication date was used for this purpose.

2.3. Newer and older journals

In order to estimate the contribution of newer and older journal titles to the growth of PubMed records, the journal titles indexed in PubMed from 2004 onward were divided in 3 groups, according to their starting date of publication and date of PubMed first indexing. The first group contained titles with start publication year and PubMed indexing from 2004 onward (group 1). The second contained titles with start publication year and year indexed in PubMed before 2004; publication of these titles continued after 2004 (group 2). Groups 1 and 2 increased the number of journal articles by the addition of new articles only. The third group contained titles with start publication year before 2004 but first indexed in PubMed from 2004 onward (group 3). These titles increased PubMed journal articles by the addition of both old and new articles. For classification of articles in the aforementioned groups, the unique identification number of the NLM catalogue (NLMID) was found for each title and classified in one of the above categories. The number of articles published in every year between 2004 and 2013 was found using the search term "2004:2013[ppdat] AND journal article[pt] AND ($NLMID_1$[jid] OR $NLMID_2$[jid] OR. . . OR $NLMID_\nu$[jid])" where ν is the last of the journal titles classified in one of the above groups.

2.4. Electronic and print journals

In order to estimate the contribution of electronic or print journals on the increase of PubMed journal articles, we classified journals in four categories: print only, electronic only (i.e. online), print and electronic, and unclassified. The last category was added because a number of journals are not indexed in PubMed in neither print nor electronic form. The lists of journal titles according to the aforementioned categories were created following the instructions from the NLM Technical Bulletin (Tybaert, 2013, http://www.nlm.nih.gov/pubs/techbull/mj13/mj13_catalog_journal_lists.html). The unique NLMID was found for each indexed journal title and classified in one of the four categories using the search term "1744:2013[syr] AND journal article[pt] AND print[is] NOT electronic[is]" for journals available only in print; "1744:2013[syr] AND journal article[pt] AND electronic[is] AND print[is]" for journals available both in print and electronically; and "1744:2013[syr] AND journal article[pt] AND electronic[is] NOT print[is]" for those available only in electronic form. The number of articles published in every year between 2004 and 2013 for all 4 aforementioned categories was found using the search term "2004:2013[ppdat] AND journal article[pt] AND ($NLMID_1$[jid] OR $NLMID_2$[jid] OR. . . OR $NLMID_\nu$[jid])", where ν is the last of the journal titles classified in any of the aforementioned categories.

2.5. Open or subscription access

The search term for open and subscriber access was "2004:2013[ppdat] journal article[pt] free full text[sb]" and "2004:2013[ppdat] journal article[pt] (full text[sb] NOT free full text[sb])". The terms "full text[sb]" and "free full text[sb]" refer to records that include a link to the full text and free full text, respectively. Therefore, journal articles without such links could not be retrieved in these searches. Since for some journals a subscription is required for a period of time and later all articles are made open access, the results will depict the proportion of open access articles as for June 2014.

2.6. Funding

The role of funding in the growth of published biomedical research was explored using the search term "2004:2013[ppdat] AND journal article[pt] AND funding[pt]", where funding was one of the 6 subcategories used in PubMed. These include Research Support, American Recovery and Reinvestment Act; Research Support, NIH, Extramural; Research Support, NIH, Intramural; Research Support, US Government, PHS; Research Support, US Government, Non-PHS; and Research Support, Non-US Government. The first five subcategories include funding from the US government and therefore were studied as one. The last subcategory includes funding from governments other than the US as well as private resources (foundations, universities, pharmaceutical companies, etc) from the US or abroad (http://www.nlm.nih.gov/mesh/pubtypes.html).

2.7. Affiliations

In order to calculate the country of origin of each article, the affiliation of the participating authors was used. Up to 2012, the affiliation of the first author only was indexed in PubMed records. Therefore, the contribution of every country in the total number of journal articles could not be calculated accurately. After 2013 the affiliations of all authors are indexed. The applied search term for every country in the globe was "2004:2013[ppdat] AND journal article[pt] AND country[ad]". The

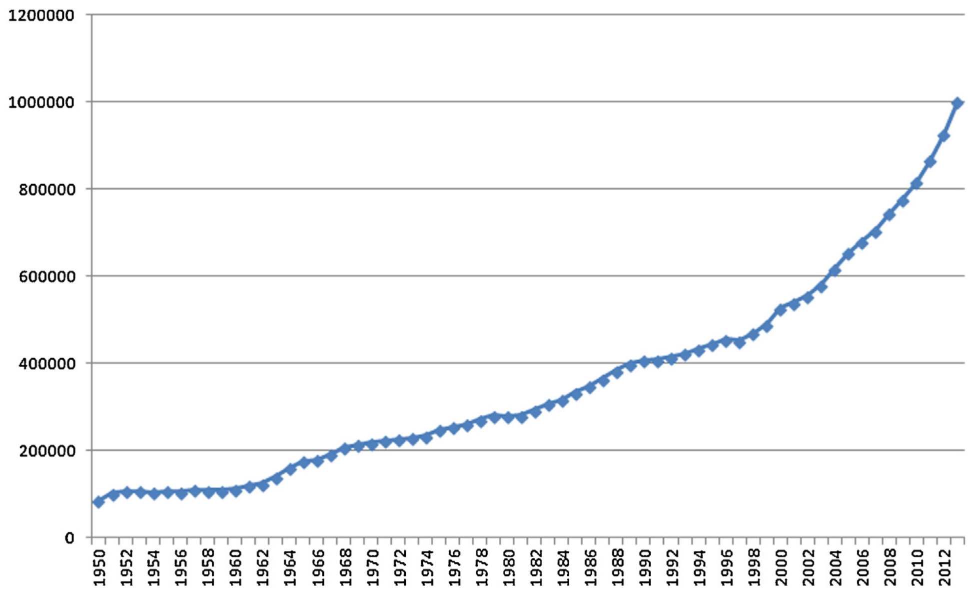

Fig. 1. PubMed journal articles according to their publication date as provided by PubMed.

top 10 countries were studied in detail, while the rest were studied together. Finally, the number of articles contributed by each continent was calculated using the search term "2004:2013[ppdat] AND journal article[pt] AND (country$_1$[ad] AND country$_2$[ad] AND . . . country$_\nu$[ad])" five times for the respective continents.

2.8. Language

We extracted data regarding the language of the published articles. The search term used was "2004:2013[ppdat] journal article[pt] language[la]". English, French, German, Italian, Spanish, Russian, Chinese and Japanese were studied in detail and the remaining languages were studied as a group. In addition, the home country of the publisher was calculated using the search term "2004:2013[ppdat] journal article[pt] country[pl]". The leading 10 countries were studied in detail, while the rest were studied together.

3. Results

Fig. 1 shows the increase of PubMed records according to the publication date as provided by PubMed. The total number of PubMed records was 23,896,035. Among them, 22,440,043 were listed as journal articles; 7733,012 and 7364,633 of them had a creation and entrez date between 2004 and 2013, respectively, representing a 52.6% and 48.9% increase from 2003, respectively. Among them, 6831,263 articles (88.3% and 92.8% of those with a creation and entrez date, respectively) had a print publication date from 2004 to 2013. Another 486,523 (among those with a creation date) and 106,324 journal articles (among those with an entrez date) had print publication date before 2004 and introduced in PubMed after. More specifically, these articles had a print publication date from 1995 to 2003 (group 3 journal articles). For additional 134,751 (with creation date) and 129,123 (with entrez date) of these articles the print publication date was 2014.

In 2003 556,091 articles were added in PubMed, while the corresponding number in 2013 was 903,759, an increase of 62.5%. On the other hand, the number of created records in 2003 was 551,002, while in 2013 this figure was 958,145 (increased by 73.9%). In fact, records with a creation date were fewer (approximately 10,000 to 20,000) than records with an entrez date up to 2008. Creation date was added in 2009 in PubMed, and since then the records with a creation date were more (approximately 50 to 60 thousands) than records with an entrez date for every year of the study.

3.1. New vs older journals, start publication year (Table 1)

By June 2014, 25,957 journal titles were listed in PubMed. Between 2004 and 2013 3173 new journal titles were added. These could be new journal titles or journal titles which changed their name. The corresponding figures for titles with start publication year in the periods 1990–2003, 1980–1989, 1960–1979 and 1744–1959 were 4772, 3866, 6678 and 7469, respectively. Using the NLMIDs of these titles, we calculated that 5180,368 journal articles were added in PubMed in the period 2004–2013. Titles with start publication year 2004–2013 contributed 626,152 new journal articles (group 1, 12.1%), while older titles (groups 2 and 3) contributed more. As noted previously, group 3 titles contributed 106,324 journal articles (2.1%). Therefore, titles in group 2 provided 4447,892 journal articles (85.8%). The number of journal articles retrieved in

Table 1
Annual number of records and changes from the previous year (%) according to the start publication year.

