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EXPLORING THE RELATIONSHIP BETWEEN MEDICAL ORGANIZATION INNOVATION AND OTHER MEDICAL SUBJECTS USING SOCIAL NETWORK ANALYSIS

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Abstract

The study aimed to investigate the current trend of research on organizational innovation to uncover topics and citations among MeSH clusters. We selected 3,751 abstracts, author names, countries, and MeSH terms on January 2, 2019, from Pubmed Central (PMC) based on the topic of organizational innovation from 2013 to 2017. We proposed a novel h-plus index that can effectively complement and efficiently improve the h-index for calculating the MeSH-type bibliometric indices in PMC. Four topics were addressed: (1) which dominant nations were in the field; (2) which MeSH terms were cited the most by papers in PMC; (3) is there any difference in indices among MeSH clusters; (4) which article was cited the most in the past. We programmed Microsoft Excel VBA routines to extract data. Google Maps and Pajek software were used for graphical representations. Social network analysis (SNA) has been widely used for visualizing author collaboration characteristics in academics. However, there is no such result of the subject research (i.e., medical subject headings, MeSH terms) in the literature on SNA. This study used the SNA and the results reveal that (1) the dominant nations that conducted research on organizational innovation were the USA, the UK, and Canada; (2) the MeSH terms of caregivers gained the highest in h-plus index (6.15) and impact factor (IF) (3.19), respectively; (3) significant differences are found in indices ($p<0.05$) among MeSH clusters; (4) the article (PMID= 23414420) published in 2013 was the most cited one (149 times). The MeSH weighted scheme and h-plus index can be applied to academics for computing MeSH citations or even authors in the future.

Key Words: H-plus index, Medical subject headings, Social network analysis, Anesthesiology, Bibliometric analysis

Introduction

Innovation can be simply defined as a "new idea, creative thoughts, and new imaginations in form of device or method" (Business Dictionary, 2019). However, innovation is also often viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs (Maranville, 1992).

The term organizational innovation can be, in turn, defined as the implementation of a new organizational method in the undertaking's business practices, workplace organization, or external relationships (Union, 2006). Organizations must launch innovations for the survival and progress of the scientific disciplines and academic journals they manage.

Concerning topics published in such journals, as of January 2, 2019, more than 23,627 papers on organizational innovation were published on PubMed that were based on keyword search; of this, the title of 20 papers included the phrase organizational innovation. Additionally, authors conduct keyword search to know about the most cited articles and authors on a particular topic. This case also presents the importance of previous author collaborations in academics on the topic of organizational innovation.

Given the importance of organizational innovation, many medical scientific researchers (Sheridan et al., 2018; Vranas et al., 2018) have focused on reviewing related literature to identify the characteristics and status of organizational innovation in recent years. However, much of these efforts focused on a specific sub-field of organizational innovation or on conclusions drawn from descriptive analysis and systematic reviews of studies on subjects such as medical management and education. Some studies have conducted citation or bibliometric analyses on articles related to organizational innovation (Bernardo et al., 2013; Roy et al., 2015).

Papers on the bibliometric perspective of organizational innovation can provide authors with innovative methods of quantitatively analyzing data in scientific literature and, subsequently, help them to gain knowledge of the metainformation related to the field in question (Shen et al., 2018; Pritchard et al., 1969). The combined use of methodologies that give information on different aspects of scientific output is recommended for research on organizational innovation (Van Leeuwen et al., 2003). However, until now, there has been no focus on topic burst incorporated with citations on organizational innovation in these studies. Additionally, discussion related to the collaborative status of research on organizational innovation still remains relatively scarce.

Thus, this study aimed to apply the h-plus index that can effectively improve the h-index in bibliometric analyses (Hirsch, 2005; Zhang, 2009) and investigate the following four aspects. Google Maps and Pajek software were applied to the study's results as dashboards in an interactive way to investigate (1) the dominant nations in the field of organizational innovation, (2) which medical subject headings (MeSH) were most cited by papers in recent years, (3) differences in bibliometric citations among MeSH clusters, and (4) which article was cited most in the past.

Data Sources

We programmed Microsoft Excel visual basic for applications' (VBA) modules to extract abstracts and their corresponding coauthor names as well as the countries/areas of the first authors' affiliations for each article on January 2, 2019, published in the PubMed Central (PMC) from 2013 to 2017, based on organizational innovation. Only abstracts related to organizational innovation and labeled with Journal Article were included. Other abstracts like those labeled with Published Erratum, Editorial, or without author nation name were excluded from this study. A total of 3,751 eligible abstracts were obtained from PMC.

