Applying Clustering Coefficient to the Pattern of International Author Collaboration in Anesthesiology

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Abstract

Objective: *To apply cluster coefficient(CC) to the pattern of international author collaborations in anesthesiology using data from Medline and to visualize results by means of Google maps and social network analysis(SNA).*

Methods: *Selecting 9,598 abstracts, author names, countries, and keywords on December 20, 2017 from Medline based on journal of anesthesiology since 1987, we reported following features: (1) nation distribution for 1st author's nationality; (2) eminent authors in the field of anesthesiology, (3) notable keywords with Medical subject heading (MESH) terms representing anesthesiology, and (4) cluster coefficients in networks. We programmed Microsoft Excel VBA routines to extract data from Medline. Google Maps and SNAPajek software were performed to display graphical representations with an easy-to-read feature for readers.*

Results: *We found that (1) the most number of papers in surgery are from U.S.(5147, 53.63 %) and Japan(660, 6.88%); (2) the productive authors in anesthesiology are Daniel Sessler(Russia) and Nichilas Dalesio (Spain); (3) the most linked MESH terms are halothane/*pharmacology and isoflurane/*analogs & derivatives/*pharmacology; (4)author networks present higher CC than those MESH networks. .*

Conclusions: *Social network analysis provides wide and deep insight into the relationships among nations, coauthor collaborations, and MESH terms. The results can be provided to readers for future submission to journal in anesthesiology.*

Keywords: *abstract keywords, authorship collaboration, Google Maps, social network analysis, Medline*

1. INTRODUCTION

Anesthesiology describes the medical specialty concerned with the study of anesthesia or anesthetics. The American Society of Anesthesiologists define anesthesiology as "*the practice of medicine dedicated to the relief of pain and total care of the surgical patient before, during and after surgery*"[1]. Anesthesia is the loss of sensation with or without the loss of consciousness.

As of December 20, 2017, more than 176,977 papers were found on Pubmed.comby searching for the keyword anesthesiology and 3,124in the paper title only including anesthesiology. The journal of Anesthesiology has published 23,900 articles since 1987. However, which nations dominate the papers published in Anesthesiology remains unknown and which keywords included in papers of anesthesiology were frequently appeared in past decades is still unclear.

Big Data is a concept that has evolved from the modern trend of "scientism"[2]. Many data scientists' develop ways to discover new

knowledge from the vast quantities of increasingly available information [2].An apocryphal story was often told to tell us the concept of co-occurrence that is about beer and diaper sales. It usually goes along with both beer and diaper sales with a strong correlation on Friday [3-5]. All possible pairs of our observed goods shown on customers' receipts are worth studying the association of goods, which is similar to the keywords and authors in journal papers. Social network analysis (SNA) [6-8] is one methodology for analyzing big data and investigating the association of any pairs of goods in a network.

Authorship collaboration using SNA is an example many authors researched in recent years [6] because co-authors among researchers form is a type of social network. Whether the keyword network in anesthesiology earns a higher centrality measure (or say density) than the author network is required to explore. We are thus interested in using SNA to explore the features in anesthesiology from published papers we observed in Medline library.

Google maps provide an overall view of geospatial visualization with coordinates of latitude and longitude on a map [9,10]. However, few papers were found in Medline library in a search of keyword google map [Title] on November 22, 2017. Many papers [6-8, 11] have studied on co-author collaboration in academics, however, none display results with the skill of incorporating Google maps into social network analysis.

Our aims are to apply clustering coefficient[12] to the pattern of international author collaboration in anesthesiology on the following topics: (i) nation distribution;(ii) the most eminent authors in anesthesiology; (iii) the recent research domains defined by MESH (medical subject headings) terms; (iv)the cluster coefficients in different networks.

2. METHODS

2.1. Data Sources

We programmed Microsoft Excel VBA (visual basic for applications) modules to extract abstracts and their corresponding coauthor names as well as author-defined keywords for each article on December 20, 2017 from *Medicine National Institutes of Health (Med*line) since 1987. Only those abstracts published by the keyword anesthesiology [journal] and labeled with Journal Article were

included. Others like those labeled with Published Erratum, Editorial or without author nation name were excluded from this study. A total of9, 598 eligible abstracts were obtained from Medline.

2.2. Data Arrangement to Fit Sna Requirement

Prior to visualize our results using SNA, we organized data in compliance with the format and guidelines defined by Pajeksoftware[13]. Microsoft Excel VBA was used to deal with data fitting to the SNA requirement.