Start publication year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	**%**	No. of change 2013–2004	% Change 2013–2004
2004–2013	6518	16,148	147.7	25,595	58.5	34,801	36.0	46,097	32.5	58,333	26.5	68,066	16.7	97,492	43.2	132,591	36.0	140,511	6.0	133,993	2055.7
1990–2003	166,132	179,515	8.1	185,651	3.4	191,911	3.4	203,018	5.8	211,594	4.2	217,946	3.0	230,899	5.9	239,798	3.9	237,465	−1.0	71,333	42.9
1980–1989	109,442	113,291	3.5	116,624	2.9	120,332	3.2	123,906	3.0	127,009	2.5	130,883	3.1	133,907	2.3	139,426	4.1	139,830	0.3	30,388	27.8
1960–1979	69,565	72,112	3.7	73,070	1.3	75,867	3.8	78,080	2.9	79,151	1.4	79,983	1.1	82,033	2.6	84,023	2.4	84,585	0.7	15,020	21.6
1744–1959	48,286	48,125	−0.3	46,241	−3.9	45,798	−1.0	45,765	−0.1	45,836	0.2	45,189	−1.4	45,335	0.3	44,758	−1.3	41,835	−6.5	−6451	−13.4

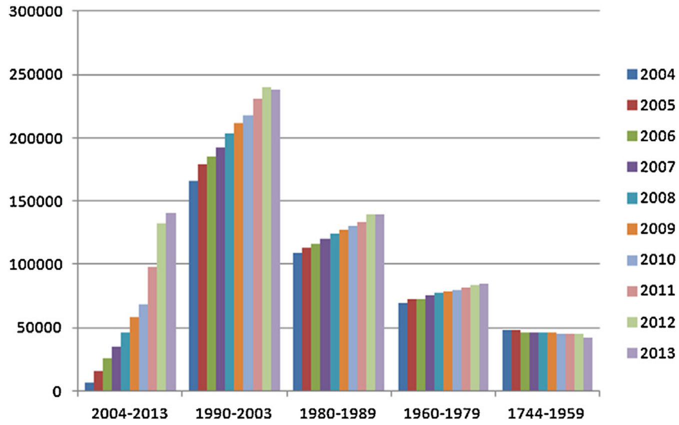

Fig. 2. Journal articles included in PubMed in the period 2004–2013 according to the publication start year of the indexed journals.

the search was lower than the total number of articles indexed in PubMed during the study period (1650,895 fewer articles, 24.2%).

Fig. 2 shows that besides journals with a publication start year in the period 1744–1959, a steady increase in annual publications was observed in all others. Journal titles with publication start years 2004–2013 showed the highest annual increase in journal articles they published during the period 2004–2013 (6–147.7%). The rate of annual increase in the number of journal articles was lower in the 3 groups containing journal titles with a start publication year during the periods 1990-2003 (range −1% to 8%), 1980–1989 (0.3% to 4.1%), and 1960–1979 (0.7% to 3.8%), while for the group with the more distant start publication years (1744–1959) the rate was negative for most of the years of the study (−6.5% to 0.3%). In fact, by 2013 the annual number of articles published in journals with a start publication year 2004–2013 had reached the number of articles published in titles with start publication year 1980–1989, while they had surpassed the articles in titles with start publication year 1960–1979 since 2011 and that of titles with start publication year 1744–1959 since 2008. Still, in 2013 the journals titles with a start publication year in the period 1990–2013 contributed the highest number of published journal articles.

3.2. Publication types

As expected, significant overlap was observed between the following pairs of categories: case reports with clinical conference, letter and review; historical article with biography; clinical trial with comparative study, controlled clinical trial, and multicenter study; comment with letter; comparative study with controlled clinical trial, evaluation studies, in vitro, meta-analysis, multicenter study, observational study, randomized controlled trial, twin study, and validation studies; evaluation studies with validation studies; review with editorial, guidelines, historical article, letter, and meta-analysis; and multicenter study with randomized clinical trial and observational study.

Fig. 3 shows the annual journal articles/records with overlapping for the 24 selected publication types. Publication types that had a minor contribution (government publications, pragmatic clinical trial, newspaper article, news) were not included. It is evident that none of the selected categories could be responsible for the observed increase in PubMed's records, since none of them increased numerically substantially from 2004 to 2013 (Table 2). The greater relative increase was seen for meta-analysis (285.1%), but their absolute increase was low (change from 2004: 4083 articles). The greater numerical increase was due to comments (7996 more comments in 2013 compared to 2004). On the contrary, the number of journal articles for most of the selected publication types decreased. The highest relative and absolute decrease was seen for comparative studies (49.9%, 37,560 articles compared to 2004).

The annual number of journal articles classified in the remaining publication types (498,520, 7.3% of total) increased from 2004 to 2008, and then dropped again gradually up to 2013. On the other hand, an impressive increase in the number of journal articles not classified in any of the PubMed publications types (beyond research support and publication formats) in this 10 year period was observed (Fig. 4, change from 2004: 246,244 articles, 81.7%). Therefore, 4207,559 journal articles (61.6%) were not classified in any of the PubMed publication types (besides that of the journal article), and 4706,079 articles were not classified in any of the selected publication types (68.9%).

3.3. Searching with and without "journal article[pt]" and/or MeSH terms (Table 3)

A greater than 10% difference between a search using only "publication type[pt]" and a search using "publication type[pt] AND journal article[pt]" was found for the publication types biography, case reports, comments, editorial, government publications, historical article, letter, news and newspaper article. The largest was seen for news (100%), newspaper article (99.7%) letter (99.3%), editorial (88.4%), and comments (70.9%). News and letters should not co-occur with journal articles,

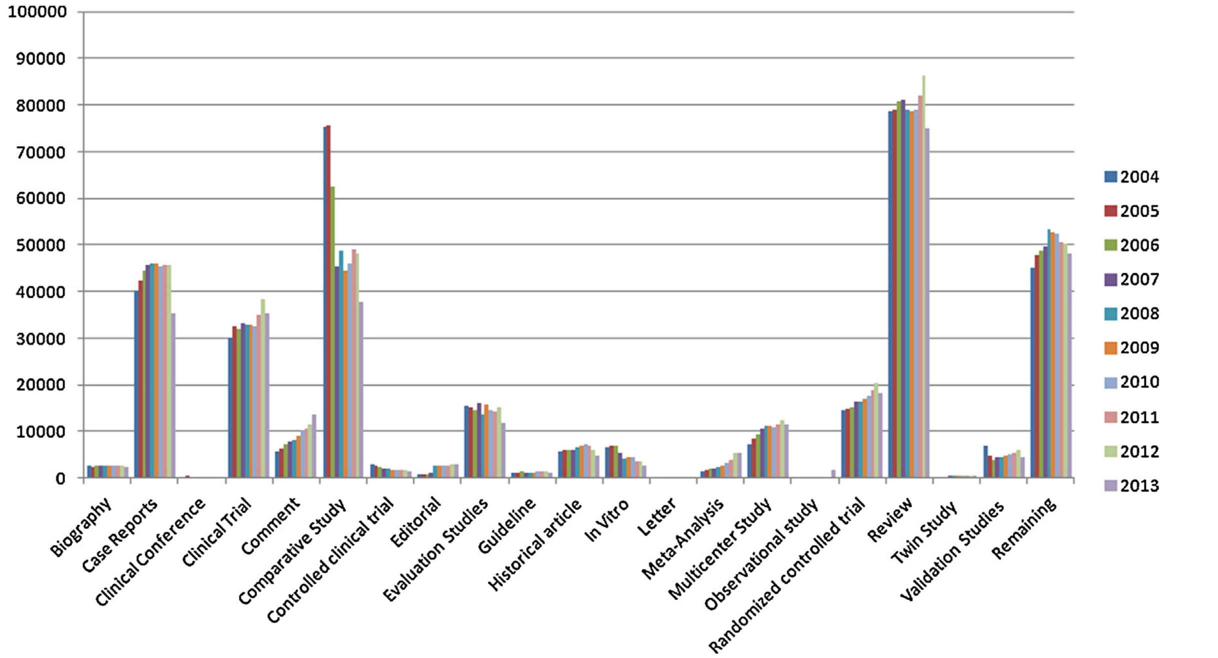

Fig. 3. Annual PubMed records with overlapping for the selected publication types.

