A bibliometric analysis of multimorbidity from 2005 to 2019

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Abstract

Context: Multimorbidity is frequently seen in primary care. We aimed to identify and analyze publications on multimorbidity, including those that most influenced this field.

Method: A bibliometric analysis of publications from 2005 to 2019 in the PubMed database containing "multimorbidity" or "multi-morbidity" identified with the tool iCite. We analyzed the number of publications, total citations, the article-level metric Relative Citation Ratio (RCR), type of study, and journals with the most cited articles.

Results: The number of publications using "multimorbidity" has continuously increased since 2005 (2005–2009: 138; 2010–2014: 823; 2015–2019: 3068). The median number of total citations per article was 3. The median RCR was 1.04. Articles with RCR at or above the 97th percentile (RCR = 7.43) were analyzed in detail (n = 104). In 34 publications of this subgroup (33%), the word multimorbidity was used but was not the subject of study. The remaining top 70 publications included 32 observational studies, 22 reviews, five guideline statements, three analysis papers, two randomized trials, three qualitative studies, two measurement development reports, and one conceptual framework development report. The publications were produced by authors from 32 countries. They were published in 37 different journals, ranging from one to four articles in the same journal.

Conclusions: We found a continuous increase in the number of publications about multimorbidity since 2005. However, our study suggests that the numbers should be considered only a general trend because multimorbidity was not the main subject in 33% of publications in a subgroup of 104 analyzed in detail.

Introduction

The coexistence of two or more chronic conditions, known as multimorbidity, is commonly seen in primary care, and is considered the rule rather than the exception.[1] Age is a major factor in prevalence of multimorbidity.[1] Taking the United Kingdom as an example, by 2034 the number of people aged 85 and over is projected to be 2.5 times larger than in 2009, reaching 3.5 million and accounting for 5% of the population.[2] These projections, combined with an increase in global life expectancy, will lead to an increased number of people with multiple chronic medical conditions. This illustrates the importance of and the need for research into all aspects of multimorbidity, including but not limited to, socio-economic determinants, prevention, management, interventions, and organization of health services.

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A bibliometric study published in 2005 demonstrated that there was a large discrepancy between the prevalence of multimorbidity in the population and the number of research studies devoted to it at that time.[3] In addition to the paucity of research in multimorbidity, research efforts were hampered by the conceptual ambiguity of using the terms "comorbidity" (conditions coexisting with an index condition or disease under study), and "multimorbidity" (co-occurrence of conditions without considering any as the index) indistinctly.[4] This conceptual ambiguity was worsened by the introduction of several other terms to describe the same phenomenon.[5] As a result, it was difficult to put together the literature that was accumulating from research on multimorbidity.

Fortunately, the situation has changed. Since 2018, the word multimorbidity, which is a term overwhelmingly accepted to describe the coexistence of chronic conditions, is a Medical Subject Heading (MeSH) with a scope note explaining that it represents "the complex interactions of several coexisting diseases" (https://meshb.nlm.nih.gov/record/ui?ui=D000076322), whereas the word comorbidity, which is a distinct MeSH, continues to be described as "the presence of coexisting or additional diseases with reference to an initial diagnosis or with reference to the index condition that is the subject of study" (https://meshb.nlm.nih.gov/record/ui?ui=D015897). The interest in the topic has increased substantially and, thanks to the contributions of many researchers, our knowledge about multimorbidity is much better today than it was only a decade ago.

A recent bibliometric study that included publications up to June 2016 summarized global research trends and activities in multimorbidity.[6] The study focused mainly on the mismatch between the high prevalence of multimorbidity and its research outputs compared with single conditions (diabetes, hypertension, depression, and COPD), as well as the imbalance in publications among countries.

The aims of this study were to identify and analyze publications on multimorbidity during the period 2005–2019, the influence of the MeSH "multimorbidity" in the publications, and to analyze in more detail the top publications influencing this field of research, that is, those that have been most cited in subsequent reports of studies on the subject.

Methods

We used the tool "iCite" developed by the National Institutes of Health Office of Portfolio Analysis. iCite is used to access a dashboard of bibliometrics for papers associated with a portfolio (https://icite.od.nih.gov/). However, iCite only allows conducting PubMed queries. With iCite, we searched in PubMed for publications of all types between 2005 and 2019. The rationale for choosing the time period 2005–2019 was that, in 2005, our team published a bibliometric study on multimorbidity demonstrating that the number and diversity of articles available on multimorbidity were insufficient at that time to provide a strong scientific basis for evidence-based care of patients affected by this situation.[3] Therefore, we wanted to analyze the evolution of such publications since that year. In the present study, the use of the word "multimorbidity" or its variant "multi-morbidity" in any field within the publication and the year of publication were used as filters. No other filters were applied for the search, meaning that publications in any language were included. The search was completed on March 20, 2020.