2.3. Graphical Representations to Report

(1)Author nations and their relations

A table (i.e., columns for publication years and rows for the 1st author nations) was made for presenting the distribution of nations regrading surgery. The bigger bubble means the more number of the nodes (i.e., nations, or keywords in this study). The wider line indicates the stronger relations between two nodes. Community clusters are filled with different colors in bubbles.

(2)Keywords to present the research domain

If keywords represent the research domain, the stronger relations between two keywords can be highlighted and linked by SNA, like the concept of co-occurrence about beer and diaper sales. The presentation for the bubble and line is interpreted similar to the previous section. Medical subject heading (MESH) terms were applied to represent the keywords in the current study.

2.4. Statistical Tools and Data Analyses

Google Maps [14] and SNA Pajeksoftware[13] were used to display visualized representations for eminent authors and keywords in relation with anesthesiology. Author-made Excel VBA modules were applied to organize data. Cluster coefficient represents the density of a network as below: =

$$\frac{\text{number of closed troplets}}{\text{number of possible connected triplets of nodes}} = \frac{\sum_{i=1}^{n} other\_two\_nodes_i\_connected}{\sum_{i=1}^{n}(m_i*(m_i-1)/2}$$

, whereas n=the number of nodes in a network and m=the number of other connected nodes with a specific ego node. A significant lever (>1.96) is defined by t-value as the formula $[=cc*\sqrt{[(n-2)/(1-cc^2)]}$.

In contrast, E-I index is defined by the formula of $\frac{EL-IL}{EL+IL}$, where EL= hte number of external friendshio links and IL= the number of internal

friendship links [15]. The negative E-I index means a coherence cluster in existence. Similarly, the higher CC indicates many members are other linked members' friends. Density is defined as the ratio of the linked members over all possible linked members.

3. RESULTS

3.1. Author Nations and Their Relations

A total of 9,598 eligible papers with complete author nations based on journal article since 1997 are shown in Table 1. We can see that the most number of papers are from nations of U.S.(5147,53.63 %) and Japan(660,6.88%). The trend in the number of publications with authorship from countries is present in the column of growth in Table 1. All continents but Europe and Africa present a positively increase.

The diagram shown by SNA and Google Maps in Figure 1displays author collaboration among nations based on the journal of anesthesiology. Overall, the highest productive nations are from

U.S. and Europe, see Figure 1. Any nation collaborated with other nations are shown with a blue line. Interested authors are recommend to click the bubble of interest to see details on a website at reference [18].

Figure1. *Google Maps on the topic of author collaboration in anesthesiology (CC=0.86)*

Table1. *Nation distribution based on the 1st author for papers published in biostatistics*

| Nation/Continent	1987-2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total	%	Growth
AFRICA	3			1		1	1		1			7	0.07	0.00
Mali	1						1		1			3	0.03	0.26
Egypt	0			1		1						2	0.02	-0.26
Other	2											2	0.02	-
Asia	702	30	30	29	27	27	25	38	36	32	38	1018	10.61	**0.60**
Japan	546	15	19	11	10	8	8	15	8	7	11	660	6.88	-0.56
China	20	6	5	8	9	10	13	20	17	17	19	145	1.51	0.93
Taiwan	28	2	3	6	5	3	1	2	6	3	3	62	0.65	-0.02
Israel	35	3		1	2	1				2		45	0.47	-0.42
Hong Kong	23	1	1	1		2	1	1	3	1	2	36	0.38	0.47
Others	50	3	2	2	1	3	2	0	2	2	3	70	0.73	-0.08
EUROPE	1882	75	100	92	74	80	78	94	77	74	77	2711	28.25	-0.35
France	385	17	18	24	23	32	14	24	13	12	22	585	6.10	-0.20
Germany	400	19	26	10	16	10	13	18	13	14	13	553	5.76	-0.43
U.K	217	4	6	3	3	4	11	5	9	10	9	282	2.94	0.70
Netherlands	149	10	10	13	10	10	5	10	9	8	12	246	2.56	-0.18
Switzerland	121	2	13	10	4	6	6	6	2	6	3	180	1.88	-0.39
Others	268	11	16	16	8	9	17	12	9	6	7	381	3.97	-0.55
N. AMERICA	4045	128	138	145	153	125	134	179	174	210	197	5646	58.82	**0.83**
U.S	3717	114	120	131	142	109	125	160	156	180	176	5147	53.63	**0.84**
Canada	321	14	18	14	11	16	9	19	18	30	21	492	5.13	0.58
Others	7	0	0	0	0	0	0	0	0	0	0	7	0.07293	-
OCEANIA	95	5	7	8	3	2	6	7	10	11	9	164	1.71	**0.57**
Australia	86	4	6	6	3	2	6	5	7	8	7	141	1.47	0.54
New Zealand	9	1	1	2				2	3	3	2	23	0.24	0.53
S. AMERICA	37	1			1	2	1	1	5	2	2	52	0.54	**0.60**
Brazil	15	1			2	1	1	3	2	1		26	0.27	0.57
Others	22	0	0	0	1	0	0	0	2	0	1	26	0.27089	0.42
Total	6764	239	275	275	258	237	245	319	303	329	323	9598	100.00	**0.75**

