

Gandasari, Dyah; Tjahjana, David; Dwidienawati, Diena; Sugiarto, Mochamad

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Bibliometric and visualized analysis of social network analysis research on Scopus databases and VOSviewer

Dyah Gandasari^a, David Tjahjana^b, Diena Dwidienawati^c and Mochamad Sugiarto^d

^aPolbangtan Bogor, Bogor, Indonesia; ^bUniversitas Multimedia Nusantara, Jakarta, Indonesia; ^cBusiness Management, BINUS Business School, Bina Nusantara University, Jakarta, Indonesia; ^dFaculty of Animal Science, Jendral Soedirman University, Indonesia

ABSTRACT

The utilization of the social network analysis (SNA) approach dates back to 1928, and since then, it has shown a notable increase and has contributed to a body of research significantly. However, recent years have seen limited bibliometric analyses focusing on the SNA approach. This study seeks to conduct an in-depth review of SNA literature through bibliometric analysis, employing the methodology derived from Garza-Reyes's Five Phases of Bibliometric Analysis. The findings reveal the refinement of 4487 datasets sourced from Scopus databases, with visualization accomplished using VOSviewer. The cluster analysis finds that as many as 5 clusters with a set of keywords. Keywords that can become potential issues for future study found in this study such as integration, risk management, politics, online social network, collaboration network, Facebook, health care organization, stakeholder engagement, group process, clinical trial, risk-taking, adolescent, family, social organization, aggression, pandemic and sars-cov-2, et cetera.

IMPACT STATEMENT

People have been studying how we connect with each other since way back in 1928. Social network analysis (SNA) is the method they use for that. Over the years, it's become super popular and has added a lot to what we know. Not many have been checking out this method in recent years using a tool called bibliometric analysis. Therefore, the authors decided to delve into it. The authors dove into a bunch of data (around 4487 sets of info) from this big research database called Scopus. The authors then used a cool tool called VOSviewer to help see all this information. The authors found 5 clusters of data with different keywords. These keywords are like the main topics such as risk management, online social network, collaboration network, health care organization, stakeholder engagement, group process, family, social organization, aggression, pandemic and more, could be big topics for future research.

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Middlesex University
Business School, UNITED
KINGDOM

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I. Introduction

Social network analysis (SNA) is a method approach used in a type of research for the field from various disciplines. SNA is used to examine various subject areas or several disciplines. Several disciplines frequently use SNA, such as sociology, anthropology, social psychology, communications and economics (Su et al., 2020). SNA is used to see the community structure, depict the structure of the network, visualize the relationship between communities and provide a model based on that (Su et al., 2020).

The systematic review to evaluate the existing academic publication is a very popular research area. Bibliometrics is usually used to investigate the efficiency of academic publications. Bibliometrics applies statistical and mathematical methods (Pritchard, 1969) and uses various analysis methods to analyze text, citation, content or keywords (Dias, 2019).

CONTACT Dyah Gandasari  dyah.gandasari@gmail.com  Polbangtan Bogor, Cinagara Campus, Snakma Street, Pasir Buncir, Caringin, Bogor 16730, West Java, Indonesia.

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Bibliometrics are popular and rigorous methods for analyzing scientific data (Donthu et al., 2021). Further, it is said that analysis with bibliometrics is based on identifying the literary corpus, such as publications in its broadest sense, in a particular subject area. Often the focus is on a broad range of subjects or, more specifically, within a publishing pattern. These factors encompass geographic or institutional elements, while performance indicators encompass changes over time, subject domains or disciplines, as well as various types of literature and authors. The analysis covers various material categories and ranges from journal articles, books, theses and patents to reports in the 'gray literature' category (Ellegaard & Wallin, 2015).

2. Related works

Al et al. (2012) conducted a bibliometric study on SNA. The source of data used is from Thomson Reuters' Web of Knowledge (WoK) to identify Turkish scholars' publications. There are included citation index from: Conference Proceedings, Social Sciences, Arts & Humanities and Science. To ensure that 'Turkey' related words are covered in the search other related languages such as Turkey, Turkiye, Turkey, Turquie) were included in the search term. Following the refinement of the search results, a comprehensive set of 198,687 publications spanning the years 1928–2009 was identified. The analysis outcomes indicated that disciplines such as economics, sociology, social psychology, anthropology and communications predominantly utilize the SNA. Moreover, there was a notable surge in Turkey's contribution to academic publications over the past 15 years, encompassing 247 diverse fields. Notably, the field of surgery emerged as the most prolific area for Turkish scholars, yielding 14,365 publications.

Another publication on bibliometric analysis was conducted by Su et al. (2020). Their objective was to ascertain the present status of scientific publications on SNA and scrutinize its knowledge foundations, including research authors, countries, document types, keyword patterns and subject areas spanning the years 1999–2018. Su et al. (2020) utilized the Social Science Citation Index (SSCI) and Web of Science databases for their study. The analysis revealed that the top two subject areas were 'Computer Science' and 'Business Economics'. Notably, the primary outlets for SNA articles were identified in Computers in Human Behavior. The study demonstrated that SNA is intertwined with various research areas, such as 'Community of Inquiry', 'Social Network Analysis', 'Online Learning', 'Social Networks' and 'Computer-Mediated Communication'. The two publications used bibliometrics on SNA publications. However, there is still limited available SNA research using bibliometric analysis such as VOSviewer. So, the researcher can update the previous studies that use bibliometrics on SNA publications.

Therefore, this research is aimed to evaluate the previous related works. Currently, there is a limited bibliometric study on SNA publications using VOSviewer. The aim of this study is to conduct a thorough bibliometric analysis of SNA literature with the intention of addressing the specified research questions (RQ):

In the research of SNA, What/Who/Which:

RQ1: The trend of annual

RQ2: Top journals that are published

RQ3: Top contributing authors

RQ4: Subject areas or disciplines

RQ5: The main research topics

RQ6: The future study potential topics

RQ7: The Top authors' origin countries and their collaborations'?

RQ8: Articles have the most citations in SNA literature?

3. Materials and methods

The five stages of Garza-Reyes (2015) will be used to analyze SNA publications (Figure 1). The process of these stages is conducted to ensure overall data and evaluations in the SNA analysis.

3.1. Establishing the keywords

This study took place on 14 March 2022. In this study, string keywords pertinent to SNA were employed in the title, keywords and abstract of the articles. The search formula utilized was: TITLE-ABS-KEY ('Social Networks Analysis') OR TITLE-ABS-KEY ('Social Networks Analyzing') OR TITLE-ABS-KEY ('Analyzing Social Networks').