An advantage of and the reason for using iCite is that it provides the article-level metric Relative Citation Ratio (RCR)[7,8] of each publication within the list resulting from the search. The RCR is generated using the co-citation network of an article—that is, the other papers that appear alongside it in reference lists—to field-normalize the number of times it has been cited. According to its developers, the RCR should primarily be considered as a measure of influence, rather than impact or intellectual rigor.[7] A value of RCR = 0 represents uncited articles which can be considered to have little if any influence in their respective fields. The RCR increases with the number of citations in the field of the article. The highest values represent the most cited publications, which can be considered as highly influential. No upper limits to RCR values were described, and it may be inferred that RCR increases as long as the citations continue to increase. Its developers mentioned RCR values above 20 as high.[7]

All data provided by the tool iCite in the form of a spread sheet (Excel file, Microsoft Office) were exported to a database of IBM SPSS Statistics 24 for all data analyses.

We did not search for other terms used to describe the presence of multiple conditions in order to be able to analyze the use of the word "multimorbidity."

We analyzed the number of publications, the total number of citations per publication, and the distribution of the RCR in all the retrieved publications. After checking that the data of the variables had a normal distribution with the Kolmogorov–Smirnov test, we conducted a Pearson correlation analysis between the RCR and the total number of citations. This allowed us to analyze the performance of the RCR versus the total number of citations, as a measure of the influence of a particular publication on subsequent scientific research within the same field.

In order to determine the top publications based on the RCR, we arbitrarily selected the 97th percentile of RCR as the lower limit for top publications. Publications at or above the 97th percentile were considered top publications and were analyzed in more detail. In these top publications, we analyzed whether the word was simply used in the text, or if multimorbidity was the subject under study, either through the reading of the abstract or the full publication, when necessary. Data extraction was conducted jointly by MAAA and JA. The screening process was conducted independently by MF and JA who agreed in the results at the
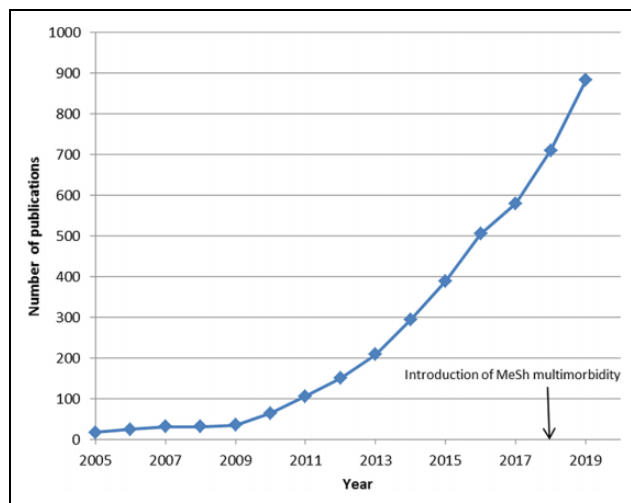
Figure 1. Number of publications on multimorbidity per year from 2005 to 2019. The arrow indicates the year (2008) in which the word multimorbidity was introduced as a medical subject Heading (MeSH) for indexing articles for PUBMED.

end. When the abstract of a publication provided enough information about the subject of study, the full text screening was not conducted. When the subject of the publication was not clear enough in the abstract or when there was no abstract at all, a full text screening was performed. It was determined that multimorbidity was the subject of the publication when it addressed the complex interactions of several coexisting diseases without considering any as the index disease. Publications in which multimorbidity was not the subject under analysis were removed from the list.

In the top publications in which multimorbidity was the main subject, we analyzed the total number of citations per publication, the RCR, type of study, the country of the institutional affiliation of the authors, and journals in which they were published. It was considered that the publication was the result of an international collaboration when the institutional affiliation of different authors included two or more different countries. In this group of top publications, a description of the first 10 publications based on the RCR was extracted in a table.

