INTRODUCTION

Traditional Chinese medicine (TCM) is based on more than 2,500 years of Chinese medical practice that includes various forms of herbal medicine, acupuncture, massage, exercise, and dietary therapy [1]. TCM is widely applied in China [1-4]. One of the basic tenets of TCM is that “the body’s vital energy circulates through channels, called meridians, that have branches connected to bodily organs and functions [5].

Concepts of the body and disease used in TCM reflect its ancient origins and its emphasis on dynamic processes over the material structure, similar to European humoral theory [6]. Many authors [7-10] have introduced TCM in academics recently. However, which articles and authors were cited most remains unknown.

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Many previous types of research [11-13] have inspected the patterns of coauthor collaboration using social network analysis. The most number of articles in science are from the U.S. and Europe [14,15]. Whether the dominant nation on the TCM topic is China has not been investigated in the literature.

As of January 20, 2019, more than 10,510 papers were published on Pubmed.com by searching the keyword traditional Chinese medicine based on major medical subject heading (i.e., MeSH Major Topic, MeSH for short) and 4,523 in the paper title including “Traditional Chinese medicine”[title] or “Chinese Traditional medicine”[title], which present the importance of author collaborations in academics in the past. The citation analysis has been applied to the TCM topic [16], addressing the United States being the dominant position regarding complementary and alternative medicine research. We were motivated to inspect whether the dominant nation is China instead of the US on the TCM topic based on articles published on Pubmed.com.

Choropleth maps (the ones in which each region is filled with a color that represents a value) have been reported in the
past [17-20], particularly the Google Map API (application for program interface) [21,22] has been popular in the digital age.

We are thus interested in following four topics: (1) which nations was dominant in the field of traditional Chinese medicine; (2) which authors were cited most in recent years; (3) is any difference in scientometrics among author clusters in research collaborations; (4) which article was cited most in the past.

We aim to apply x-index [23] and author impact factor (AIF) [24] to investigate the four questions mentioned above. Google Maps will be applied to the study results as dashboards in an interactive way.

METHODS

Data Source

We obtained 2417 abstracts based on journal article from Pubmed Central (PMC) by searching the keywords of “traditional Chinese medicine” [MeSH Major Topic] from 2013 to 2016. A total number of 4760 citing articles matching to the cited papers in PMC were attained. The number of 1164 articles were cited by at least one publication in PMC. All data were downloaded from PMC, which means the study is not necessary for ethical approval according to the regulation promulgated by the Taiwan Ministry of Health and Welfare.

Four Metrics Proposed in this Study

The h-index [25] can be divided into three parts [26,27]. Many modified h-index had been suggested, such as (1) the g-index [28] (≤ \( \sum_{i=1}^{m} c_i^g \), where ci = number of citations to i-th publication); (2) the x-index [23] (\( = \sqrt{\text{max}(i \times c_i) } \ )); (3) AIF [24]; (4) the h'-index [26] (\( = h^*r_h \), where \( r_h = e/t \), and le t=1 if t<1, perfectionist at \( r_h >1 \), prolific type at \( r_h =1 \), and mass-production at \( r_h <1 \)).

Due to the contradiction on h’-index for the results through the formula (\( = h^*r_h \)) which lets h’ be greater than h+1 (e.g., h=2 and rh =2 make h’ be 4 greater that h+1=3). We thus propose the complemental one [i.e., h-plus=h+ rh/ (1+ rh)] ranging h-plus between h and h+1.

The Weighted Author Scheme (AWS) for Quantifying Coauthor Contributions

One of the drawbacks for h-index was proposed without fairly quantifying coauthors’ credits in an article byline [29,30]. Similarly, other indices mentioned above ignore the author contributions, too, to the article. Even though some used the alphabet ordering of author names [31] in the mathematical discipline and assumed all coauthor with equal credits, we particularly applied the author-weighted scheme [32,33], i.e., \( W_j = \frac{\exp(\gamma_j)}{\sum_{j=0}^{m} \exp(\gamma_j)} \), to this study for quantifying coauthor contributions. The AIF is defined as the formula (2) [24] below:

\[
AIF = \frac{\sum Cited\_papers\_based\_on W_j}{\sum Citable\_papers \times W_j \_in\_the\_given\_yrs}, \tag{2}
\]

Social Network Analysis using Pajek Software

In keeping with the Pajek guidelines [34], we applied social network analysis (SNA) to cluster authors. Usually, the relation valued by the weight is defined by the number of connections between two authors [32,33,35]. The clusters can be determined by a specific algorithm as named degree centrality.

Using Bootstrapping Sampling Method to Estimate 95% Confident Intervals

SNA was applied to determine the representative of each cluster. The algorithm of community partition was performed to identify the number of clusters. Each author was, in turn, assigned to the designated cluster represented by the author who owns the highest centrality degree in his/her cluster. As such, each author can be matched to his/her metrics, clusters, and even the affiliated nation by the author-made MS-Excel module.