The information source relies on the search results obtained from the electronic database using the specified keywords. In this research, Scopus is used as the electronic database. According to Krisnaningsih et al. (2021) and Napitupulu (2021), Scopus is a reputable international journal database whose article quality is guaranteed.

3.2. The Result of the initial search

Four thousand four hundred and eighty-seven articles were obtained from the initial search. The authors did not set a period limitation because the objective of this study is mapping the research development of SNA theme (state of the art) as a whole. It is showed that the SNA-related article was first found in early 1981, as shown in Table 1.

3.3. Refining result of search

To enhance the accuracy of the initial search outcome, inclusion criteria were employed. Two criteria were applied: IC1 necessitated that articles be composed in English, while IC2 mandated that the articles originate from peer-reviewed journals. Exclusions were made for articles from books, proceedings, book chapters, editorials and newspaper. The objective is to ensure that the scientific contribution will only be from the peer-reviewed journal source. Duplication of paper will also be excluded. The findings were stored in RIS format for further analysis. Refinement of Search showed in Table 2.

3.4. Compiling initial data statistics

RIS refinement files are then processed with reference management software (RMS) Mendeley to obtain the metadata which includes author, title, keywords, abstract, and name, year, issue, volume and pages



Figure 1. Bibliometric analysis.

Source: Garza-Reyes (2015).

Table 1. The first SNA study in publications.

Author	Title	Source	Year of publication
Foster, B.L., Seidman, S.B.	Network structure and the kinship perspective	American Ethnologist 8(2), pp. 329–355	1981
Sokolovsky, J., Cohen, C.I.	Measuring social interaction of the urban elderly: A methodological synthesis	International Journal of Aging and Human Development, 13(3), pp. 233–244	1981
Cohen, C.I., Sokolovsky, J.	Social networks and the elderly: Clinical techniques	International Journal of Family Therapy, 3(4), pp. 281–294	1981
Hurd, G.S., Pattison, E.M., Llamas, R.	Models of social network intervention	International Journal of Family Therapy, 3(4), pp. 246–257	1981
Anderson, James G., Gray-Tuft, Pamela, Lloyd, Frank P., Jay, Stephen	Factors affecting physician utilization of a computerized hospital medical information system: a social network analysis	Proceedings - Annual Symposium on Computer Applications in Medical Care, pp. 791–796	1981

of the journal. Afterward verification process was conducted to ensure the completeness of the data. Then, data were undergone analyzing and classifying based on the number of documents published annually, journal name, author and discipline.

3.4.1. The trend of SNA research based on the number of annual publications (RQ1)

The following figure depicts the SNA research trend based on the number of articles published annually (Figure 2). It shows that worldwide research on SNA started to increase starting in 2005 (a total of 17 published articles), and the ongoing trend in research continues to progress, evident in the increasing number of publications. The result is aligned with Su et al. (2020) which shows that there has been a noticeable surge in SNA research since 2005. In Figure 2 also showed that there has been a significant increase in SNA documents in the last 3 years, in 2019 (a total of 546 published articles), 2020 (a total of 737 published articles) and 2021 (a total of 849 published articles).

3.4.2. Top journals that published most articles in the area of SNA research (RQ2)

The leading five peer-reviewed journals with the highest number of publications was depicted in Figure 3. They contribute to 510 articles (11.36%) out of 4487 articles over 40 years publications (1981–2021). The top journal with the most papers published is Sustainability Switzerland, with 165 articles, articles, followed by

Table 2. Refinement of search.

Search keyword	Number of Scopus documents
TITLE-ABS-KEY ('Social Networks Analysis') OR TITLE-ABS-KEY ('Social Networks Analyzing') OR TITLE-ABS-KEY ('Analyzing Social Networks') AND PUBYEAR > 1980 AND PUBYEAR < 2022 AND (LIMIT-TO (DOCTYPE, 'ar')) AND (LIMIT-TO (OA, 'all')) AND (LIMIT-TO (SRCTYPE, 'j')) AND (LIMIT-TO (LANGUAGE, 'English'))	4487

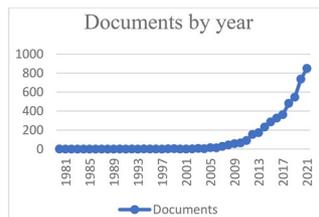


Figure 2. Trend of SNA articles published per year.

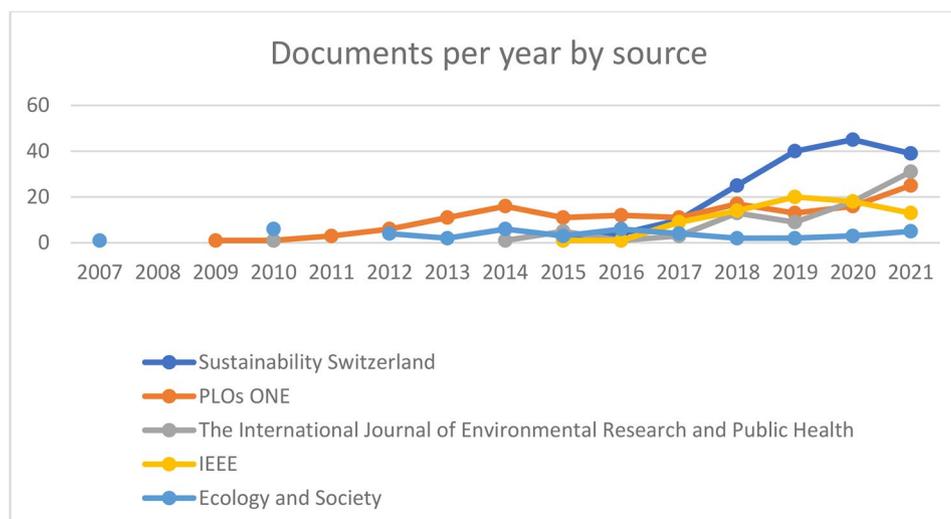


Figure 3. Top five journals based on the number of paper published in SNA study.

PLoS ONE with 143 articles. International Journal of Environmental Research And Public Health (82 articles), IEEE Access contributes 76 articles and Ecology and Society (44 articles).

From the findings, it is clear that top five journals that published these articles are from the sciences. These were not in line with the findings of Su et al. (2020) and Al et al. (2012). According to Su et al. (2020) and Al et al. (2012), several disciplines frequently use SNA, such as sociology, anthropology, social psychology, communications and economics.

Sustainability Switzerland is an Open Access Journal. Scopus coverage years are from 2009 to the present. The publisher of this journal is the Multidisciplinary Digital Publishing Institute (MDPI). The study areas of this journal are Social Science, Computer Science, Policy and Legal Science, Computer Science and Environmental Science. Several documents published in 2021 include the topics of Social Science (Martínez-Fernández et al., 2021; Y. Wang, Chen, et al., 2021), Computer Science (Yoo et al., 2021), Policy and Legal Science (B. Wang, Sun, et al., 2021; L. Zhang et al., 2021) and Environmental Science (Wei et al., 2021; Yao et al., 2021).