Results

The total number of publications containing the MeSH multimorbidity, or its variant multi-morbidity from 2005 to 2019 was 4029. The number continuously increased from 17 in 2005 to 884 in 2019 (Figure 1). The quinquennial number of publications was 138 (3.4% of the total of 4029) from 2005 to 2009, 823 (20.4%) from 2010 to 2014 (5.9-fold the previous 5 year period), and 3068 (76.1%) from 2015 to 2019 (3.7-fold the previous 5 year period). Nine hundred and thirty-five (23.2% of the total of 4029) publications were never cited up to the moment of concluding the data collection for this study, 497 (12.3%) were cited once, and 311 (7.7%) were cited twice. The number

of publications cited from 3 to 100 times was 2219 (55.1%), 42 (1%) publications from 101 to 200 times, 14 (0.3%) publications from 201 to 300 times, 5 (0.1%) publications from 300 to 400 times, and 6 (0.1%) publications were cited more than 400 times.

Calculation of the RCR was missing in 864 publications. The number of citations of these publications with missing RCR was between 0 and 4. Among the 3165 publications with calculated RCR, the number of citations ranged from 0 to 1841 and 373 (11.8% of the 3165 publications) had an RCR = 0. Of the 3165 publications with a calculated RCR, the maximum RCR was 112.97, and the median was 1.04.

In the correlation analysis between RCR and the total number of citations, we found a positive linear correlation (r = 0.88). A plot with "total citations" in the abscissa and "RCR" in the ordinate was drawn. It was visually concluded that a point situated in the upper part of the plot was an outlier because its coordinates (y, x) (113, 1841) were about double those of the second highest point (43, 757), and it was far off the "cloud" of the other data points in the plot. This prompted us to also estimate the correlation coefficient without the point considered an outlier. The correlation decreased (r = 0.81) after removing from the calculation the point representing the publication with the highest number of citations and highest RCR.

The 97th percentile of RCR was at the value of 7.43. There were 104 publications at or above the RCR value of 7.43. A list of the publications is provided in the appendix. An analysis of these publications showed that multimorbidity was not the subject of study in 34 of the 104 publications (33%), which means they could not be considered as publications on multimorbidity. Two situations were found in the publications in which multimorbidity was not the subject: 1) the study was focused on an index disease and its comorbidities, and not multimorbidity without index disease; 2) the word multimorbidity was simply used in the text for some reason without being the subject of the publication. These publications were removed from the group and were not considered for further analyses.

The remaining 70 top publications included 31 observational studies, 23 reviews (18 systematic reviews, two literature reviews, one clinical review, one guideline review, and one meta-analysis), five guideline statements, three analysis papers (one viewpoint, one guideline analysis, and one opinion paper), three qualitative studies, two measurement development reports, two randomized trials, and one conceptual framework development report. Up to the time of finishing data collection for this study, these publications had been cited a minimum of 13 times and a maximum of 1841 times (Figure 2), with a median of 108 citations. These publications had a calculated RCR which ranged from 7.43 to 112.97, for a median value of 9.77.

The top 70 publications selected by the RCR were produced by authors from 32 countries, and 23 publications were the result of international collaborations. They were found in 37 different journals which published from one to
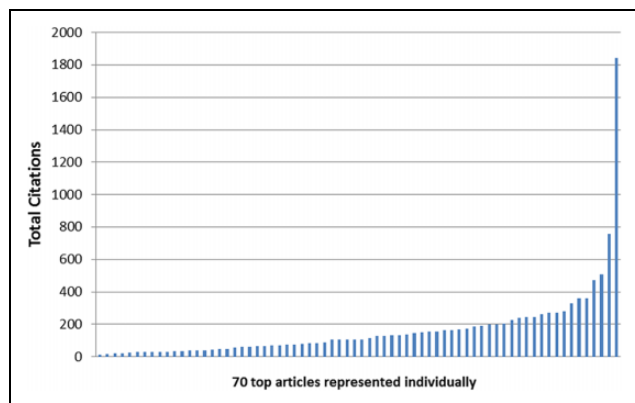
Figure 2. Total citations of each of the 70 publications on multimorbidity with a value of the relative citation ratio (RCR) at or above the 97th percentile. Each bar in the figure represents a publication.

Table 1. Journals which published the publications on multimorbidity with a value of the Relative Citation Ratio (RCR) at or above the 97th percentile.