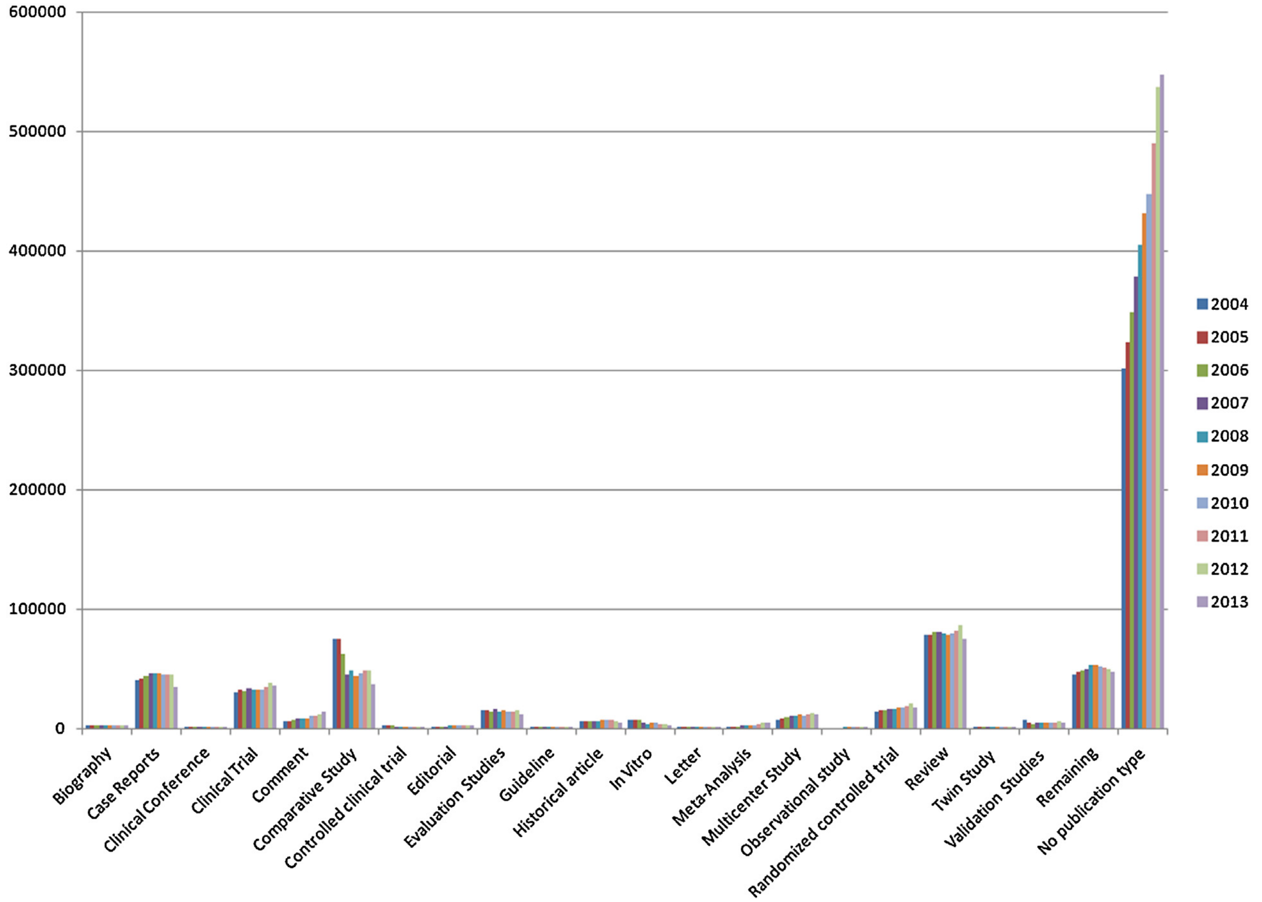

Fig. 4. Annual distribution of journal articles included in PubMed according to other publications types (beyond research support and publication formats) in the period 2004–2013.

Table 2

Annual number of records and changes from the previous year (%) according to the selected publication types for journal articles as provided by PubMed (overlaps included).[*]

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
Biography	2560	2464	−3.8	2638	7.1	2580	−2.2	2662	3.2	2602	−2.3	2587	−0.6	2511	−2.9	2626	4.6	2230	−15.1	−330	−12.9
Case reports	40,208	42,208	5.0	44,452	5.3	45,774	3.0	45,951	0.4	45,904	−0.1	45,500	−0.9	45,592	0.2	45,599	0.0	35,203	−22.8	−5005	−12.4
Clinical conference	271	377	39.1	291	−22.8	266	−8.6	256	−3.8	218	−14.8	189	−13.3	178	−5.8	176	−1.1	159	−9.7	−112	−41.3
Clinical trial	30,019	32,466	8.2	31,890	−1.8	33,255	4.3	32,769	−1.5	33,030	0.8	32,679	−1.1	35,073	7.3	38,347	9.3	35,478	−7.5	5459	18.2
Comment[#]	5685	6194	9.0	7109	14.8	7901	11.1	8218	4.0	8928	8.6	10,190	14.1	10,565	3.7	11,512	9.0	13,681	18.8	7996	140.7
Comparative study	75,199	75,537	0.4	62,636	−17.1	45,293	−27.7	48,840	7.8	44,549	−8.8	45,962	3.2	49,098	6.8	48,043	−2.1	37,639	−21.7	−37,560	−49.9
Controlled clinical trial	2924	2754	−5.8	2386	−13.4	2073	−13.1	2001	−3.5	1859	−7.1	1634	−12.1	1618	−1.0	1854	14.6	1521	−18.0	−1403	−48.0
Editorial[#]	966	775	−19.8	847	9.3	1076	27.0	2793	159.6	2712	−2.9	2784	2.7	2695	−3.2	2917	8.2	2856	−2.1	1890	195.7
Evaluation studies	15,610	15,217	−2.5	14,609	−4.0	15,998	9.5	13,636	−14.8	15,640	14.7	14,678	−6.2	14,187	−3.3	15,043	6.0	11,718	−22.1	−3892	−24.9
Guideline	1189	1081	−9.1	1299	20.2	1180	−9.2	1270	7.6	1163	−8.4	1326	14.0	1337	0.8	1367	2.2	1041	−23.8	−148	−12.4
Historical article	5757	5900	2.5	6132	3.9	5993	−2.3	6595	10.0	6785	2.9	7093	4.5	7031	−0.9	6156	−12.4	4741	−23.0	−1016	−17.6
In vitro	6749	7000	3.7	7080	1.1	5511	−22.2	4201	−23.8	4408	4.9	4622	4.9	3633	−21.4	3533	−2.8	2735	−22.6	−4014	−59.5
Letter[#]	228	222	−2.6	203	−8.6	179	−11.8	205	14.5	187	−8.8	207	10.7	200	−3.4	213	6.5	214	0.5	−14	−6.1
Meta−analysis	1432	1614	12.7	1910	18.3	2105	10.2	2335	10.9	2680	14.8	3197	19.3	3965	24.0	5407	36.4	5515	2.0	4083	285.1
Multicenter Study	7333	8539	16.4	9269	8.5	10,520	13.5	11,263	7.1	11,297	0.3	10,889	−3.6	11,593	6.5	12,491	7.7	11,592	−7.2	4259	58.1
Observational study	0	0	NA	0	NA	0	NA	1	NA	2	100.0	7	250.0	5	−28.6	65	1200.0	1828	2712.3	1828	NA
Randomized controlled trial	14,434	14,937	3.5	15,308	2.5	16,378	7.0	16,440	0.4	17,070	3.8	17,771	4.1	18,901	6.4	20,479	8.3	18,160	−11.3	3726	25.8
Review	78,710	78,928	0.3	80,896	2.5	81,123	0.3	79,099	−2.5	78,593	−0.6	79,119	0.7	82,040	3.7	86,275	5.2	75,167	−12.9	−3543	−4.5
Twin study	293	329	12.3	341	3.6	414	21.4	442	6.8	427	−3.4	407	−4.7	412	1.2	428	3.9	457	6.8	164	56.0
Validation studies	6947	4752	−31.6	3863	−18.7	4516	16.9	4528	0.3	4662	3.0	5241	12.4	5424	3.5	5875	8.3	4569	−22.2	−2378	−34.2
Remaining[**]	44,974	47,738	6.1	48,814	2.3	49,751	1.9	53,300	7.1	52,659	−1.2	52,347	−0.6	50,604	−3.3	50,298	−0.6	48,035	−4.5	3061	6.8
No publication type	301,256	322,999	7.2	347,978	7.7	377,962	8.6	404,637	7.1	431,066	6.5	447,427	3.8	489,406	9.4	536,328	9.6	547,500	2.1	246,244	81.7

NA not applicable (cannot calculate because the denominator is 0).

[*] From the selected publication types, the following had very small number of entries in PubMed during the study period and were not included in the table: government publications 11 articles, pragmatic clinical trial 19 articles, newspaper article 16 articles, news 0 articles.

[**] This category does not contain articles with research support or publication formats as additional publication types.

[#] For the categories comment, editorial, letter (and for news and newspaper articles) the retrieved articles without the limitation of journal article[pt] is much higher since they cannot co-occur with it.

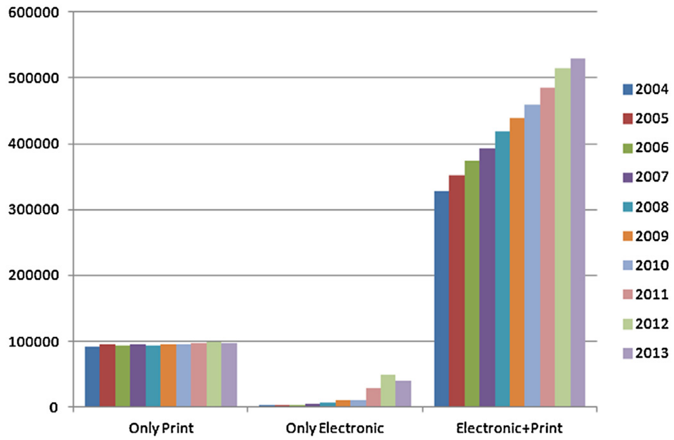

Fig. 5. Annual distribution of journal articles included in PubMed according to their availability in print or electronic form.

and therefore the finding was expected. However, editorials, which should also not co-occur with journal articles, had significant overlap with journal articles. Another unexpected finding was that for reviews, which are considered a different publication type from journal articles, the searches provided similar results.