3.2. The Eminent Authors in Surgery
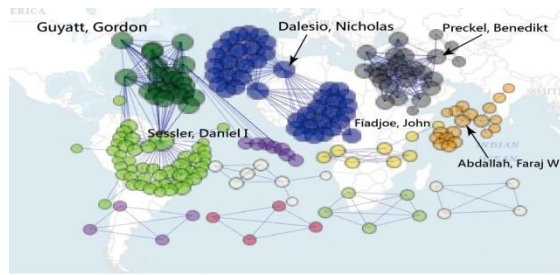
Figure2. *Google Maps on eminent authors in anesthesiology (CC=0.95)*

The most eminent authors who published most number of papers in anesthesiology are Daniel Sessler (Russia) and NichilasDalesio (Spain), see Figure 2. The link on website was referred to reference [16]

3.3. Keywords to Present the Research Domain of Anesthesiology Recently

The most linked MESH termsarehalothane/* pharmacology and isoflurane/*analogs & derivatives/*pharmacology, see Figure 3 or click it on the reference [17]. We can see that the

MESH terms consisting of many clusters with different cluster coefficients.
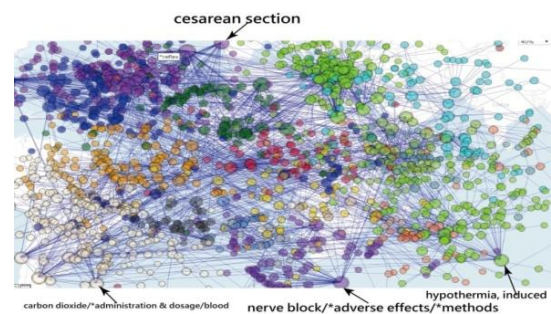
Figure3. *Google Maps on MESH terms in anesthesiology (CC=0.60)*

3.4. Cluster Coefficients in a Network

Each cluster has its own cluster coefficient representing the density of a network. We found that author clusters earn higher CC than have MESH clusters. Cluster coefficient has a significant effect in comparison with a significant t-value (>2.0), indicating author network with more significance than those MESH terms (Table 2).

Table2. *Cluster coefficients in each cluster and their relevant indicators*

Name	CC	EI	node	degree	t-value
fentanyl/*administration & dosage/blood	0.60	-0.85	16	25	2.81*
malignant hyperthermia/*complications/diagnosis	0.53	-0.88	6	8	1.25
*laryngoscopes	0.19	-0.79	22	26	0.87
anesthetics, local/*administration & dosage	0.17	-0.47	91	126	1.63
*anesthesia and analgesia	0.13	-0.42	81	125	1.17
*biomedical research	0.13	-0.55	146	322	1.57
anesthesia, inhalation/*instrumentation	0.13	-0.81	55	67	0.95
pain, postoperative/*diagnosis/*drug therapy	0.12	-0.66	107	159	1.24
*hypothermia, induced	0.12	-0.52	126	166	1.35
*analgesia, epidural	0.10	-0.57	35	53	0.58
*anesthesiology	0.08	-0.52	188	279	1.09
oxygen/*administration & dosage/adverse effects/blood	0.07	-0.33	94	121	0.67
*respiration, artificial	0.07	-0.46	61	72	0.54
*preanesthetic medication	0.07	-0.59	124	168	0.78
anesthesia, general/*adverse effects/*methods	0.06	-0.66	92	107	0.57
pulmonary alveoli/*analysis/metabolism	0.06	-0.50	16	18	0.22
*needles	0.06	-0.56	33	35	0.33
Author					
Chong, Carol P W	0.95	-0.70	7	20	1.04
Beach, Michael L	0.83	-1.00	4	6	2.52*
Ahlstrand, Rebecca	0.67	-1.00	4	6	2.87*
Preckel, Benedikt	0.59	-1.00	25	217	3.50*
Goobie, Susan M	0.59	-0.82	20	190	3.10*
Peelen, Linda M	0.56	-1.00	8	17	1.85
Szmuk, Peter	0.54	-0.85	22	231	6.80*
Chan, Matthew T V	0.50	-0.85	21	210	1.66
Auyong, David B	0.50	-1.00	5	10	0.43
Abdallah, Faraj W	0.41	-1.00	19	37	1.00
Fox, Amanda A	0.19	-1.00	7	11	0.24
Abriel, Hugues	0.17	-1.00	4	6	1.28
Sessler, Daniel I	0.15	-0.80	49	123	2.10*