Journal	Number of top publications
Ann Fam Med	4
BMJ	4
J Gerontol A Biol Sci Med Sci	4
BMC Health Serv Res	3
BMJ Open	3
Health Policy	3
J Am Geriatr Soc	3
Lancet	3
PLoS ONE	3
Age Ageing	2
Ageing Res Rev	2
BMC Fam Pract	2
BMC Geriatr	2
BMC Med	2
BMC Public Health	2
Br J Gen Pract	2
Cochrane Database Syst Rev	2
J Clin Epidemiol	2
JAMA	2
Lancet Public Health	2
Qual Life Res	2
Am J Public Health	1
Arch Gerontol Geriatr	1
BMC Psychiatry	1
Clin Nutr	1
CMAJ	1
Epidemiol Rev	1
Eur J Gen Pract	1
Eur J Public Health	1
Fam Pract	1
J Affect Disord	1
J Racial Ethn Health Disparities	1
Lancet Diabetes Endocrinol	1
Med J Aust	1
Patient Educ Couns	1
Risk Manag Healthc Policy	1
Soc Psychiatry Psychiatr Epidemiol	1

four articles from this list (Table 1). Journals with four articles each were Annals of Family Medicine, The British Medical Journal, and The Journals of Gerontology Series A: Medical Sciences. The most cited article (1841 citations) also had the highest RCR (112.97) and was published in The Lancet.[9] The second most cited article (757 citations) also had the second highest RCR (43.44) and was published in Ageing Research Reviews.[10]

Table 2 shows the top 10 publications based on the RCR.[9–18] The RCR does not follow exactly the number of citations of an article. Seven of the top 10 publications are review articles, two are observational studies, and one is an analysis paper (viewpoint).

Discussion

The results of this bibliometric study provide an overview of the trend of multimorbidity research over the past 15 years. The growing challenge of multimorbidity requires more evidence-based knowledge and effective practices. This study shows the vitality of multimorbidity research.

Indeed, global trends published in a previous article show a continuous and rapid growth of research on multimorbidity, although only about 5% of research on multimorbidity originated from low- and middle-income countries.[6] The results were based mainly on the lists generated by the search engine, without going into the analysis of the use of terms in individual articles. The authors published a table showing the top 15 most cited articles up to 2016. However, there are five articles in the table in which multimorbidity was not the subject of the publication.[19–23] Our analysis of the publications at or above the 97th percentile of RCR showed that multimorbidity was not the subject of study in 33% of these papers. The word multimorbidity had simply been used in the text, or it had been incorrectly used. These publications were not included in our analysis of top multimorbidity publications.

The greatest number of publications on multimorbidity was recorded over the last 5 years (2015–2019), with 3068 out of the 4029 articles retrieved, i.e. 76.1% of the scientific production. However, these numbers should be considered with caution and only to document a general trend because many of them may not be on multimorbidity per se as reflected in our analysis of the 97th percentile or greater. It would be necessary to conduct a study analyzing a random sample of multimorbidity studies over a period of time to determine more exactly the frequency of this situation.

Nevertheless, the numbers show a growing productivity relating to research on multimorbidity. This is in line with the increasing prevalence of multimorbidity and its importance in terms of clinical activity, particularly in primary care.[24–26] An increase in academic primary care researchers over the last 15 years may have contributed to the increase in production of papers on the topic.

Table 2. Top 10 publications on multimorbidity in the period 2005–2019 according to the Relative Citation Ratio (RCR) at the moment of completing the data collection for the present study (RCR values are constantly updated as publications are being cited).

Title	Type of study	Authors	Journal	RCR	Total citations
Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study.[9]	Observational	Karen Barnett, Stewart W Mercer, Michael Norbury, Graham Watt, Sally Wyke, Bruce Guthrie	Lancet 2012	112,97	1841
Aging with multimorbidity: a systematic review of the literature.[10]	Review	Alessandra Marengoni, Sara Angleman, René Melis, Francesca Mangialasche, Anita Karp, Annika Garmen, Bettina Meinow, Laura Fratiglioni	Ageing Res Rev 2011	43,44	757
A systematic review of prevalence studies on multimorbidity: toward a more uniform methodology.[11]	Review	Martin Fortin, Moira Stewart, Marie-Eve Poitras, José Almirall, Heather Maddocks	Ann Fam Med 2012	22,88	362
Interventions for improving outcomes in patients with multimorbidity in primary care and community settings.[12]	Review	Susan M Smith, Emma Wallace, Tom O'Dowd, Martin Fortin	Cochrane Database Syst Rev 2016	22,14	139
Defining comorbidity: implications for understanding health and health services.[13]	Review	Jose M Valderas, Barbara Starfield, Bonnie Sibbald, Chris Salisbury, Martin Roland	Ann Fam Med 2009	21,97	509
Designing health care for the most common chronic condition—multimorbidity.[14]	Analysis	Mary E Tinetti, Terri R Fried, Cynthia M Boyd	JAMA 2012	20,19	360
Epidemiology and impact of multimorbidity in primary care: a retrospective cohort study.[15]	Observational	Chris Salisbury, Leigh Johnson, Sarah Purdy, Jose M Valderas, Alan A Montgomery	Br J Gen Pract 2011	20,17	329
Multimorbidity in older adults.[16]	Review	Marcel E Salive	Epidemiol Rev 2013	20,09	272
Managing patients with multimorbidity in primary care.[17]	Review	Emma Wallace, Chris Salisbury, Bruce Guthrie, Cliona Lewis, Tom Fahey, Susan M Smith	BMJ 2015	19,6	167
Prevalence, determinants and patterns of multimorbidity in primary care: a systematic review of observational studies.[18]	Review	Concepció Violan, Quintí Foguet-Boreu, Gemma Flores-Mateo, Chris Salisbury, Jeanet Blom, Michael Freitag, Liam Glynn, Christiane Muth, Jose M Valderas	PLoS ONE 2014	19,26	227