When the publication type and its similar MeSH term were combined (e.g. clinical trial[pt] AND clinical trial[mh]), the overlap between the searches with and without the additional MeSH term was minimal, as demonstrated by their large difference (>99% in 21 out of the 24 selected publication types). "Evaluation studies[pt]" was the publication type with the higher overlap with its similar MeSH term (difference 75.8%).

When the search required the publication type or its similar MeSH term (e.g. clinical trial[pt] OR clinical trial[mh]), the MeSH terms provided considerably more retrieved journal articles for most of the selected publication types; the highest increase was observed for government publications (518.2%) and guideline (486.9%) and the lower for validation studies (3.9%), biography (5.9%), and multicenter study (7.2%). A significant number of the additional retrieved journal articles in all these searches have been classified as review[pt] (53.7% for clinical trial, 41.7% for meta-analysis, 38.8% for twin study).

3.4. Electronic or print journals titles (Fig. 5, Table 4)

The number of journal articles available only in print form showed a small increase from 2004 to 2013 (4510 articles, 4.9%), but this was not constant annually, since in 3 occasions a decrease was observed. A gradual increase was seen for articles found in both electronic and print form; the difference between 2004 and 2013 was substantial (200,573 articles, 61.1%). The number of articles available only electronically showed an impressive increase up to 2013 (36,997 more articles compared to 2004, 1810.9%), but their number in 2004 was extremely small. A minority of the journal articles had neither print nor electronic availability (designated as unclassified in Table 4). The number of journal articles retrieved in the search was lower than the total number of journal articles indexed in PubMed during the study period (1415,077 less articles, 20.7%).

3.5. Open or subscription access journal articles (Fig. 6, Table 5)

The annual number of journal articles requiring subscription for access increased from 2004 up to 2012 by 36.1%. Their percentage among all published articles decreased slightly (from 63.7% to 59.8%). On the other hand, the number of open access journal articles increased substantially from 2004 to 2012 (134.5%), as did their percentage among all published articles (20.6% to 33.3%). A sharp increase in paid access and a decrease in open access articles were noticed in 2013. Finally, the number of articles with no link to full text decreased over time (change from 2004: −41.9%).

3.6. Funding

Funding has been used in PubMed as a publication type. Among the 3250,081 "funded" PubMed journal articles, 2372,911 (73%) were not classified in any of the 24 selected PubMed publication types. In addition, 87,918 funded journal articles were classified in non-selected publication types. Therefore, 2284,993 (70.3%) of funded journal articles were only classified according to research support, without any other more specific PubMed publication type.

An annual increase was seen in both US government and non-US government supported publications (includes funded studies from non-government US resources and government and private grants from the rest of the globe) up to 2012. In 2013, publications by non-US government grants continued to increase, but US government funded studies decreased slightly (Fig. 7, Table 6). US government funded journal articles increased from 80,039 to 106,703 (change from 2004: 33.3%).

Table 3
PubMed search differences using journal articles, publication types and/or MeSH terms for the 24 selected publication types during the period 2004–2013.

Publication types	Pt only	Pt and journal article	No. of difference*	% Difference*	(pt and MeSH) journal articles	No. of difference$	% Difference$	(pt or MeSH) journal articles	No. of addition&	% Addition&
Biography	39,338	25,423	13,915	35.4	2215	23,208	91.3	26,922	1499	5.9
Case reports	506,450	435,564	70,886	14.0	pt only	NA	NA	pt only	NA	NA
Clinical conference	2381	2381	0	0.0	pt only	NA	NA	pt only	NA	NA
Clinical trial	338,586	334,095	4491	1.3	3070	331,025	99.1	433,805	99,710	29.8
Comment	309,090	89,928	219,162	70.9	pt only	NA	NA	pt only	NA	NA
Comparative study	542,828	531,948	10,880	2.0	pt only	NA	NA	pt only	NA	NA
Controlled clinical trial	20,866	20,673	193	0.9	24	20,649	99.9	67,433	46,760	226.2
Editorial	176,150	20,389	155,761	88.4	pt only	NA	NA	pt only	NA	NA
Evaluation studies	147,643	146,078	1565	1.1	35,297	110,781	75.8	544,565	398,487	272.8
Government publications	13	11	2	15.4	0	11	100.0	68	57	518.2
Guideline	12,625	12,215	410	3.2	687	11,528	94.4	71,687	59,472	486.9
Historical article	71,439	62,078	9361	13.1	pt only	NA	NA	pt only	NA	NA
In vitro	49,831	49,430	401	0.8	pt only	NA	NA	pt only	NA	NA
Letter	308,157	2055	306,102	99.3	1	2054	100.0	4426	2371	115.4
Meta-analysis	30,394	30,035	359	1.2	108	29,927	99.6	36,615	6580	21.9
Multicenter study	105,698	104,559	1139	1.1	109	104,450	99.9	112,046	7487	7.2
News	64,491	0	64,491	100.0	pt only	NA	NA	pt only	NA	NA
Newspaper article	5826	16	5810	99.7	pt only	NA	NA	pt only	NA	NA
Observational study	2104	2070	34	1.6	3	2067	99.9	3049	979	47.3
Pragmatic clinical trial	19	19	0	0.0	0	19	100.0	56	37	194.7
Randomized controlled trial	172,117	170,396	1721	1.0	1286	169,110	99.2	216,325	45,929	27.0
Review	798,768	789,297	9471	1.2	pt only	NA	NA	pt only	NA	NA
Twin study	4002	3945	57	1.4	23	3922	99.4	4695	750	19.0
Validation studies	50,675	50,239	436	0.9	27	50,212	99.9	52,181	1942	3.9

Abbreviations: pt publication type; MeSH medical subject headings; NA not applicable.

* Difference between “pt only” and “pt and journal article”, % defined as difference/“pt only”.

$ Difference between “pt and journal article” and “pt and MeSH journal article”, % defined as difference/“pt and journal article”.

& Addition to “pt and journal article”, % defined as addition/“pt and journal articles”.

Table 4
Annual number of records and changes from the previous year (%) according to availability (electronic or print publication).

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% change 2013–2004
Only print	92,435	95,380	3.2	93,957	−1.5	94,423	0.5	93,342	−1.1	95,391	2.2	95,542	0.2	96,926	1.4	99,636	2.8	96,945	−2.7	4510	4.9
Only electronic	2043	3079	50.7	3556	15.5	4115	15.7	7136	73.4	10,078	41.2	9750	−3.3	28,602	193.4	49,092	71.6	39,040	−20.5	36,997	1810.9
Electronic + print	328,283	353,016	7.5	373,565	5.8	393,638	5.4	418,401	6.3	439,394	5.0	459,440	4.6	486,015	5.8	514,123	5.8	528,856	2.9	200,573	61.1
Unclassified	1436	1604	11.7	1336	−16.7	1330	−0.4	1256	−5.6	1213	−3.4	879	−27.5	972	10.6	940	−3.3	749	−20.3	−687	−47.8

Table 5
Annual number of records and changes from the previous year (%) according to the access to their full text.

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
Subscription access	357,118	383,398	7.4	404,214	5.4	414,026	2.4	427,914	3.4	436,776	2.1	449,458	2.9	460,897	2.5	485,968	5.4	552,716	13.7	195,598	54.8
Open access	115,360	124,578	8.0	132,024	6.0	148,586	12.5	170,583	14.8	191,737	12.4	202,075	5.4	237,857	17.7	270,493	13.7	208,559	−22.9	93,199	80.8
No link	86,494	82,781	−4.3	75,924	−8.3	71,124	−6.3	63,945	−10.1	59,013	−7.7	56,099	−4.9	57,478	2.5	54,510	−5.2	50,286	−7.7	−36,208	−41.9

Table 6
Annual number of records and changes from the previous year (%) according to funding.

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
No funding*	313,787	329,885	5.1	334,523	1.4	340,736	1.9	350,677	2.9	357,457	1.9	364,443	2.0	385,779	5.9	407,419	5.6	405,169	−0.6	91,382	29.1
US gov't	80,039	84,475	5.5	90,476	7.1	93,311	3.1	94,948	1.8	96,647	1.8	97,539	0.9	105,076	7.7	111,274	5.9	106,703	−4.1	26,664	33.3
Non-US gov't	205,212	217,478	6.0	230,751	6.1	244,849	6.1	263,955	7.8	281,912	6.8	295,006	4.6	317,775	7.7	348,786	9.8	358,161	2.7	152,949	74.5
Both US gov't and non-gov't	39,848	40,931	2.7	43,431	6.1	44,957	3.5	46,935	4.4	48,149	2.6	48,884	1.5	52,239	6.9	55,249	5.8	54,226	−1.9	14,378	36.1
US gov't only	40,191	43,544	8.3	47,045	8.0	48,354	2.8	48,013	−0.7	48,498	1.0	48,655	0.3	52,837	8.6	56,025	6.0	52,477	−6.3	12,286	30.6
Non-US gov't only	165,364	176,547	6.8	187,320	6.1	199,892	6.7	217,020	8.6	233,763	7.7	246,122	5.3	265,536	7.9	293,537	10.5	303,935	3.5	138,571	83.8

* Data regarding funding is not available in PubMed.