PLoS ONE is an open-access journal. Scopus coverage years: from 2006 to present. The publisher of this journal is the Public Library of Science with fields of study namely Multidisciplinary. Some of the authors in this journal include Jafarzadeh et al. (2021) about assessing the public conversation; Yang et al. (2021) about contact tracing of Covid-19 in tourist areas; Wäsche et al. (2021) on inter-organizational cooperation topic; Gao and Sun (2021) about transport accessibility and social demand; and Y. Zhang and Wu (2021) about spatial association network structure for innovation efficiency.

The International Journal of Environmental Research and Public Health is an open-access journal with Scopus year coverage, namely from 2004 to the present. The publisher of this journal is the MDPI. The field of study for this journal is Medicine and Environmental Sciences. Some of the authors in Medicine and Environmental Sciences are Binkheder et al. (2021), Xu et al. (2021), Fullana et al. (2021), (Rodríguez-Madrid et al., 2021), (Kim et al., 2021) and (Lin et al., 2021).

IEEE Access is open access with Scopus coverage from 2013 to the present. The publisher of this journal is IEEE with fields of study including Engineering, Computer Science and Materials Science. Several publications from IEEE cover topics in engineering (Baydogan & Alatas, 2021; Qureshi et al., 2021; Riquelme et al., 2021; Skarding et al., 2021), and computer science (Skarding et al., 2021; Zarei et al., 2021).

Ecology and Society was previously known as Conservation Ecology, which is an open-access journal. Scopus coverage years from 1997 to the present. The publisher of this journal is the Resilience Alliance with the subject area being Environmental Science. Several articles on the topic of Ecology such as rural cooperatives for promoting resource-conserving agriculture (Nyantakyi-Frimpong et al., 2019), Multilevel stakeholder networks for marine biosecurity (McAllister et al., 2020), Connectors and coordinators in natural resource governance (Angst et al., 2018) and Stakeholder networks for urban water sustainability (Wutich et al., 2020).

3.4.3. The top productive authors in SNA research publication (RQ3)

The ten most contributors published articles in peer-reviewed journals are highlighted in Figure 4. Farine emerges as the most prolific author, contributing approximately 21 articles. Valente and Rienties have authored 20 articles, followed by Dijkstra (18 articles), Colladon (17 articles), Veenstra (16 articles), Daly and Clemente (15 articles), Fujimoto (14 articles) and Leydesdorff (12 articles).

Figure 5 shows that SNA finds frequent application across various disciplines, particularly in the social sciences, computer sciences, medicine, environmental sciences, engineering, business management, agriculture, psychology, mathematics and multidisciplinary. The social sciences became the most subject area, published around 19.8% (1627 articles). Computer sciences published around 13.5%, followed by medicine (9.7% or 799 articles), environmental science (8.0% or 662 articles), engineering (6.5% or 538 articles), business, management and accounting (5.5% or 450 articles), agricultural and biological sciences (5.2% or 426 articles), psychology (4.1% or 337 articles), mathematics (3.7% or 305 articles), multidisciplinary (3.3% or 269 articles) and others (20.8% or 1084 articles).

Several SNA articles by several disciplines such as social sciences (Martínez-Fernández et al., 2021; Scott & Richardson, 2021; Tran, 2021; Y. Wang, Chen, et al., 2021); computer sciences (Mohan et al., 2021; Skarding et al., 2021; Zarei et al., 2021), medicine (Chopra et al., 2021; Liu et al., 2021; Smith et al., 2021),

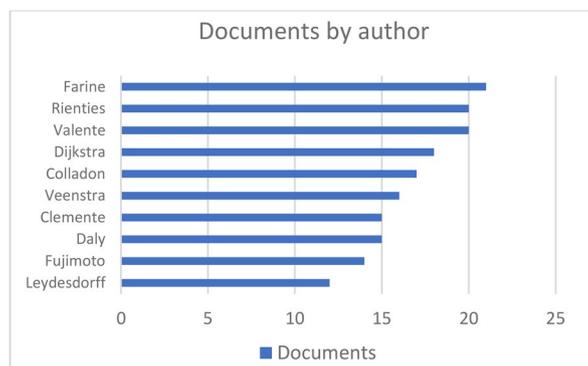


Figure 4. Top ten contributing authors in SNA study.

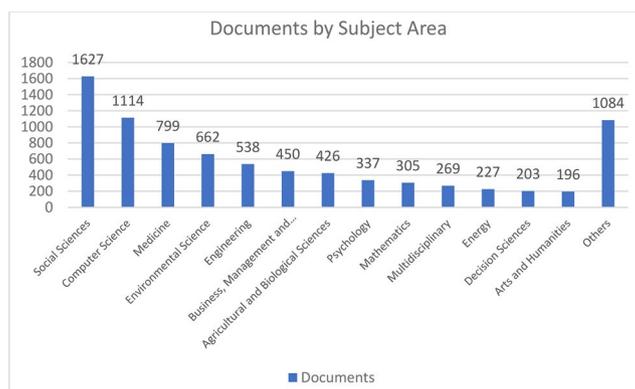


Figure 5. Several disciplines of SNA study.

environmental science (Binkheder et al., 2021; Fullana et al., 2021; Kim et al., 2021; Lin et al., 2021; Rodríguez-Madrid et al., 2021; Wei et al., 2021; Xu et al., 2021; Yao et al., 2021), engineering (Baydogan & Alatas, 2021; Qureshi et al., 2021; Riquelme et al., 2021; Skarding et al., 2021), business management and accounting (Chen et al., 2021; Love et al., 2021; Rocha et al., 2021; Scott & Richardson, 2021), agriculture and biological sciences (Angst et al., 2018; McAllister et al., 2020; Nyantakyi-Frimpong et al., 2019; Scott & Richardson, 2021; Wutich et al., 2020) psychology (Fotopoulou et al., 2021; Kušen & Strembeck, 2021; Tubaro et al., 2021), mathematics (Elmezain et al., 2021; Khodadadi & Saeidi, 2021; Ur Rehman et al., 2021) and multidisciplinary (Gao & Sun, 2021; Jafarzadeh et al., 2021; Wäsche et al., 2021; Yang et al., 2021; Y. Zhang & Wu, 2021).