Description of Methods

The MeSH weighted scheme and the h-plus index used for quantifying citations

In the L-index (= $\ln(\sqrt{\sum_{i=1}^{n}\frac{c_i}{a_i y_i}})+1$) (Belikov et al., 2015), where a_i is the number of authors of *i*-th publication (i.e., equal size to that of the coauthors) and y_i is the length of *i*-th publications measured by the year, like other indices mentioned above, such as the h-index (Hirsch, 2005), h'-index (Zhang, 2009; Zhang, 2013), g-index (Egghe, 2006), and x-index (Fenner et al., 2018). It is assumed that all coauthors contribute equally with a weight (=1.0) in an article byline. We define the MeSH weighted scheme as $W_i = \sqrt{\sum_{i=1}^{n}\frac{c_i}{n_i}}$ and $\sqrt{\sum_{i=1}^{n}\frac{p_i}{n_i}}$ for citations and publications, respectively, where n=number of articles, and c_i and p_i are citations and publications on the *i*-th article, respectively.

The h-plus index is defined as below:

$$\text{h-plus} = h + rh/(1+ rh)$$

where h denotes the h-index and rh=e parts/t parts in Figure 1. Thus, the h-plus is ranged between h and h+1.

Keyword impact factor (IF) like author IF (Pan et al., 2014) is applied to the MeSH impact factor (MIF). The weighted publications are set at 1.0 if the values<1.0 for avoiding the MIF is inflated too much.

$$MIF = \frac{\sum Cited\ papers\ based\ on\ W_i}{\sum Citable\ papers \times W_i\ in\ the\ given\ yrs}$$

$$= \frac{weighted\ citations}{weighted\ publications}$$

Social network analysis using the Pajek software

In keeping with the Pajek's guidelines (Batagelj et al., 2004), by using social network analysis (SNA), we defined a MeSH term as a node (or an actor) that is connected to another

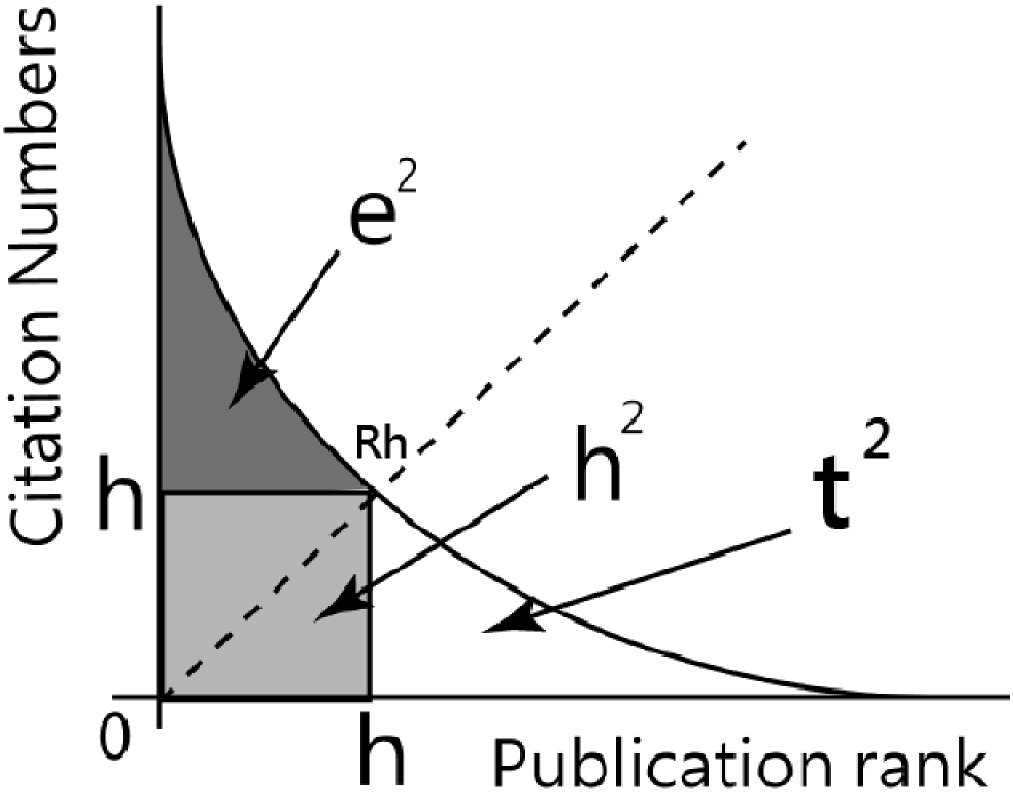

Figure 1. The h-index divided into three areas

counterpart at another node through the edge of a line. Usually, another weight is defined by the number of connections between two nodes.