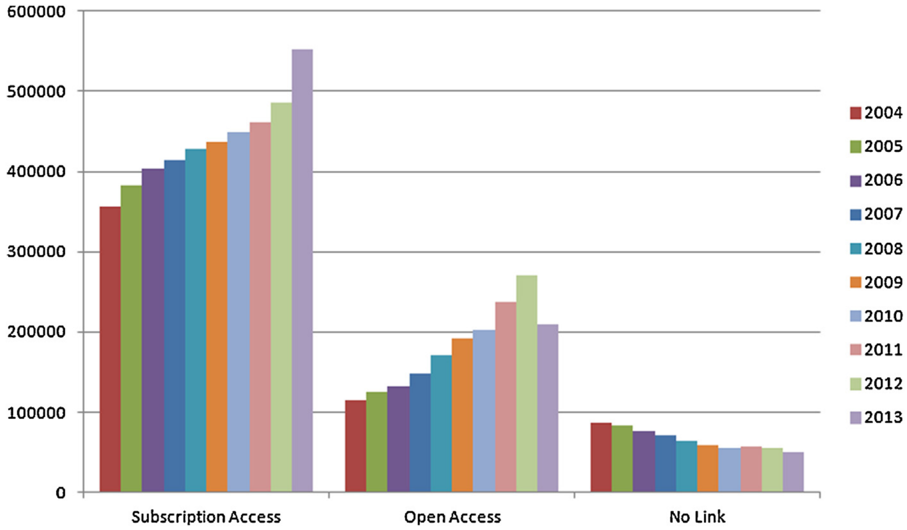

Fig. 6. Annual distribution of journal articles included in PubMed according to the access to the full article.

US government only funded journal articles increased by a mean 3% per year throughout the study period; the corresponding figure for journal articles receiving US government only or US government and non-US government funding was 4.5%. A greater increase was seen in non-US government supported publications, from 205,212 in 2004 to 358,161 in 2013 (change from 2004: 74.5%, mean annual increase 6.4%); the mean annual increase for journal articles receiving non-US government grants only was 7%. Publications without reported funding also increased from 313,787 to 405,169 (change from 2004: 29.1%, mean annual increase 2.9%).

3.7. Country (affiliation)

Fig. 8 shows the number of journal articles from the ten most productive countries and those from the remaining countries are shown together. It is evident that publications from all countries increased, more or less, the production of articles from 2004 to 2012. USA was increasing its productivity up to 2012 (25,504 articles, 13%), but a sharp decrease was observed in 2013 at levels lower than that of 2004 (Table 7). The sharpest increase was observed in China, which almost quadrupled its production (change from 2004: 59,724 articles, 270%). Japan and United Kingdom did not show substantial changes in their

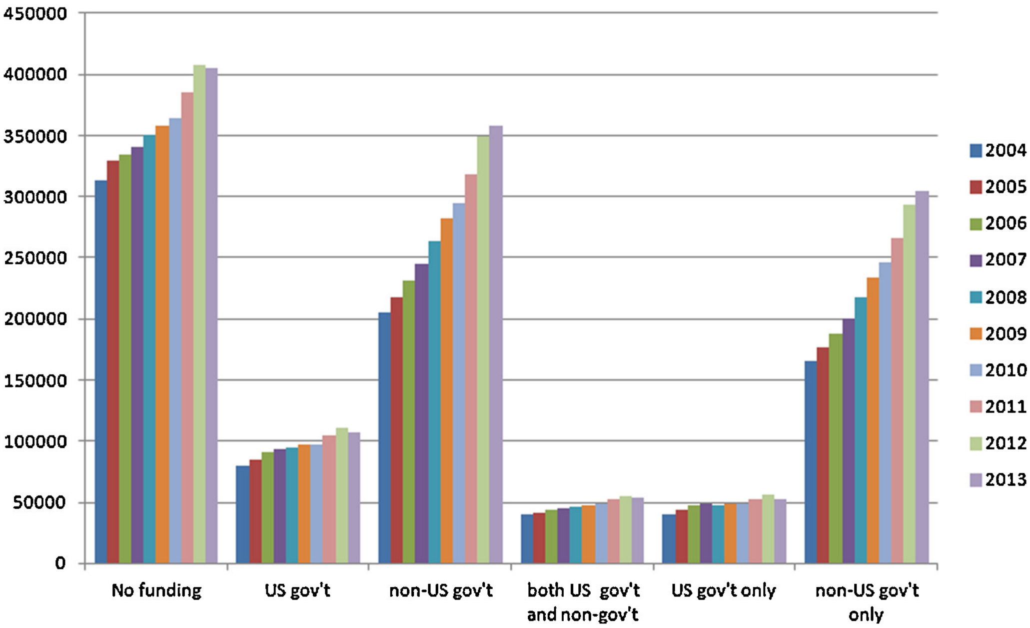

Fig. 7. Annual distribution of journal articles included in PubMed according to funding.

Table 7
Annual number of records and changes from the previous year (%) according to the affiliation of the first author per country.

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
USA	170,020	176,392	3.7	181,456	2.9	181,932	0.3	186,359	2.4	188,792	1.3	189,300	0.3	190,678	0.7	195,524	2.5	167,491	−14.3	−2529	−1.5
China	22,061	27,551	24.9	31,462	14.2	35,648	13.3	41,671	16.9	48,855	17.2	53,808	10.1	62,578	16.3	74,552	19.1	81,785	9.7	59,724	270.7
Japan	37,141	37,219	0.2	36,444	−2.1	37,254	2.2	37,895	1.7	37,951	0.1	37,339	−1.6	39,436	5.6	41,561	5.4	38,844	−6.5	1703	4.6
United Kingdom	32,167	33,202	3.2	33,636	1.3	34,994	4.0	35,025	0.1	36,061	3.0	35,580	−1.3	36,815	3.5	38,129	3.6	35,662	−6.5	3495	10.9
Germany	26,215	27,910	6.5	28,829	3.3	29,983	4.0	30,272	1.0	31,706	4.7	31,913	0.7	33,117	3.8	35,210	6.3	34,044	−3.3	7829	29.9
Italy	18,338	19,192	4.7	20,052	4.5	21,273	6.1	22,498	5.8	22,903	1.8	23,360	2.0	24,336	4.2	26,662	9.6	26,375	−1.1	8037	43.8
France	18,275	19,113	4.6	19,453	1.8	20,022	2.9	22,029	10.0	22,388	1.6	22,408	0.1	22,844	1.9	24,255	6.2	24,307	0.2	6032	33.0
Canada	16,713	18,107	8.3	19,500	7.7	20,421	4.7	21,380	4.7	22,539	5.4	22,212	−1.5	23,142	4.2	24,731	6.9	24,011	−2.9	7298	43.7
Australia	11,402	11,931	4.6	13,080	9.6	13,905	6.3	14,698	5.7	15,614	6.2	16,199	3.7	17,617	8.8	19,013	7.9	20,114	5.8	8712	76.4
India	7449	8596	15.4	9443	9.9	11,196	18.6	13,257	18.4	14,977	13.0	17,386	16.1	20,656	18.8	24,148	16.9	25,603	6.0	18,154	243.7
Remaining countries	119,106	126,948	6.6	134,342	5.8	131,843	−1.9	150,477	14.1	157,744	4.8	165,215	4.7	179,257	8.5	197,347	10.1	189,135	−4.2	70,029	58.8