3.5. Data analysis

VOSviewer software is used to visualize RIS format the bibliometric data. VOSviewer is a tool that commonly used in analyzing and producing a visual representation in the bibliometric map form (Hudha et al., 2020). The widespread adoption of the tools is attributed to their ability to analyze large datasets effectively and further display them in an easy-to-understand bibliometric map and interpretation. van Eck and Waltman (2010) further claim that VOSviewer demonstrates its capability to handle extensive maps and create visual representations of co-citation networks, even from major scientific journals. This versatile tool can generate various maps, including those for authors, journals, publications and countries, by leveraging co-citation networks or constructing keyword maps through topic modeling. Additionally, being a freely accessible tool, VOSviewer has been effectively employed for data mining research, grouping articles and mapping articles from diverse database sources (Xie et al., 2020).

4.1.1. *The main topics of research in the SNA field (RQ5)*

The visualization of five clusters and their relationships is depicted in [Figure 6](#). A comparable cluster reveals keywords that exhibit a strong correlation among them. Significantly, each cluster exhibits frequent instances of keywords that reflect the research emphasis noted in previous studies. This study set a limitation of the top three most occurrence frequency keywords ([Table 3](#)).

The top three most occurrence frequency keywords in the first cluster were SNA, social networks and network analysis. SNA has the most occurrence frequency keywords (2214), followed by social networks (1314), network analysis (485). The top three most occurrence frequency keywords in the second cluster were humans (785), social networking (273), and public health (116). The top three most occurrence frequency keywords in the third cluster were female (528), male (510) and adult (335). The top three most occurrence frequency keywords in the fourth cluster were social behavior (173), animals (160) and animal (154). The top three most occurrence frequency keywords in the fifth cluster that related to coronavirus were aged (83), covid-19 (76) and epidemiology (72).

There were 202 items in Cluster 1. The top three most occurrence frequency keywords in the Cluster 1 were SNA, social networks and network analysis. SNA has the most occurrence frequency keywords (2214) with 498 links and 13,363 total link strength; followed by social network with 1314 occurrence keywords, 495 links and 14,723 total link strength; and network analysis with 485 occurrence keywords, 454 links and 3925 total link strength.

In Cluster 2, there were 119 items. The top three most occurrence frequency keywords in the Cluster 2 were human (980 occurrence keywords, 490 links, and 15,029 total link strength); humans (785 occurrence keywords, 473 links, and 12,940 total link strength); and social networking (273 occurrence keywords, 428 links and 4466 total link strength).

The top three most occurrence frequency keywords in Cluster 3 were female (528 occurrence keywords, 428 links and 4,466 total link strength), male (510 occurrence keywords, 428 links and 4466 total link strength) and adult (335 occurrence keywords, 428 links and 4466 total link strength).

The top three most occurrence frequency keywords in Cluster 4 were social behavior (173 occurrence keywords, 428 links and 4466 total link strength), animals (160 occurrence keywords, 428 links and 4466 total link strength), and animal (154 occurrence keywords, 428 links and 4466 total link strength).

The top three most occurrence frequency keywords in Cluster 5 that related to coronavirus were aged (83 occurrence keywords, 428 links and 4466 total link strength), covid-19 (76 occurrence keywords, 428 links and 4466 total link strength), and epidemiology (72 occurrence keywords, 428 links and 4466 total link strength).

4.1.2. *The potential topics in SNA research for further research (RQ6)*

[Table 2](#) provides an overview of keywords characterized by less frequent occurrence. These terms hold the potential to serve as topics for in-depth analysis in future research. This study set a limitation of 15–30 for occurrence frequency keywords. Those words are such as integration (18), risk management (21), politics (19), online social network (16), collaboration network (22), health care organization (16), sociometric status (19), stakeholder engagement (22), group process (18), clinical trial (16), risk-taking (20), adolescent (19), family (16), social organization (21), aggression (29), pandemic (35) and sars-cov-2 (34).

The research topic based on the year of publication is shown in [Figure 7](#). [Figure 7](#) shows that the most occurrence keywords show up from 2017 until 2019. Keywords show up in 2017 such as cooperation, cooperative behavior, peer group, social network (online), social support, social organization, organization and management. Keywords show up in 2018 such as social behavior, social structure, human, psychology, female and friend. Keywords show up in 2019 such as Twitter, social media, covid-19, epidemiology, sustainable development, machine learning, diffusion, bibliometric analysis, human experiment and intersectoral collaboration.

Moreover, [Figure 8](#) portrays the density visualization, illustrating the depth of research within certain SNA domains. The color density in the figure corresponds to the frequency of occurrence of keywords, providing insight into the intensity of research focus in different areas. The density of the colors shows the high growth research. [Figure 8](#) showed less frequent occurrence keywords that had less density colors. The density colors can indicate the topics that are still limited and need move exploration for

Table 3. Cluster analysis.