The introduction of the word "multimorbidity" as a MeSH occurred relatively recently (2018), and we think it is too soon to observe any effect on the scientific production in this field. As a MeSH with a scope note clearly explaining its meaning, which is different from "comorbidity," we expect that the main effect of its introduction should be the correct utilization of the terms in the publications produced thereafter. We believe that it should be a joint effort of authors, reviewers and editors to ensure that the terms are correctly used and publications are correctly classified. This would lead to an improvement in the quality of search queries and ultimately to better research.

Regarding the Relative Citation Ratio (RCR), it is a new and attractive way to indicate whether an article is cited more or less frequently compared to publications in the same field.[7] In this study, we analyzed the correlation between the RCR and the total number of citations. We found that the correlation coefficient was above 0.80. A correlation greater than 0.8 is generally described as strong,

confirming that the RCR represents the influence of a particular publication on the subsequent scientific production.

Among the top publications, we found very few randomized clinical trials and qualitative studies, whereas observational studies were more frequent. These results are in line with a Cochrane review that identified a relatively small number of trials addressing interventions for improving outcomes in patients with multimorbidity in primary care and community settings.[12] The review also showed that the overall results of the randomized trials were mixed. This may partly explain why this type of study has poor influence on subsequent studies. However, it also should be taken into account that it takes some time for recent publications to accumulate several citations in order to be among the most cited.[7]

The most cited article, by far, is the report of an observational study published in 2012.[9] This highly influential article was a cross-sectional study with data on 40 morbidities from a database of 1 751 841 people.[9] The results

showed that: 1) the absolute number of people with multi-morbidity was higher in those younger than 65 years; 2) the onset of multimorbidity occurred earlier in people living in the most deprived areas, and; 3) the likelihood of a mental health disorder increased as the number of physical morbidities increased.[9] These results have been echoed in many articles published subsequently, and seem to represent an important landmark in multimorbidity research.

The main limitation of this study is that we used only one database and one term in our search, and this does not provide an exhaustive list of publications on the subject. However, PubMed comprises more than 30 million citations for biomedical literature from MEDLINE, life science journals, and online books, and we considered that such database was enough to have a good idea of the trend of the scientific production about multimorbidity and the use of the MeSH in the last 15 years. Using other databases would have provided an additional number of publications, and probably included different types of publication. However, it is unlikely that this would have changed the general trend of the production on multimorbidity we observed in this study. We explained in the methods that we did not search for other terms used to describe the presence of multiple conditions in order to be able to analyze the use of the word "multimorbidity." This is a limitation of our study, although it was found in a previous bibliometric analysis that multimorbidity was the term most frequently used when studying multiple chronic conditions and no index disease was designated.[5] Another limitation is that calculation of the RCR was missing in 864 publications and we could not include these publications in the analysis of this new index.

Conclusions

This bibliometric analysis showed the important progress made in accumulating knowledge on multimorbidity, with a continuous increase that included 76% of all publications only in the last quinquennium. Nonetheless, more high impact randomized trials and qualitative studies are needed in this field of research. Our study also suggests that these numbers should be taken with caution and considered a general trend because the analysis of a subgroup of publications showed that multimorbidity was not the subject of research in one third of the publications.

Declaration of conflicting interests

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Supplemental material

Supplemental material for this article is available online.

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