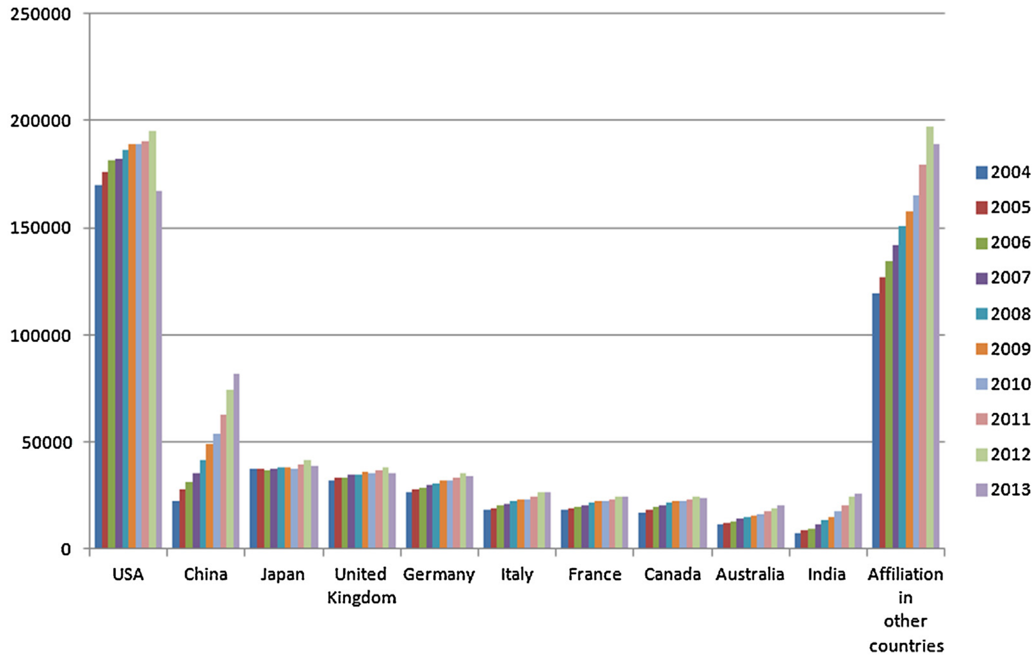

Fig. 8. Annual distribution of journal articles included in PubMed according to the affiliation of the first author for the top 10 countries.

affiliations. A gradual increase was observed for Germany, Italy, France, Canada and Australia. India increased its affiliations substantially (18,154 more journal articles than 2004, 244%), and by 2013 it was the 7th more productive country supplanting France, Canada and Australia. More journal articles were observed for the remaining countries as a whole (70,029 more articles in 2013 than 2004, 58.8%). The number of journal articles retrieved in the search was lower than the total number of articles added in PubMed during the study period (962,320 articles, 14.1%).

Fig. 9 shows the journal articles according to the continent of origin. It is evident that although all continents contributed to the increase of journal articles, Asia conferred the highest absolute (101,878) and relative increase (114%) from 2004, followed by Europe (61,720 articles, 34.9%) and America (15,685 articles, 7.9%). The annual number produced in Europe surpassed those from America for the first time in 2013. Again, a sharp decrease was observed in the journal articles from America in 2013. Oceania and Africa contributed to a lesser extend to the overall increase of journal articles (Table 8).

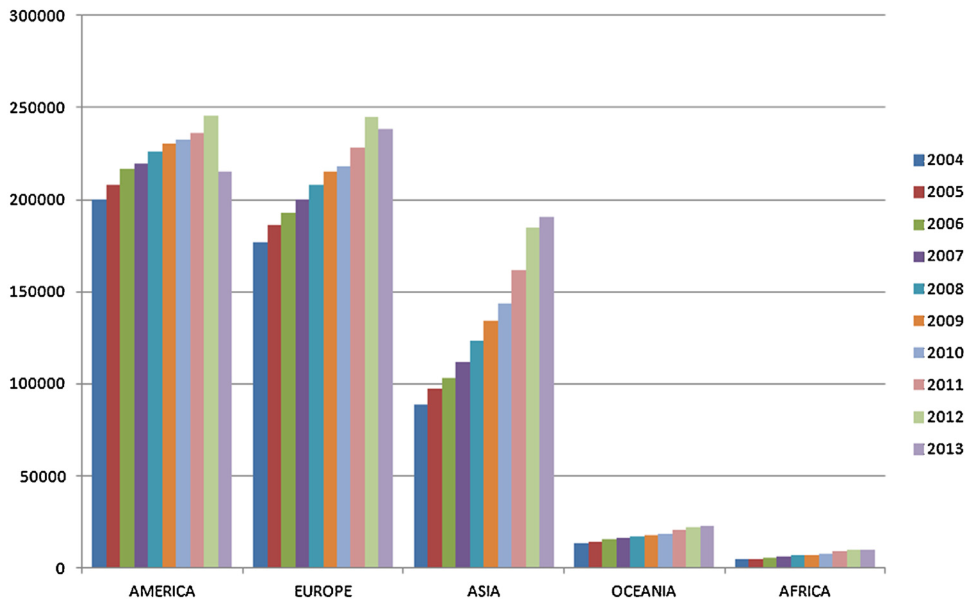

Fig. 9. Annual distribution of journal articles included in PubMed according to the affiliation of the first author by continent.

Table 8
Annual number of records and changes from the previous year (%) according to the affiliation of the first author per continent.

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
America	199,761	208,248	4.2	216,703	4.1	219,431	1.3	226,333	3.1	230,740	1.9	232,324	0.7	236,492	1.8	245,959	4.0	215,446	−12.4	15,685	7.9
Europe	176,931	186,562	5.4	192,522	3.2	200,169	4.0	207,699	3.8	215,016	3.5	217,948	1.4	228,616	4.9	244,787	7.1	238,651	−2.5	61,720	34.9
Asia	89,024	97,251	9.2	103,106	6.0	112,004	8.6	123,322	10.1	134,123	8.8	143,501	7	161,842	12. .8	184,602	14.1	190,902	3.4	101,878	114.4
Oceania	13,384	14,066	5.1	15,301	8.8	16,200	5.9	17,089	5.5	18,142	6.2	18,821	3.7	20,398	8.4	22,040	8.0	22,910	3.9	9526	71.2
Africa	4570	4959	8.5	5417	9.2	6140	13.3	6649	8.3	7272	9.4	7920	8.9	9013	13.8	9886	9. .7	9779	−1.1	5209	114.0

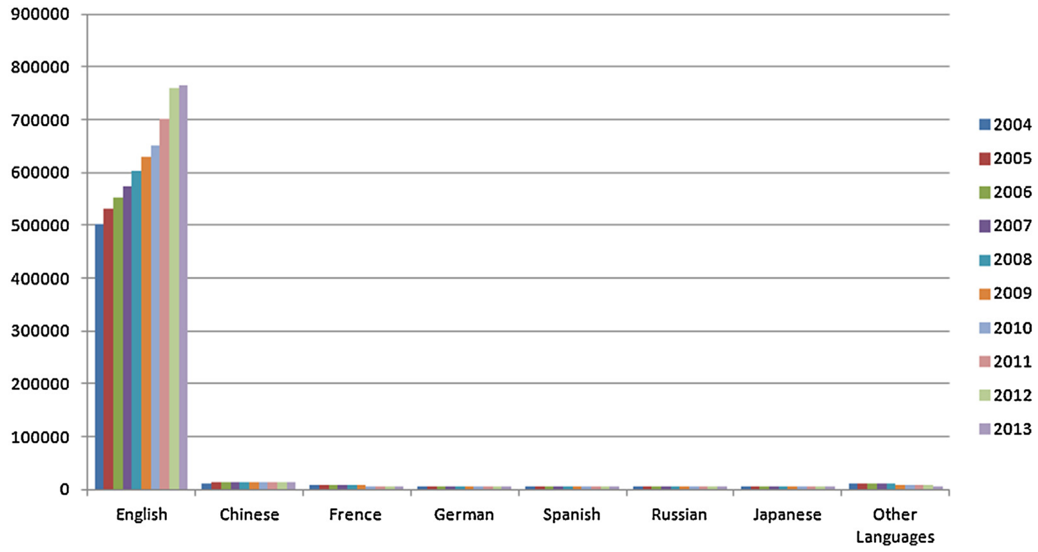

Fig. 10. Annual distribution of journal articles included in PubMed according to the language of the publication.

3.8. *Language (Fig. 10, Table 9)*

English language remains the predominant publication language in biomedical sciences. It was the only language (from those studied) to exhibit an increase in the number of published journal articles (change from 2004: 263,720 articles, 52.5%). Articles in Chinese tended to increase slightly up to 2009, but the annual number of articles decreased thereafter. The number of articles in the remaining languages had ups and downs, but in general they tended to decrease (Fig. 11). The number of journal articles retrieved in this search was similar to the total number of articles indexed in PubMed during the study period.

3.9. *Home country of publisher (Fig. 12, Table 10)*

Most of the journal articles added in PubMed from 2004 to 2013 were published in the USA. In addition, they showed the greater numerical increase during the study period (change from 2004: 82,427 articles, 31.3%), despite their drop in 2013. English publishers also increased their contribution (69,602 more articles compared to 2004, 66.8%), as did those from the Netherlands (29,119 more articles, 91.5%) during the study period. Articles from publishers in Germany and China

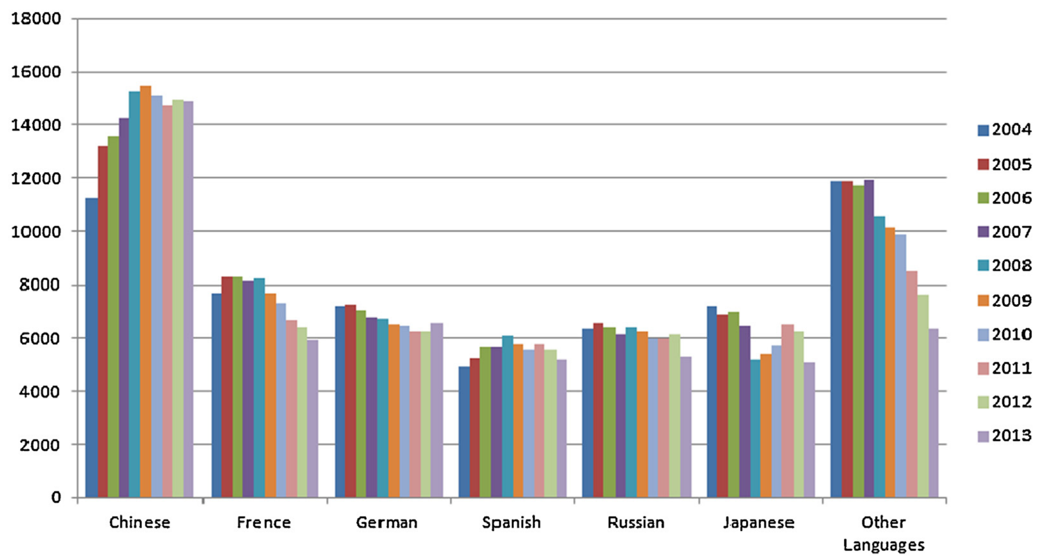

Fig. 11. Annual distribution of journal articles included in PubMed according to the language of the publication excluding English.