No	Cluster	Most frequent keywords	Keywords
1	Cluster 1 (202 items)	Social network analysis (2214), social networks (1314), network analysis (485)	adaptive management (21), agriculture (29), artificial intelligence (32), behavioral research (60), betweenness centrality (40), bibliometric (15), bibliometric analysis (39), bibliometrics (92), bid data (66), biodiversity (19), brazil (32), centrality (46), centrality measures (31), china (159), citation analysis (22), cities (16), city (20), classification (21), classification (of information) (20), climate change (53), closeness centralities (15), clustering algorithms (23), co-authorship (30), co-authorship networks (18), co-word analysis (18), collaboration (47), collaboration (22), collective action (15), commerce (29), community detection (71), community structures (19), complex networks (99), complexity (16), computer networks (15), conceptual framework (26), connectivity (15), conservation (15), conservation of natural (22), construction industry (18), content analysis (52), correlation analysis (17), crime (23), criminal network (17), culture (18), data analysis (30), data mining (84), data set (26), data visualization (22), decision making (141), deep learning (20), degree centrality (15), density (16), design/methodology/approach (15), diffusion (39), disasters (18), distributed computer systems (21), e-learning (16), ecology (27), economic and social effects (41), economic development (24), ecosystem (24), ecosystems (20), efficiency (20), empirical analysis (19), environmental management (17), environmental policy (22), environmental protection (35), Europe (23), European union (19), exponential random graph models (18), Facebook (25), forecasting (62), France (17), Germany (31), governance (35), governance approach (80), graph algorithms (17), graph theory (77), graphic methods (20), gravity model (15), health care (29), higher education (26), homophily (35), housing (18), Indonesia (25), infectious disease (15), influence (21), influence maximization (16), influence maximizations (15), information diffusion (17), information dissemination (56), information management (28), information services (16), information sharing (16), information systems (25), innovation (77), integration (18), internet (66), investment (17), Italy (35), knowledge (55), knowledge management (39), knowledge sharing (17), language (15), learning (55), learning analytics (18), learning systems (30), link prediction (30), literature review (25), local participation (24), machine learning (57), management (40), marketing (24), migration (23), monitoring (17), natural language processing (25), Netherlands (21), network (22), network structures (30), networks (60), numerical model (19), on-line social networks (41), online social network (16), online social networks (16), online systems (18), optimization (26), participatory approach (24), patents and inventions (15), perception (42), policy approach (15), policy implementation (19), policy making (43), policy networks (19), politics (19), populations dynamics (50), productivity (23), project management (25), public policy (17), publishing (25), quality control (17), quantitative analysis (64), questionnaire survey (23), regression analysis (33), research and development (18), research work (35), resilience (23), resource management (15), risk assessment (57), risk management (21), scientific collaboration (21), scientometrics (20), semantics (50), sentiment analysis (39), SNA (52), social aspects (19), social capital (78), social influence (30), social interactions (23), social learning (18), social media (224), social network analysis (SNA) (71), social network services (18), social networking (online) (554), social networks (230), social networks analysis (31), social relationships (21), social sciences (20), social sciences computing (67), sociology (23), software (41), south Africa (18), South Korea (21), spatial analysis (37), stakeholder (77), stakeholder analysis (25), stakeholder (15), state of the art (15), statistical analysis (24), statistics (32), strategic approach (31), surveys (32), sustainability (91), sustainable development (63), Switzerland (17), systematic review (46), teaching (17), technology (16), text mining (34), theoretical study (25), time series analysis (17), topology (30), tourism (27), twitter (141), united kingdom (57), urban area (32), virtual reality (16), visualization (38), water management (23), web of science (22)
2	Cluster 2 (119 items)	human (980), humans (785), social networking (273)	attitude to health (24), Australia (52), authorship (20), biomedical research (27), Canada (34), capacity building (16), case study (22), centralization (32), child preschool (18), clinical article (45), clinical practice (17), clinical trial (16), communication (71), community (24), community care (43), community networks (24), cooperation (89), cooperative behavior (79), data collection (17), delivery of health care (28), developing countries (25), developing country (17), economics (38), education (56), England (21), evidence based practice (17), evidence-based practice (16), family (16), feasibility study (15), financial management (16), funding (22), global health (16), government (44), group process (18), group processes (18), health (25), health care delivery (35), health care organization (16), health care personnel (45), health care planning (19), health care policy (49), health care quality (15), health care system (16), health education (16), health knowledge, attitudes, practice (17), health personnel (28), health policy (39), health program (16), health promotion (59), health service (28), health services (26), health services research (27), hospital (20), hospitals (18), India (26), infant (17), information processing (55), interdisciplinary communication (17), international cooperation (37), interpersonal communication (63), interprofessional relations (24), intersectoral collaboration (16), interview (58), interviews as topic (23), leadership (78), mass communication (16), medical information (18), medical research (49), methodology (55), mixed methods (23), multicenter study (16), nurse (19), organization (55), organization and management (111), organizations (19), outcome assessment (36), patient care (40), patient care team (23), patient referral (19), personnel (26), physician (28), physicians (15), pilot study (17), practice guideline (16), preschool child (19), primary health care (26), priority journal (114), procedures (143), program evaluation (31), public health services (24), public health (116), public relations (37), public-private partnership (17), publication (42), qualitative analysis (32), qualitative research (41), randomized controlled trial (30), research (36), research design (20), research personnel (19), retrospective studies (19), retrospective study (22), scientist (28), semi structured interview (20), sociometric status (19), stakeholder engagement (22), stakeholder participation (15), standards (25), statistics and numerical data (80), translational medical research (19), translational research (22), trends (17), trust (25), Uganda (20), united states (115), writing (28)

(Continued)

Table 3. Continued.

No	Cluster	Most frequent keywords	Keywords
3	Cluster 3 (99 items)	female (528), male (510), adult (335)	Academic achievement (18), adolescence (21), adolescent behavior (44), adolescents (19), age (23), alcohol (15), alcohol consumption (20), alcohol drinking (17), behavior (24), child (102), cohort analysis (35), cohort studies (18), comparative study (53), controlled study (224), cross-sectional studies (69), cross-sectional study (84), demography (45), depression (20), drinking behavior (19), drug dependence (19), ethnology (16), exercise (20), follow up (26), football (18), friend (80), friends (59), friendship (62), gender (35), health behavior (38), health status (20), health survey (22), high risk behavior (22), HIV (23), HIV infections (44), human experiment (121), human immunodeficiency virus (20), human immunodeficiency virus infection (39), human relations (66), incidence (18), interpersonal relations (63), intimacy (21), juvenile (18), longitudinal studies (43), longitudinal study (56), major clinical study (164), mental health (34), middle aged (116), models, statistical (22), motivation (16), neighborhood (15), obesity (23), observational study (20), peer group (80), peer influence (26), peer pressure (20), performance analysis (17), physical activity (31), prevalence (30), psychology (191), questionnaire (122), risk (16), risk factor (64), risk factors (36), risk-taking (20), rural area (31), rural population (34), school (42), school child (17), schools (38), self-concept (15), self-report (15), sex difference (27), sex factor (15), sex factors (22), sexual behavior (29), sexuality (15), smoking (16), social environment (48), social status (41), social support (217), socioeconomic factors (18), socioeconomics (19), Spain (41), sport (16), statistical model (48), stochastic model (17), student (59), students (61), substance abuse (23), substance-related disorders (22), surveys and questionnaires (86), universities (20), urban population (16), young adult (107)
4	Cluster 4 (63 items)	social behavior (173), animals (160), animal (154)	Africa (18), aggression (29), algorithm (64), algorithms (60), animal behavior (49), animal experiment (25), animal husbandry (16), animalia (54), article (76), aves (16), behavior, animal (32), biological model (17), bird (17), cluster analysis (64), commercial phenomena (19), community structure (23), computer simulation (33), databases, factual (16), disease control (23), disease outbreaks (30), disease transmission (51), dominance (16), epidemic (50), feeding behavior (19), fitness (22), genetics (31), geographic distribution (23), geography (17), grooming (25), livestock (17), model (23), model, biological (17), models, theoretical (44), nonhuman (128), pan troglodytes (15), physiology (86), pig (19), prediction (33), primate (24), primates (21), probability (22), sampling (18), season (18), seasons (15), simulation (27), social behavior (15), social dominance (16), social interaction (91), social organization (21), social structure (76), spatiotemporal analysis (42), theoretical model (44), time factor (16), time factors (24), traffic and transport (22), transmission (32), transportation (22), vaccination (23), virus transmission (20), wild population (24)
5	Cluster 5 (16 items)	Aged (83), covid-19 (76), epidemiology (72)	aged, 80 and over (25), contact examination (21), contact tracing (18), coronavirus (19), coronavirus disease (37), isolation and purification (18), pandemic (35), pandemics (29), prevention and control (24), public opinion (16), sars-cov-2 (34), tuberculosis (15), very elderly (27)

Table 4. Top ten influential articles: citations measure.