Graphical representations to report

A visual display was created with the publication outputs labeled by the first author's nations for presenting the distribution of nations on anesthesiology. The quantity was colored by the size of publications. The most cited MeSH terms sized by MIF and colored by h-index were shown based on both axes (i.e., x-index on the x-axis and h-plus index on the y-axis)

MeSH clustering using SNA

SNA was applied to determine the representative for each cluster. The algorithm of community partition was performed to identify the clusters. Each MeSH was assigned to the cluster represented by the MeSH; this is similar to authors' analysis that indicates authors with the highest degree centrality in a cluster. As such, each MeSH contributes equally proportional parts (i.e., 1/n) in an article, which are, subsequently, matched to the respective metrics and clusters.

The bootstrapping method (Efron, 1992) was applied to examine differences in metrics among MeSH clusters. A total of 1,000 medians retrieved from the median of the 100 random cases were used to estimate the 95% confidence intervals (CI) for a metric of a given cluster. As such, the difference

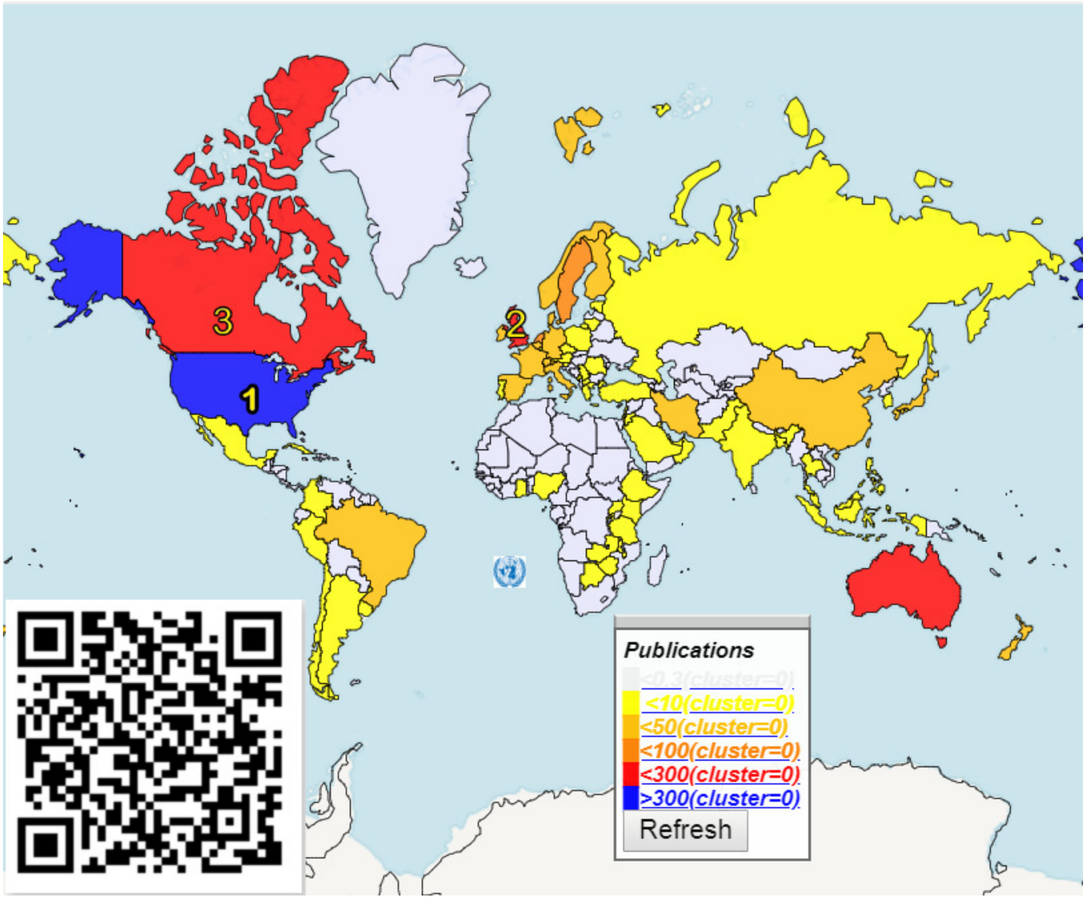

Figure 2. Dominant nations that focus on organizational innovation by publication

can be determined by judging the two 95% CI bands separated from each other.