Table 9
Annual number of records and changes from the previous year (%) according to the written language.

Year	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
English	502,583	531,504	5.8	552,591	4.0	574,568	4.0	604,099	5.1	630,601	4.4	652,052	3.4	701,925	7.6	758,973	8.1	766,303	1.0	263,720	52.5
Chinese	11,240	13,208	17.5	13,545	2.6	14,266	5.3	15,261	7.0	15,455	1.3	15,115	−2.2	14,740	−2.5	14,923	1.2	14,915	−0.1	3675	32.7
French	7669	8271	7.8	8270	0.0	8137	−1.6	8197	0.7	7690	−6.2	7316	−4.9	6685	−8.6	6404	−4.2	5965	−6.9	−1704	−22.2
German	7239	7282	0.6	7072	−2.9	6777	−4.2	6763	−0.2	6536	−3.4	6478	−0.9	6284	−3.0	6287	0.0	6562	4.4	−677	−9.4
Spanish	4959	5268	6.2	5692	8.0	5676	−0.3	6126	7.9	5780	−5.6	5563	−3.8	5764	3.6	5577	−3.2	5231	−6.2	272	5.5
Russian	6370	6564	3.0	6425	−2.1	6141	−4.4	6439	4. .9	6269	−2.6	6005	−4.2	5994	−0.2	6138	2.4	5301	−13.6	−1069	−16.8
Japanese	7243	6917	−4.5	6992	1.1	6465	−7.5	5221	−19.2	5433	4.1	5718	5.2	6517	14.0	6269	−3.8	5102	−18.6	−2141	−29.6
Other languages	11,875	11,893	0.2	11,732	−1.4	11,909	1.5	10,539	−11.5	10,103	−4.1	9857	−2.4	8475	−14.0	7658	−9.6	6391	−16.5	−5484	−46.2

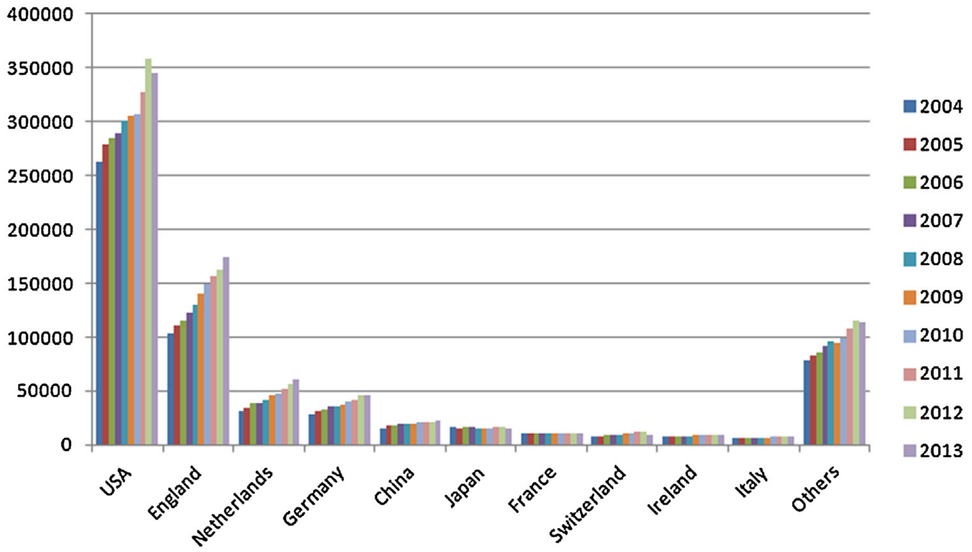

Fig. 12. Annual distribution of journal articles included in PubMed according to the home country of the publisher.

showed a smaller increase, while those from Japan, France, Switzerland, Ireland and Italy showed a variation in their annual publications without specific trends. Although 90 countries had no article published in their territory, countries other than the aforementioned above also contributed significantly to the increase of journal articles (change from 2004: 35,171 articles, 45%).

4. Discussion

PubMed has been an invaluable research and education tool for all Biomedical and Life scientists around the globe since its establishment. Its contribution to the diffusion of up to date and late breaking scientific advances has been considerable. In addition, PubMed database is continuously enriched by older journal articles. Thus, the original article can be found and studied. Bearing in mind the difficulties and economic burden of this initiative, we sought to study the factors that contributed to PubMed's growth during the last decade. While doing that, we noticed a few misclassifications and discrepancies in its databases. We hope that these remarks could help PubMed become even better.

4.1. Implication of findings

Besides the titles with a start publication year from 1744 to 1959, all other groups showed an increase in their annual contribution to the literature. However, newer titles, promoted literature growth more than any other group of titles with earlier start publication year. When a journal title changes its name at a given time, from that point onward this is considered a new journal and new articles are assigned only to the "new journal title". Any changes in the name of journal titles may have also affected the outcomes in favor of more recent ones. We did not study further whether this was due to increase in the number of newly established titles or due to changes in a title's name. Furthermore, the number of retrieved publications during this search was lower than the number of total publications during this period. This should be partially attributed to the number of records added in PubMed without further processing (records not indexed in MEDLINE). In addition, we should acknowledge that not all journal titles can be searched in PubMed using their NLMID (PubMed communication) and therefore the number of retrieved articles could be affected substantially. This limitation applies for the search done for electronic and print availability of journal articles.

No conclusion regarding the contribution of publication types to literature growth could be drawn. Only letters and comments (and these not as journal articles) showed an increasing tendency, but their absolute number was small and could not account for the observed increase. Although someone might find that worrisome regarding the quality of the growing literature, we should keep in mind that several important journals (e.g. Nature) continue to publish articles of fundamental importance in the form of letters. In addition, points missed, underestimated or deliberately hidden in a study, even after a rigorous peer-review process, can be revealed via communication with the readers, thus enhancing scientific debate and providing solid ground for further research. The decrease in comparative studies was another worrisome finding, which was balanced, at least in part, by a small increase in the number of randomized trials. Regarding the mistaken co-occurrence of journal article[pt] with other publication types (e.g. with letter, editorial, etc), we were informed that several errors have been already identified and there is a plan to correct them during the first half of December 2014 (PubMed communication, August 2014).

Table 10
Annual number of records and changes from the previous year (%) according to the home country of publisher.

	2004	2005	%	2006	%	2007	%	2008	%	2009	%	2010	%	2011	%	2012	%	2013	%	No. of change 2013–2004	% Change 2013–2004
USA	263,024	278,938	6.1	285,082	2.2	289,235	1.5	300,476	3.9	305,881	1.8	306,236	0.1	328,227	7.2	358,023	9.1	345,451	−3.5	82,427	31.3
England	104,155	110,189	5.8	115,005	4.4	122,467	6.5	129,820	6.0	140,513	8.2	149,523	6.4	157,025	5.0	161,752	3.0	173,757	7.4	69,602	66.8
Netherlands	31,822	33,981	6.8	38,143	12.2	39,375	3.2	41,786	6.1	46,210	10.6	47,958	3.8	51,507	7.4	56,906	10.5	60,941	7.1	29,119	91.5
Germany	28,776	31,070	8.0	33,200	6.9	35,026	5.5	36,295	3.6	37,871	4.3	39,597	4.6	41,807	5.6	45,368	8.5	46,643	2.8	17,867	62.1
China	15,194	17,869	17.6	18,253	2.1	18,884	3.5	19,789	4.8	19,965	0.9	20,296	1.7	20,419	0.6	21,426	4.9	21,871	2.1	6677	43.9
Japan	15,943	15,783	−1.0	15,829	0.3	15,976	0.9	15,162	−5.1	15,218	0.4	15,745	3.5	16,722	6.2	16,226	−3.0	15,317	−5.6	−626	−3.9
France	10,146	10,317	1.7	10,737	4.1	10,166	−5.3	10,687	5.1	10,649	−0.4	10,625	−0.2	10,188	−4.1	10,096	−0.9	10,033	−0.6	−113	−1.1
Switzerland	7284	8092	11.1	8449	4.4	9226	9.2	9456	2.5	10,641	12.5	10,889	2.3	11,970	9.9	12,204	2.0	9478	−22.3	2194	30.1
Ireland	7196	7463	3.7	7779	4.2	7905	1.6	8029	1.6	8657	7.8	8601	−0.6	9511	10.6	9645	1.4	9477	−1.7	2281	31.7
Italy	6598	6386	−3.2	6174	−3.3	6664	7.9	6617	−0.7	6538	−1.2	7217	10.4	7615	5.5	8291	8.9	7646	−7.8	1048	15.9
Others	78,188	83,259	6.5	86,408	3.8	91,093	5.4	95,621	5.0	94,989	−0.7	98,660	3.9	107,348	8.8	115,698	7.8	113,359	−2.0	35,171	45.0

The most intriguing finding however was the fact that several articles could not be classified in any of the PubMed's publication types or characteristics (journal article[pt] is excluded, since it was the default search term). Rather, all studied journal articles had publication formats as a default [pt] and several had an additional [pt] according to funding only. Although this is acceptable since PubMed does not have to utilize more than one publication types for each record, this may raise questions as to whether PubMed's filters can be safely used to retrieve all articles for a given publication type, unless an experienced librarian is involved in the process.