No	Author	Year	Title	Citation	Cit./Year
1	Jacomy, M., Venturini, T., Heymann, S., Bastian, M.	2014	ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software	1604	200.5
2	Eagle, N., Pentland, A., Lazer, D.	2009	Inferring friendship network structure by using mobile phone data	1489	114.5
3	Wagner, C.S., Leydesdorff, L.	2005	Network structure, self-organization, and the growth of international collaboration in science	708	41.6
4	Wilson, R.E., Gosling, S.D., Graham, L.T.	2012	A Review of Facebook Research in the Social Sciences	858	85.8
5	Colleoni, E., Rozza, A., Arvidsson, A.	2014	Echo Chamber or Public Sphere? Predicting Political Orientation and Measuring Political Homophily in Twitter Using Big Data	736	92
6	Wagner, C.S., Leydesdorff, L.	2005	Network structure, self-organization, and the growth of international collaboration in science	708	41.6
7	Liu, X., Bollen, J., Nelson, M.L., Van De Sompel, H.	2005	Co-authorship networks in the digital library research community	623	36.6
8	Gardy, J.L., Johnston, J.C., Ho Sui, S.J., Brunham, R.C., Tang, P.	2011	Whole-genome sequencing and social network analysis of a tuberculosis outbreak	580	52.7
9	Costenbader, E., Valente, T.W.	2003	The stability of centrality measures when networks are sampled	541	28.5
10	Farine, D.R., Whitehead, H.	2015	Constructing, conducting, and interpreting animal social network analysis	531	75.8

influential publication in the field. The article from Jacomy et al. became the most influential article with 1604 citations. The title of the article is 'ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software' (Jacomy et al., 2014). It is also held as the most popular article with 200.5 average citations per year.

4. Conclusion

The bibliometric analysis is utilized in this study to analyze all journal documents in SNA research areas from the Scopus database. This area of research has been shown as advanced and has shown a significant number of literature in the last 40 years. However, it is believed that this area of research has not reached its maturity yet. The initial result obtained 24,101 articles from the Scopus database. After refinement with inclusion criteria, there are 4487 articles remaining. This study shows the trends of SNA research, subject areas, authors, countries of author, and most influential articles. This study also uses cluster analysis to show the primary research topics. The potential future topics as the contribution of this study can be shown by the less frequent occurrence of keywords. This study also fills the gap of the last three years' SNA literature analysis. There has been a significant increase in SNA documents. In 2018 there were 482 documents, but in 2019 the published articles increased to 546 documents, in 2020 there were 737 documents and in 2021 there were 849 documents. In bibliometric keywords show up in 2018 such as social behavior, social structure, and human, but keywords show up in 2019–2021 such as social media, COVID-19, epidemiology, sustainable development, and machine learning. Enrichment and updating the SNA research bibliometric are also other contributions of this study. This study has successfully mapped and visualized SNA bibliometric analysis with the VOSviewer application. Given the restricted utilization of VOSviewer analytics in SNA bibliometric analysis, the outcomes of this analysis stand as an additional contribution of this study. This study's limitation is the limited data source. The dataset resource of this study is only the Scopus dataset. Therefore, using various datasets is recommended for the future study.

Contribution of individual authors to the creation of a scientific article

Dyah Gandasari, Diena Dwidienawati carried out conceptualization, funding acquisition and writing-original draft.

Mochamad Sugiarto carried out the experiment.
David Tjahjana carried out Data curation and formal analysis.
Dyah Gandasari, Diena Dwidienawati carried out writing-review & editing.

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About the authors

Dyah Gandasari completed a doctorate degree from the Doctoral Program in IPB. She is a faculty member in Polbangtan Bogor. Her research of interest includes communication, communication development, information and communication technology, and organizational behavior.

David Tjahjana obtained his Doctorate degree from DRM Bina Nusantara University. He is a faculty member at Universitas Multimedia Nusantara. His research of interest is in innovation, leadership, and strategic management

Diena Dwidienawati is a faculty member in BINUS Business School, Bina Nusantara University. She completed a doctorate degree from DRM Bina Nusantara University. Interest in research and areas of expertise are in digital business, leadership, and strategic management.

Mochamad Sugiarto, SPT., MM., PhD, completed his undergraduate studies (S1/SPT) and earned a Bachelor's degree in Animal Husbandry from the Faculty of Animal Husbandry at UNSOED then pursued a Master's of Management program at the College of Economics and Management, University of the Philippines Los Baños (UPLB). In the years 2003-2006, he pursued a Doctoral program (S3/PhD) at the Department of Community Development, College of Public Affairs, University of the Philippines Los Baños (UPLB).

Data availability statement

Available upon request.

References

- Al, U., Taşkın, Z., & Düzyol, G. (2012). *Use of social network analysis in bibliometric researches 1* (pp. 1–4). Bobcatsss. <http://yunus.hacettepe.edu.tr/~umutalhttp://yunus.hacettepe.edu.tr/~ztaskinhttp://www.bby.hacettepe.edu.tr/akademik/guledaduzoy/>
- Angst, M., Widmer, A., Fischer, M., & Ingold, K. (2018). Connectors and coordinators in natural resource governance: Insights from Swiss water supply. *Ecology and Society*, 23(2), 15. <https://doi.org/10.5751/ES-10030-230201>
- Baydogan, C., & Alatas, B. (2021). Metaheuristic ant lion and moth flame optimization-based novel approach for automatic detection of hate speech in online social networks. *IEEE Access*, 9, 110047–110062. <https://doi.org/10.1109/ACCESS.2021.3102277>
- Binkheder, S., Aldekhyyel, R. N., Almogbel, A., Al-Twairish, N., Alhumaid, N., Aldekhyyel, S. N., & Jamal, A. A. (2021). Public perceptions around mhealth applications during covid-19 pandemic: A network and sentiment analysis of tweets in Saudi Arabia. *International Journal of Environmental Research and Public Health*, 18(24), 13388. <https://doi.org/10.3390/ijerph182413388>
- Chen, J., Liang, Y., Zhang, J., & Qi, G. (2021). The online social network and user innovation in the context of an online innovation platform. *Journal of Organizational and End User Computing*, 33(6), 1–27. <https://doi.org/10.4018/JOEUC.20211101.oa7>