Creating dashboards on Google Maps

We applied the author-made modules in MS-Excel and the SNA in Pajek to obtain the MeSH clusters. The Hypertext Mark-up Language (HTML) pages used for Google Maps were created. All relevant bibliometric indices were linked to dashboards on Google Maps.

Results

The results found that the dominant nations that conducted research on organizational innovation are the United States of America, the United Kingdom, and Canada (Figure 2).

The MeSH terms of caregivers gained the highest in h-plus index (6.15) and impact factor (IF) (3.19) on anesthesiology, respectively. To see the details of a specific MeSH's term regarding the relevant outputs in PMC, the QR-Code in Figure 3 can be scanned, followed by selecting the specific MeSH bubble.

The top 10 MeSH clusters were separated, as shown in Figure 4. The representatives with the highest degree centrality (DC) are shown for each cluster, such as psychology, organization and administration, and diffusion of innovation. The term psychology earned the highest DC, indicating the methods with high centrality by the bubble size.

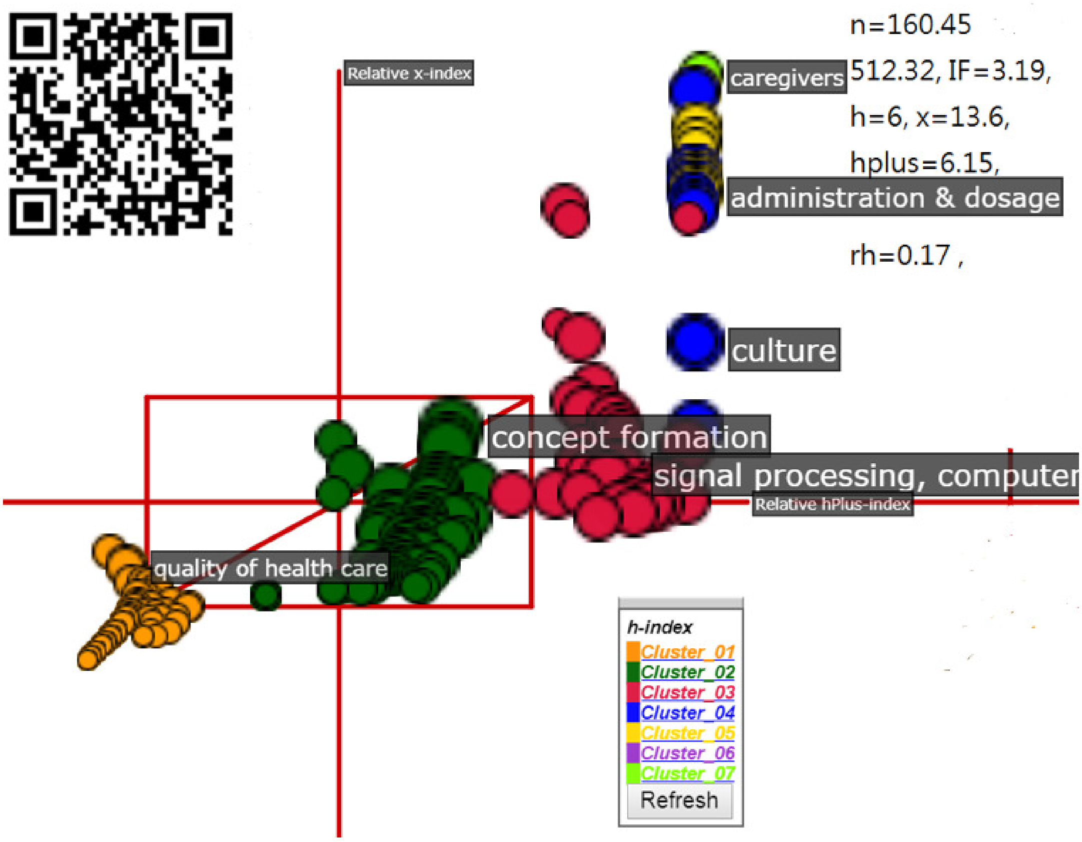

Figure 3. The most cited Mesh terms shown on a dashboard

To see the detailed information in PMC, the QR code in Figure 4 can be scanned, followed by selecting the specific MeSH bubble and, subsequently, the word of publication.