The use of additional MeSH terms improved search outcomes; however it also increased the number of articles that were out of scope for the search term used. The most notable example was the percentage of review articles retrieved for "clinical trials" as publication type or MeSH term. Therefore, the use of MeSH terms improves the probability for retrieval of relevant studies, but it also increases the number of studies requiring evaluation by the researcher (Gehanno et al., 2009). Several publication types, including "observational study" and "pragmatic study" were introduced in the later years of the study period, which may explain for the small number of retrieved journal articles. Other publication types, e.g. intervention study, will be probably added in MeSH terms in the future. Finally, study characteristics like cohort, case-control, prospective or retrospective studies are not used as publication types in PubMed but as MeSH terms, and therefore were not studied alone. Their use should probably fill the gap between the cited publications and their classification as publication types, but since several MeSH terms can be applied to an article, this may not be convenient for a bibliometric analysis.

Two characteristics regarding the availability of an article were studied, print or electronic form and open or subscription access. The number of print-only articles remained stable, while those with electronic versions (alone or mainly together with print ones) showed a continuous increase. Similarly, the gradual increase in open access articles was higher than the one in subscription access until 2012. The increase in 2013 was much higher for subscription access articles, with a simultaneous decrease in open-access articles, a figure that should be probably attributed to journals that provide open access after a short period of time. Electronic availability facilitates the global dissemination of the journals' products, increases the readership and probability of an article to become cited in other works, and improve or maintain the prestige of the journal and therefore its revenue (Curti, Pistotti, Gabutti, & Klersy, 2001). Open access works in a similar fashion, but its value in the citation hunting was subverted in RCTs and reviews demonstrating that open access alone has little or no effect on the number of subsequent citations (Craig, Plume, McVeigh, Pringle, & Amin, 2007; Davis, Lewenstein, Simon, Booth, Connolly, & 2008; Davis, 2011).

PubMed provides data only according to US or non-US government funding. Therefore, the contribution of private and governmental (from other countries) contribution could not be calculated. Non-US government funded research contributed more to literature growth, but the cooperation with the US government was successful. The present analysis refers to funding of published articles, i.e. the studies were funded years ago. According to the US National Science Foundation, the private sector was the single most important investor, accounting for 69% of the US research and development funding (Science and Engineering Indicators, 2014). Another analysis showed that during the period 2004–2012 the United States had the slowest annual growth in medical research investment (1.5% per year), followed by Europe (4.1%) and Canada (4.5%). The Asian countries, led by China, India, Singapore and South Korea, showed the highest growth (9.4%) (Moses et al., 2015). Despite that, USA remained the leader of global funding in medical research in 2011 (44%), followed by Europe (33%) and Asia (20%) for the year 2011 (Moses et al., 2015). In addition, a disproportionate increase of US government funds for specific diseases was observed, mainly cancer and human immunodeficiency virus research (Moses et al., 2015). The finding that funded research increases continuously is encouraging as long as the role of the funding source to the analysis and interpretation of data is limited or negligible. Still, articles without data on funding continue to increase and their contribution to literature growth is substantial.

From the country point of view, China showed the greater expansion, by almost quadrupling its productivity in this ten year period. India showed a similar relative increase, but the absolute one was lower. However, it is evident that all countries contributed more or less to literature's growth. On the contrary, unless proven to be a temporary classification issue and not replicated in the years to come, the sudden drop in the productivity of the USA was a worrisome finding. If China's productivity continues to increase with a similar rate to that of the period 2004–2013 (approximately 15% per year) and USA productivity does not accelerate, it is expected that by 2020 China will become the most productive country in the biomedical literature supplanting USA. Similarly, India will become the third most productive country in the next 4–5 years. Beginning in 2013 the affiliations of all authors (instead of the first only) are listed in PubMed, which will most probably accelerate the process of succession in leadership, depending on the participation of Chinese scientists in current or future international collaborations. Finally, as a result of PubMed's policy to include the affiliation of the first author only up to 2012, the contribution of several countries participating in international studies should have been underestimated.

From the continent point of view, Asian primarily and European thereinafter publications seem to confer more to literature growth. On the other hand, America continued to lead the production of publications, but its contribution to the growth seen during the study period was not pronounced. As a result, the European publications in 2013 were more than the American ones. And soon, Asian articles will dominate the literature drifted by Chinese and Indian contributions. Finally, from the publisher's head office point of view, most of the articles continue to be published in USA- and England-based organizations, which conferred the higher relative and absolute increase in the number of publications. This was also reflected in the selection of English as the primary publication language, seen in the present as well as previous bibliometric analyses (Haiqi, Yamazaki, & Urata, 1997; Valkimadi, Karageorgopoulos, Vliagoftis, & Falagas, 2009).

4.2. Quality or quantity?

The explosion in the production of new research in Biomedical and Life Sciences and therefore new articles was accompanied by concerns regarding its quality and value in promoting health improvements (Ioannidis, 2005; Anonymous, 2013). It has been estimated that approximately 85% of research investments is wasted due to inefficiencies of research design, regulation, management and dissemination (Chalmers & Glasziou, 2009). Researchers, politicians and governments, pharmaceutical companies, universities or other non-profit institutions, regulatory agencies, and publishers are all engaged in a competitive and profitable game with established scientific, social and cultural rules in which research occurs, but without mechanisms for investigating and dealing with research misconduct (Macleod et al., 2014). Investigators focus on publishing their articles in high impact factor journals in order to secure their fame and inevitably their next funds instead of conducting and disseminating rigorous, qualitative and reproducible research (Macleod et al., 2014). Politicians and governments rely on the demonstration of findings that something was produced and returned profit in order to estimate the success of funding policies instead of aiming at funding research that promotes human health (Morris, Wooding, & Grant, 2011). Journals promote fund raising through advertisements, reprint charges and impact factor manipulation instead of securing the publication of research of the highest quality via a rigorous peer-review process (Falagas & Alexiou, 2008; Lundh, Barbateskovic, Hróbjartsson, & Gøtzsche, 2010; Macleod et al., 2014). Even reviewers may advocate acceptance of original research or reviews for publication when these are unlikely to influence practice, but likely to receive multiple citations and affect the impact factor (Fuster, 2014). And the industry, which nowadays provides the majority of the available funds in Biomedical and Life Sciences, controls the study design process and promotes familiarity with drugs, consumables or devices instead of dissemination of knowledge (Stamatakis, Weiler, & Ioannidis, 2013).

4.3. Similar works

A similar to our analysis work for the period 1978–2001 showed that 8.1 million records were added in Medline during that 23 year period (Druss & Marcus, 2005). The authors concluded that the number of articles increased in each of the three sub-periods (1978–1985, 1986–1993, and 1994–2001). The number of randomized trials more than tripled, public funding decreased, private funding alone or in combination with public one increased, while non-funded articles decreased. Furthermore, the literature growth was due to clinical research, with an increase in the proportion of human studies, health care and public health and a shift away from basic science (Druss & Marcus, 2005). Another analysis showed that despite the increase in literature, the productivity of scientists decreased, as shown by the number of papers per unique author. Reasons behind this could be the greater effort required completing a study and the dissemination to conference abstracts (Larsen & von Ins, 2010).

5. Conclusion

PubMed contains only a part of the available titles in Biomedical and Life Sciences but it continues to expand. Even so, its records are still a small fraction of the data and reviews that become available on the World Wide Web or the increasing number of abstracts presented in conferences around the globe. Physicians and researchers should develop their skills to allow them search efficiently this enlarging body of literature, identify potential biases, and distinguish up to date and critical reviews that might help them to synthesize the available data. PubMed will have a key role as one of the most frequently used tools for retrieving biomedical data and its further development and improvement will contribute enormously to any such effort.

Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.joi.2015.06.001.

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