- Chopra, D., Li, C., Painter, J. T., Bona, J. P., Nookaew, I., & Martin, B. C. (2021). Characteristics and network influence of providers involved in the treatment of patients with chronic back, neck or joint pain in Arkansas. *The Journal of Pain*, 22(12), 1681–1695. <https://doi.org/10.1016/j.jpain.2021.06.002>
- Dias, G. P. (2019). Fifteen years of e-government research in Ibero-America: A bibliometric analysis. *Government Information Quarterly*, 36(3), 400–411. <https://doi.org/10.1016/j.giq.2019.05.008>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Ellegaard, O., & Wallin, J. A. (2015). The bibliometric analysis of scholarly production: How great is the impact? *Scientometrics*, 105(3), 1809–1831. <https://doi.org/10.1007/s11192-015-1645-z>
- Elmezain, M., Othman, E. A., & Ibrahim, H. M. (2021). Temporal degree-degree and closeness-closeness: A new centrality metrics for social network analysis. *Mathematics*, 9(22), 2850. <https://doi.org/10.3390/math9222850>
- Fotopoulou, E., Zafeiropoulos, A., & Papavassiliou, S. (2021). EmoSocio: An open access sociometry-enriched Emotional Intelligence model. *Current Research in Behavioral Sciences*, 2, 100015. <https://doi.org/10.1016/j.crbeha.2021.100015>
- Fullana, J., Díaz-Garolera, G., Puyaltó, C., Rey, A., & Fernández-Peña, R. (2021). Personal support networks of young people with mild intellectual disabilities during the transition to adult life. *International Journal of Environmental Research and Public Health*, 18(22), 11810. <https://doi.org/10.3390/ijerph182211810>
- Gao, X., & Sun, D. (2021). Transport accessibility and social demand: A case study of the Tibetan Plateau. *PLoS One*, 16(9), e0257028. <https://doi.org/10.1371/journal.pone.0257028>
- Garza-Reyes, J. A. (2015). Lean and green—a systematic review of the state of the art literature. *Journal of Cleaner Production*, 102, 18–29. <https://doi.org/10.1016/j.jclepro.2015.04.064>
- Hudha, M. N., Hamidah, I., Permasari, A., Abdullah, A. G., Rachman, I., & Matsumoto, T. (2020). Low carbon education: A review and bibliometric analysis. *European Journal of Educational Research*, 2020(9), 319–329. <https://doi.org/10.12973/eu-jer.9.1.319>
- Jacomy, M., Venturini, T., Heymann, S., & Bastian, M. (2014). ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software. *PLoS One*, 9(6), 1–12. <https://doi.org/10.1371/journal.pone.0098679>
- Jafarzadeh, H., Pauleen, D. J., Abedin, E., Weerasinghe, K., Taskin, N., & Coskun, M. (2021). Making sense of COVID-19 over time in New Zealand: Assessing the public conversation using Twitter. *PLoS One*, 16(12), e0259882. <https://doi.org/10.1371/journal.pone.0259882>
- Khodadadi, A., & Saeidi, S. (2021). Discovering the maximum k-clique on social networks using bat optimization algorithm. *Computational Social Networks*, 8(1), 6. <https://doi.org/10.1186/s40649-021-00087-y>
- Kim, E. J., Lim, J. Y., Kim, G. M., & Kim, S. K. (2021). Nursing students' subjective happiness: A social network analysis. *International Journal of Environmental Research and Public Health*, 18(21), 11612. <https://doi.org/10.3390/ijerph182111612>
- Krisnaningsih, E., Nurdiana Putri, M. A., Irba, T., Suppto, N., Deta, U. A., & Hariyono, E. (2021). Bibliometric analysis of multi representation based on problem-solving skills using VOS viewer. *Berkala Ilmiah Pendidikan Fisika*, 9(3), 274. <https://doi.org/10.20527/bipf.v9i3.11329>
- Kušen, E., & Strembeck, M. (2021). Building blocks of communication networks in times of crises: Emotion-exchange motifs. *Computers in Human Behavior*, 123, 106883. <https://doi.org/10.1016/j.chb.2021.106883>
- Lin, Q., Xiang, M., Zhang, L., Yao, J., Wei, C., Ye, S., & Shao, H. (2021). Research on urban spatial connection and network structure of urban agglomeration in Yangtze river delta—Based on the perspective of information flow. *International Journal of Environmental Research and Public Health*, 18(19), 10288. <https://doi.org/10.3390/ijerph181910288>
- Liu, Y., Huang, W., & Luo, D. (2021). The reception of support in peer-to-peer online networks: Network position, support solicitation, and support provision in an online asthma caregivers group. *Health Informatics Journal*, 27(5), 14604582211066020. <https://doi.org/10.1177/14604582211066020>
- Love, H. B., Cross, J. E., Fosdick, B., Crooks, K. R., VandeWoude, S., & Fisher, E. R. (2021). Interpersonal relationships drive successful team science: An exemplary case-based study. *Humanities and Social Sciences Communications*, 8(1), 1–10. <https://doi.org/10.1057/s41599-021-00789-8>
- Martínez-Fernández, M. C., García-Rodríguez, I., Arias-Ramos, N., García-Fernández, R., Trevissón-Redondo, B., & Liébana-Presa, C. (2021). Cannabis use and emotional intelligence in adolescents during covid-19 confinement: A social network analysis approach. *Sustainability*, 13(23), 12954. <https://doi.org/10.3390/su132312954>
- McAllister, R. R. J., Kruger, H., Stenekes, N., & Garrard, R. (2020). Multilevel stakeholder networks for Australian marine biosecurity: Well-structured for top-down information provision, requires better two-way communication. *Ecology and Society*, 25(3), 1–12. <https://doi.org/10.5751/ES-11583-250318>
- Mohan, A., Nakano, A., & Ferrara, E. (2021). Graph signal recovery using restricted Boltzmann machines. *Expert Systems with Applications*, 185, 115635. <https://doi.org/10.1016/j.eswa.2021.115635>
- Napitupulu, D. (2021). A bibliometric analysis of e-government research. *Library Philosophy and Practice*, 6, 1–20.
- Nyantakyi-Frimpong, H., Matou, P., & Isaac, M. E. (2019). Smallholder farmers' social networks and resource-conserving agriculture in Ghana: A multicas comparison using exponential random graph models. *Ecology and Society*, 24(1), 1–13. <https://doi.org/10.5751/ES-10623-240105>
- Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, 25(4), 348–349.