Differences in metrics (i.e., h-plus, x-index, and MIF) were found (p < .05), see Figure 5, when any two 95% CI bands were separated from each other. The representative of nursing topped in these three indices among MeSH clusters. Conversely, the MeSH term nursing home was ranked at the bottom in the metrics among clusters.

The article (PMID= 23414420) entitled "Measuring factors affecting implementation of health innovations: a systematic review of structural, organizational, provider, patient, and innovation level measures in 2013" was found to be cited most (i.e., 149 times) (Chaudoir et al., 2013).

Discussions and Conclusion

We found that (1) the dominant nations that conducted research on organizational innovation were the United States of America, the United Kingdom, and Canada; (2) the MeSH terms of caregivers gained the highest in h-plus index (6.15) and impact factor (IF) (3.19), respectively; (3) differences were found significantly among MeSH clusters in indices (p<0.05); and (4) the article (PMID= 23414420) (Chaudoir et al., 2013) published in 2013 was the most cited article (i.e., 149 times).

Although the h-index (Hirsch, 2005) being a popular author-level metric can simultaneously measure the

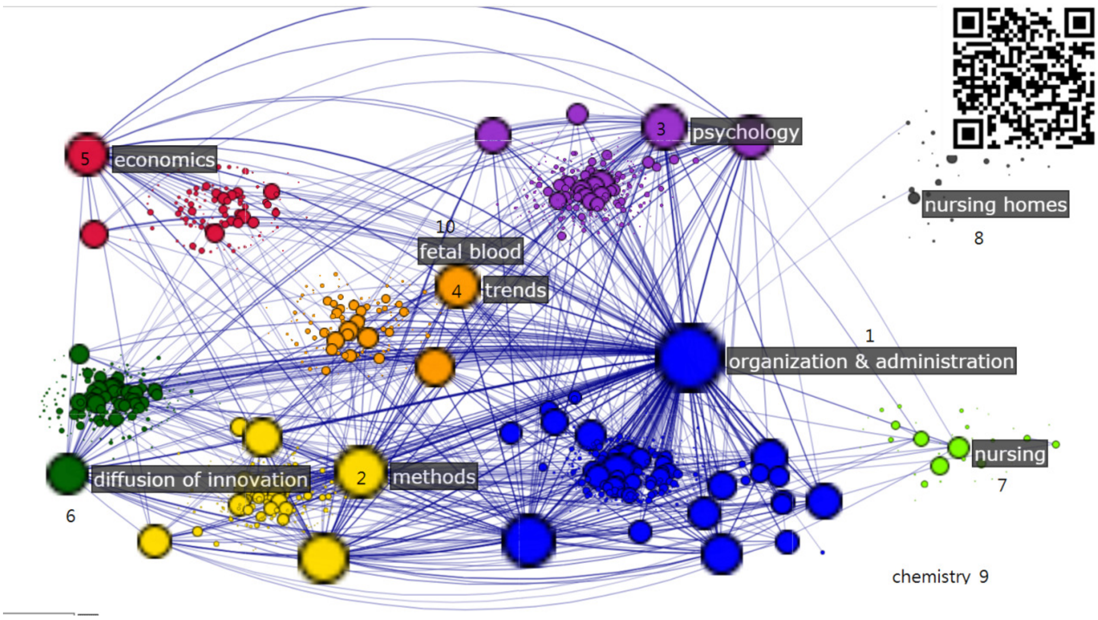

Figure 4. Major mesh terms on organizational innovation in PMC

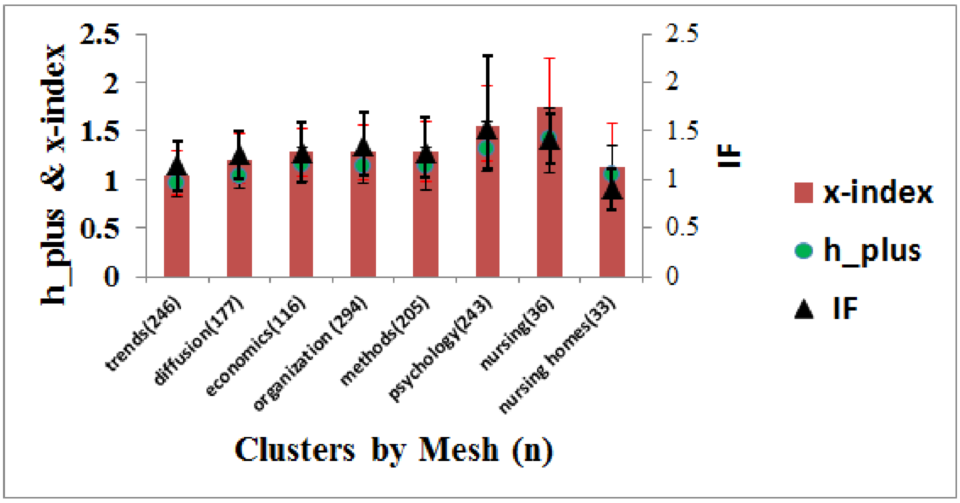

Figure 5. Comparison of metrics among MeSH clusters

productivity and citation impact of the publications of a scientist, one of its shortcomings is less discriminative power (Huang et al., 2010) in the presence of many identical values (i.e., in an integer form). Many concepts of bibliometrics have already been proposed in the past (Hirsch, 2005; Zhang, 2009; Zhang, 2013; Belikov et al., 2015; Egghe, 2006; Fenner et al., 2018; Pan et al., 2014), but we have not seen any concept that can be successfully applied to the scientific disciplines in use. We applied the h-plus index to improve h-index effectively with high discriminative power for evaluating MeSH terms, as we did in this study. On this basis, we recommend the application of h-plus to other fields of authors in the discernible future.

We demonstrated the application of the h-plus index on organizational innovation in academics, particularly, on articles in PMC, using the MIF; additionally, we showed the use of the weighted scheme for quantifying contributions among MeSH terms in an article byline, which was rarely seen in the literature before. In Figure 3, we see the MeSH-based x- and h-plus indexes shown on a dashboard using Google Maps that can be also applied to other fields in the future.

The bibliometric indices are dependent on both quantity (i.e., the number of publications) and the quality (i.e., the number of articles being cited), which is suitable for use in the field of topic burst, as shown in this study. When compared to the author-based bibliometrics (Kan et al., 2018), the MeSH-based metrics gained higher values than the author indices because of a huge amount of frequency relatively produced in the past 5 years. Figures 3 and 4 clearly show topic burst regarding organizational innovation in the past.