4. DISCUSSION

This study found that (1) the most number of papers in surgery are from U.S.(5147, 53.63 %) and Japan(660, 6.88%); (2) the productive authors in anesthesiology are Daniel Sessler(Russia) and NichilasDalesio(Spain); (3) the most linked MESH terms are halothane/* pharmacology and isoflurane/*analogs & derivatives/*pharmacology; (4)author networks present higher CC than those MESH networks.

What This Adds to What Was Known

Many previous researches [6-8] have investigated coauthor collaboration using social network analysis. The results(the most number of articles in anesthesiology from U.S. and Europe) are similar to the findings that dominant nations in science come from U.S. and Europe[19,20].Referring to the apocryphal story told to discover the co-occurrence about beer and diaper sales[3-5], we showed a novel method incorporating SNA with Google maps to explore the data. It can be seen that visual representations rendered to readership is rare in literature. Traditionally, it is very hard to observe the association of two or more symptoms or entities together appeared in a network at a moment.

Journal authorship collaboration can be compared with each other using Google Maps. We can see that many links connecting two nations which indicate a collaboration pattern in paper publication similar to the previous study [4]. Hence the researchers have a high level of international author collaboration in anesthesiology, which is inconsistent with the previous studies that investigated scientific collaboration of Iranian Psychology and Psychiatry Researchers [21, 22].

There are 1,084 papers with the keyword social network analysis in paper title when searching Medline in December21, 2017. There were two papers [23, 24] incorporated MESH into social network analysis to release relevant knowledge to readers. However, no any that can incorporate Google maps link we used in the current study. The CCs we illustrated in reference [16-18] are called overall CCs. The highest cluster in figures are0.86, 0.95 and 0.60, respectively. Different form of global CCs or or individual CC are defined by each cluster or by each node. Evidence suggests that in most real-world networks, nodes tend to create tightly knit groups characterized by a relatively high density of ties; this likelihood tends to be greater than the average probability of a tie randomly established between two nodes [25, 26].

What It Implies and What Should Be Changed?

Scientific publication is one of the objective measurements to evaluate the achievements of a medical specialty or discipline [27]. It is worth using SNA and Google Maps to explore knowledge to readers in future.

Many algorithms and measures (or indicators) have been developed using SNA to graphically explore data. If we investigate whether any author or paper most fits the research domain of a target journal, the centrality measures can be used [6]. It means that the core subject can be analyzed using the centrality measure [22, 28] yielded by SNA.

Strengths of This Study

The way incorporating SNA with Google Maps is unique when in comparison with those published papers [6-8] merely using a single SNA. Another strength and feature for this study is that Google Maps are used and linked in references [16-18] for interested readers who can manipulate the link by their own ways on the dashboards. The nation distribution in Figure 1 is merit in easily understanding the feature of international author collaborations on anesthesiology. One picture is worth ten thousand words. We hope following studies can report other kinds of information using Google API in future.

5. LIMITATIONS AND FUTURE STUDY

The interpretation and generalization of the conclusions of this study should be carried out with caution. First, the data of this study were collected from Medline for a single journal. It is worth noting that any attempt to generalize the findings of this study should be made in the similar fields of journal domains.

Second, although the data were extracted from Medline and carefully dealt with every linkage as correct as possible, the original downloaded text file including some errors in symbols such as period and comma in author address that might lead to some bias in the resulting nation distribution.

Third, there are many algorithms used for SNA. We merely applied separation components showing in Figures. Any changes made along with algorithm used will present different pattern and inference making.

Fourth, the social network analysis is not subject to the Pajeck software we used in this study, Others such as Ucinet[29] and Gephi[30] are suggested to readers for use in future.

6. Conclusion

Social network analysis provides wide and deep insight into the relationships among nations, coauthor collaborations, and the keyword MESH terms. The results can be provided to readers for future submission to journal in anesthesiology.

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