- Qureshi, K. A., Malick, R. A. S., Sabih, M., & Cherifi, H. (2021). Complex network and source inspired COVID-19 fake news classification on Twitter. *IEEE Access*, 9, 139636–139656. <https://doi.org/10.1109/ACCESS.2021.3119404>
- Riquelme, F., Aguilera, A., & Inostrosa-Psijas, A. (2021). Contagion modeling and simulation in transport and air travel networks during the COVID-19 pandemic: A survey. *IEEE Access*, 9, 149529–149541. <https://doi.org/10.1109/ACCESS.2021.3123892>
- Rocha, A., Brown, R., & Mawson, S. (2021). Capturing conversations in entrepreneurial ecosystems. *Research Policy*, 50(9), 104317. <https://doi.org/10.1016/j.respol.2021.104317>
- Rodríguez-Madrid, M. N., Del Río-Lozano, M., Fernández-Peña, R., & García-Calvente, M. D. M. (2021). Changes in caregiver personal support networks: Gender differences and effects on health (cuidar-se study). *International Journal of Environmental Research and Public Health*, 18(21), 11723. <https://doi.org/10.3390/ijerph182111723>
- Scott, C. K., & Richardson, R. B. (2021). Farmer social connectedness and market access: A case study of personal networks among emerging farmers. *Journal of Agriculture, Food Systems, and Community Development*, 10(2), 1–23. <https://doi.org/10.5304/jafscd.2021.102.024>
- Skarding, J., Gabrys, B., & Musial, K. (2021). Foundations and modeling of dynamic networks using dynamic graph neural networks: A survey. *IEEE Access*, 9, 79143–79168. <https://doi.org/10.1109/ACCESS.2021.3082932>
- Smith, M. B., Blakemore, J. K., Ho, J. R., & Grifo, J. A. (2021). Making it (net)work: A social network analysis of “fertility” in Twitter before and during the COVID-19 pandemic. *F&S Reports*, 2(4), 472–478. <https://doi.org/10.1016/j.xfre.2021.08.005>
- Su, Y. S., Lin, C. L., Chen, S. Y., & Lai, C. F. (2020). Bibliometric study of social network analysis literature. *Library Hi Tech*, 38(2), 420–433. <https://doi.org/10.1108/LHT-01-2019-0028>
- Tran, H. D. (2021). Studying the community of trump supporters on twitter during the 2020US presidential election via Hashtags #maga and #trump2020. *Journalism and Media*, 2(4), 709–731. <https://doi.org/10.3390/journalmedia2040042>
- Tubaro, P., Ryan, L., Casilli, A. A., & D'Angelo, A. (2021). Social network analysis: New ethical approaches through collective reflexivity. Introduction to the special issue of Social Networks. *Social Networks*, 67(2), 1–8. <https://doi.org/10.1016/j.socnet.2020.12.001>
- Ur Rehman, S., Liu, K., Ali, T., Nawaz, A., & Fong, S. J. (2021). A graph mining approach for ranking and discovering the interesting frequent subgraph patterns. *International Journal of Computational Intelligence Systems*, 14(1), 1–17. <https://doi.org/10.1007/s44196-021-00001-4>
- van Eck, N. J., & Waltman, L. (2010). Software survey: VOS viewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. <https://doi.org/10.1007/s11192-009-0146-3>
- Wang, Y., Chen, H., & Wu, X. (2021). Spatial structure characteristics of tourist attraction cooperation networks in the Yangtze river delta based on tourism flow. *Sustainability*, 13(21), 12036. <https://doi.org/10.3390/su132112036>
- Wang, B., Sun, A., Zheng, Q., & Wu, D. (2021). Spatio-temporal characteristics of green development cooperation network among belt and road initiative regions and countries. *Sustainability*, 13(20), 11216. <https://doi.org/10.3390/su132011216>
- Wäsche, H., Wolbring, L., & Woll, A. (2021). Physical activity promotion in an urban district: Analyzing the mechanisms of interorganizational cooperation. *PLoS One*, 16(11), e0260053. <https://doi.org/10.1371/journal.pone.0260053>
- Wei, D., Wang, Z., & Zhang, B. (2021). Traditional village landscape integration based on social network analysis: A case study of the yuan river basin in south-western China. *Sustainability (Switzerland)*, 13(23), 13319. <https://doi.org/10.3390/su132313319>
- Wutich, A., Demyers, C., Bausch, J. C., White, D. D., & Sullivan, A. (2020). Stakeholders and social influence in a shadow network: Implications for transitions toward urban water sustainability in the Colorado River basin. *Ecology and Society*, 25(1) <https://doi.org/10.5751/ES-11451-250128>
- Xie, L., Chen, Z., Wang, H., Zheng, C., & Jiang, J. (2020). Bibliometric and visualized analysis of scientific publications on atlantoaxial spine surgery based on web of science and VOS viewer. *World Neurosurgery*, 137, 435–442.e4. <https://doi.org/10.1016/j.wneu.2020.01.171>
- Xu, X., Li, Z., Wang, R., & Zhao, L. (2021). Analysis of the evolution of user emotion and opinion leaders' information dissemination behavior in the knowledge Q&A community during covid-19. *International Journal of Environmental Research and Public Health*, 18(22), 12252. <https://doi.org/10.3390/ijerph182212252>
- Yang, Z., Song, J., Gao, S., Wang, H., Du, Y., & Lin, Q. (2021). Contact network analysis of Covid-19 in tourist areas—Based on 333 confirmed cases in China. *PLoS One*, 16(12), e0261335. <https://doi.org/10.1371/journal.pone.0261335>
- Yao, X., Hu, Y., Gong, H., & Chen, D. (2021). Characteristics and evolution of China's industry–university–research collaboration to promote the sustainable development: Based on policy text analysis. *Sustainability*, 13(23), 13105. <https://doi.org/10.3390/su132313105>
- Yoo, W., Kim, T., & Lee, S. (2021). Predictors of viewing YouTube videos on Incheon Chinatown tourism in south Korea: Engagement and network structure factors. *Sustainability*, 13(22), 12534. <https://doi.org/10.3390/su132212534>
- Zarei, K., Farahbakhsh, R., Crespi, N., & Tyson, G. (2021). Dataset of coronavirus content from Instagram with an exploratory analysis. *IEEE Access*, 9(2020), 157192–157202. <https://doi.org/10.1109/ACCESS.2021.3126552>
- Zhang, Y., & Wu, Z. (2021). Research on the spatial association network structure for innovation efficiency of China's new energy vehicle industry and its influencing factors. *PLoS One*, 16(8), e0255516. <https://doi.org/10.1371/journal.pone.0255516>
- Zhang, L., Zhu, Y., & Fan, L. (2021). Temporal-spatial structure and influencing factors of urban energy efficiency in China's agglomeration areas. *Sustainability (Switzerland)*, 13(19), 10961. <https://doi.org/10.3390/su131910961>