Similarly, the x-index (Fenner et al., 2018) on organizational innovation in Figure 3 will be higher than (or equal to) the h (or h-plus) index due to the inclusion of excessive citations, see Figure 1. For instance, 10 publications with 10 citations each have an identical h-index and x-index at 10 (or $\sqrt{10 \times 10}$ for x-index). Conversely, one publication with 100 citations leads to a difference between h-index (=1) and x-index $(= 10 = \sqrt{(1 \times 100)})$, and 100 publications with only one citation each produce different results in h-index $(= 1)$ and x-index $(= 10 = \sqrt{(100 \times 1)})$ (Fenner et al., 2018). The h-plus index, as proposed, might have a high correlation, theoretically, with x-index than with h-index.

The most notable feature is the general scheme of weight allocations that can be fully congruent with the true scenario in practice (i.e., equal size on contributions), determined by the weights $(= 1/n)$ instead of all weights an identical value $(= 1)$, irrespective of the ordering of MeSH terms.

The second feature is the intrinsic dynamic character of the simple 5-year moving average MIFs; this is similar to the journal citation report (JCR) locating JIF each year in June to examine the change in MIF (or h-plus index). Conversely, the h-index is a growing measure, taking into account the whole career path (Pan et al., 2014).

The reason we applied x-index in this study is the strength of the index in practice. According to the illustration in the study of Fenner and his colleagues (Fenner et al., 2018), the x-index can truly extend the feature of an author with quality and quantity achievements in academics, as mentioned above.

Although this study’s findings are based on the above analysis, there are several potential limitations that may encourage further research efforts. First, all data were extracted from the PubMed database. There might be some biases in understanding the matched MeSH terms because of different terms with asterisks representing major MeSH terms in the article; this will affect the result of the MeSH relationship analysis based on the accuracy of the indexed MeSH terms.

Second, many algorithms have been used for SNA. We merely applied the algorithm of degree centrality in the figures. Any changes in the algorithm used in this study might change the pattern and judgment of the results.

Third, the data extracted from PMC cannot be generalized to other major citation databases—such as the Scientific Citation Index (SCI; Thomson Reuters, New York, NY, USA) and Scopus (Elsevier, Amsterdam, The Netherlands). As such, the most cited authors are determined by the paper selections on PubMed.

In conclusion, SNA provides wide and deep insight into the relationships among MeSH terms. The MeSH-weighted scheme and h-plus index can be applied to academics for computing MeSH citations in the future.

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