The bootstrapping method [36] was applied to examine differences in metrics among author clusters. A total of 1000 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 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 gain the author clusters. The pages of Hyper Text Mark-up Language (HTML) used for Google Maps were created. All relevant bibliometric indices were linked to dashboards on Google Maps.

RESULTS

TASK1: Which Countries/Areas Dominate the TCM Around the World

We observed the top three dominant countries/areas were and China, Taiwan, and Hong Kong. The top three provinces
in China were Beijing, Taiwan, and Shanghai, respectively, with the higher x-index on TCM, see Figure 1 and 2.

**TASK2: Selecting the Eight Top Author Clusters with High Degree Centrality**

The top eight author clusters were separated as shown in Figure 3. The representatives with the most degree centrality (DC) are shown for each cluster. The author Yong-Yan Wang from Beijing earns the highest DC, implying more author collaborations and articles exist. The interested readers are also recommended to scan the QR-code in Figure 3 to see the detailed information in PMC by clicking the word of publication when the specific author bubble is selected.

**TASK3: Comparisons of Differences in Metrics among Clusters**

The differences in metrics (i.e., x-index, h-plus, and AIF) were found ($p < .05$), see Figure 4, when any two 95% CI bands were separated from each other.

**TASK 4: Presenting the Most Cited Article and Author on the TMC Topic**

The most cited author is Shao Li from Beijing who gains author impact factor=57.36 and x-index=7.65 using weighted author schemes to calculate. The interested readers are also suggested to scan the QR-code in Figure 5 to see the detailed information in PMC by clicking the word of publication when the specific author bubble is selected. We see the h-plus index on X-axis and x-index on the Y-axis. The bubble was sized by the AIF and colored by the ratio- $h(=\text{excess citations/h-tail citations mentioned in the section of Methods})$.

The most cited article(i.e., PMID=23787177 [37]) authored by Shao Li in 2013 had been mentioned by 80 citing articles.

**DISCUSSION**

We observed the top three dominant countries/areas with higher metrics on TCM are China, Taiwan, and Hong Kong, which is different from the previous research [14,15] claimed the dominant nations in science are from the U.S. and Europe. When we focus the topic on TMC, the citation...
analysis in the previous study[16] addressing the United States is the dominant position, which is also different from our study using citation analyses, see Figure 1. The main reason might be the disparate criteria used in study, such as x-index in this study and publication outputs in others.

As for the h-index[25], an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar, proposed for determining IRA, both citations and publications should be combined, as h-index and other complementary metrics, to determine the IRA.

Another feature in this study is the choropleth maps applied to present the results, see Figure 1 and 2, which imply that choropleth maps are great to show a clear regional pattern in the data. If our data doesn’t show a clear regional pattern, consider other chart types, e.g., bar chart or line chart, readers would prefer to find themselves on a map. If we are mapping an area in which our readers live, do consider a choropleth map even if they do not live in those regions. Accordingly, the top three provinces of Beijing, Taiwan, and Shanghai are most in x-index in China regarding articles on the TCM topic in PMC.

The most cited author is Shao Li from Beijing who gains author impact factor=57.36 and x-index=7.65 using weighted author schemes to calculate which can fairly allocate credits in an article. Otherwise, all coauthors who enjoy an equal size of contributions to the article are unfair when calculating the bibliometrics[29,30].

A total of 233 articles were extracted from PMC using the keyword “most cited articles” in paper title. Only four [38-41] referred Pubmed as the citations database. Other famous major citation databases, such as the Scientific Citation Index (SCI; Thomson Reuters, New York, NY, USA) and Scopus (Elsevier, Amsterdam, The Netherlands), are paid for use[42]. We applied the web crawler technique and obtained the citations from PMC, which is rarely seen in the previous research. The most cited article with PMID=23787177 in 2013 was, thus found. A total of 80 citations was extracted from PMC.

Although the h-index[25] being a popular author-level metric that can measure both the productivity and citation impact of the publications of a scientist, one of its shortcomings is less discriminative power[43] was criticized. The h-plus index used in this study can be complementary to h-index because both parts of excess and h-tail citations have been considered[26, 27].

Another feature is about the AWS used for quantifying coauthor contributions in an article byline. Even many concepts have already been proposed in the past [29,30,44], but none has been applied to the scientific disciplines in use successfully as we did use the Eq.(1).

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[23], the x-index can truly extend the feature of an author with quality and quantity achievements in academics as mentioned above.

Although findings are based on the above analysis, there are still several potential limitations that may encourage further research efforts. First, all data were extracted from PMC. There might be some biases when matching author names because of some with identical names, particularly in China, which will affect the result of author clusters.

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 present a different pattern and judgment to the results.

Third, the data extracted from PMC cannot be generalized to other major citation databases. Such as the most cited articles and authors might be disparate if others were applied.

In conclusion, social network analysis provides wide and deep insight into the relationships among author collaborations. The weighted author scheme and h-plus index (or other metrics) can be applied to other disciplines in the discernable future.

REFERENCES

3. Wang J, Cui M, Jiao H, Tong Y, Xu J, Zhao Y, Han M, Liu J. Content analysis of systematic reviews on effectiveness...


