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Analysis of the intellectual and social structure of health system response plan to earthquake studies adopting word co-occurrence and narrative approaches

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Abstract:

BACKGROUND AND AIM: Earthquake is a natural disaster severely affecting the societies' health, hygiene, and welfare as such the most effective method to respond to its damages is to develop a readiness plan. This study aimed to discover thematic patterns and co-author relationships extracted from relevant publications to plan an earthquake response.

MATERIALS AND METHODS: This descriptive–analytical study adopted the scientometric approach and used word co-occurrence and social network analysis. The published articles indexed in PubMed were retrieved from 1970 to 2021 using a combination of keywords "earthquake and response." The data were analyzed in VOSviewer, UCINET, and NetDraw software.

RESULTS: The following six thematic clusters with a social map were extracted: Initial response of the healthcare system, response to probabilistic risks after the hazard, response to mental health and community resilience, response to public health, response to post-traumatic stress disorders, and staff's response to the needs assessment and continuity of diagnostic treatment services. Moreover, social network analysis revealed the great impact of Japanese and Chinese authors and institutes.

CONCLUSION: The present study detected many gaps in the literature on earthquake response, which can contribute to developing a general framework to prepare integrated healthcare earthquake response plans to promote the performance of this system.

Keywords:

Co-authorship network, co-word analysis, earthquake, narrative approach, response plan

Introduction

In the 21st century, earthquakes accounted for 48% of mortalities caused by natural disasters.[1] Such disasters impact society's health, hygiene, and welfare as such the most effective method to respond to its damages is to develop a readiness plan and train the personnel. For various reasons, including the inadequacy of management processes at supporting the national and regional levels, there is still a lack of national standards or programs to respond to earthquake hazards in the health system. Health emergency response guide to hazards is provided only the approach of common features of all hazards and also it focuses on the accident command department and describes the duties of each position regardless of the type of hazard. At the majority, the need to develop a model for earthquake's priority hazards yet has been fully felt. Therefore,

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a model developed solely in response to an earthquake is necessary and awareness of it to all departments of the health system can lead to planning for an effective response.[2,3] Accordingly, authorities need to use planning and management knowledge to respond to and deal with earthquakes and other natural disasters appropriately. The knowledge can be acquired by adopting various approaches such as monitoring credible scientific publications. However, with the growth of different knowledge domains, scientific publications on earthquakes have also rapidly expanded, thereby making the scientific trends hard to follow.[4] In this regard, scientometric experts have drawn up comprehensive scientific maps by integrating visualization tools and developing different indices. The term "drawing a scientific map" refers to the analysis of publications in a scientific domain from different perspectives to discover the relationships and patterns among scientists, research domains, and countries, evaluate and rank researchers, countries, journals, and subjects accurately, and present an overall view of the evolutionary trends.[5-7] On the other hand, co-occurrence analyses are quantitative analyses delineating such relationships. The main point in the co-occurrence analysis is the simultaneous occurrence of two scientific components in a set of publications as the larger the number of co-occurrences between two components is, the stronger their relationship will be. The analysis mainly aims to discover the relationships and shared topics among scientific components or social relationships regarding the centrality measures.[8-11] Several researchers have performed thematic cluster analysis in healthcare during crises by examining the number of publications, citations, and thematic clusters.[1,12-14] Moreover, Qian and Liu *et al*.[15,16] publications were examined from the seismological perspective. They revealed a rise in publications, with the highest word occurrence for "earthquake," as well as close scientific cooperation among disaster-prone countries. Obviously, these studies mainly focused on presenting the quantitative aspects and analyses. It also seems that the extraction of earthquake response programs specifically from research backgrounds in articles has been neglected. The concepts in the articles in this field are derived from real observations and data that should be further interpreted and analyzed qualitatively. In addition to drawing topic networks and social relationships regarding the co-occurrences, this study aimed to identify the strengths, weaknesses, and challenges of the topic and present the elements required for developing a healthcare response plan for earthquake victims.

Materials and Methods

Study design and setting

This research was a descriptive-analytical study using co-occurrences. The thematic clusters and the authors' social network maps were plotted in VOSviewer, UCINET, and NetDraw software.[8-10]

Study participants and sampling

According to the authors, the best search strategy was set to be a combination of the keywords (earthquake) AND (response) to detect relevant data published from 1970 to mid-May 2021 in PubMed. It should be noted that searching additional databases with overlapping coverage but fewer precision-enhancing features occurred more indexing the geology and soil engineering in related to the field of the earthquake (such as Web Of Science, Scopus) which resulting data mapping was not successful to processes). Consequently, 1517 articles in English were retrieved.

Data collection tool and technique

To create the word co-occurrence map, screening was used to detect and remove possible errors and repetitive terms, equalize the words, including synonym combinations, and replace them with the MeSH terms in some cases, write some abbreviations in the complete form, and remove ambiguous and meaningless keywords from the 3312 extracted keywords. A thesaurus file has two columns, a label column and a replace by column. The first line in a thesaurus file is a header line containing column headers. With the exception of the first line, each line in a thesaurus file specifies a label (in the label column) and an alternative label (in the replace by column), indicating that the label is to be replaced by the alternative label. The briefs section, some examples are provided for better detail at abbreviation. Subsequently, a refined thesaurus was created in the TXT format. Finally, all the extracted records and the thesaurus were inputted to VOSviewer. To detect the close semantic relations among words and intellectual structures of the publications in each cluster, we adopted the narrative approach to define and rebuild the terms as a narration to extract the foundations of the healthcare system's earthquake response simply. In the narrative approach, critical information is presented in a simple, straightforward, and concise language (similar to a scientific story) so that it can be understood by readers with different intellectual abilities.[17,18] After inputting the bibliographical data and the researcher-made thesaurus, nine clusters containing 460 terms were retrieved [Figure 1]. Note that Clusters 6, 7, 8, and 9 were merged and interpreted as Cluster 6 because of the small number of terms included in those clusters.

Ethical consideration

This study was approved by the Ethics Committee of the Isfahan University of Medical Sciences (Code: IR.MUI.RESEARCH.REC.1399.758).

Figure 1 displays a set of terms and their links. The map's color scheme shows the formation of relevant

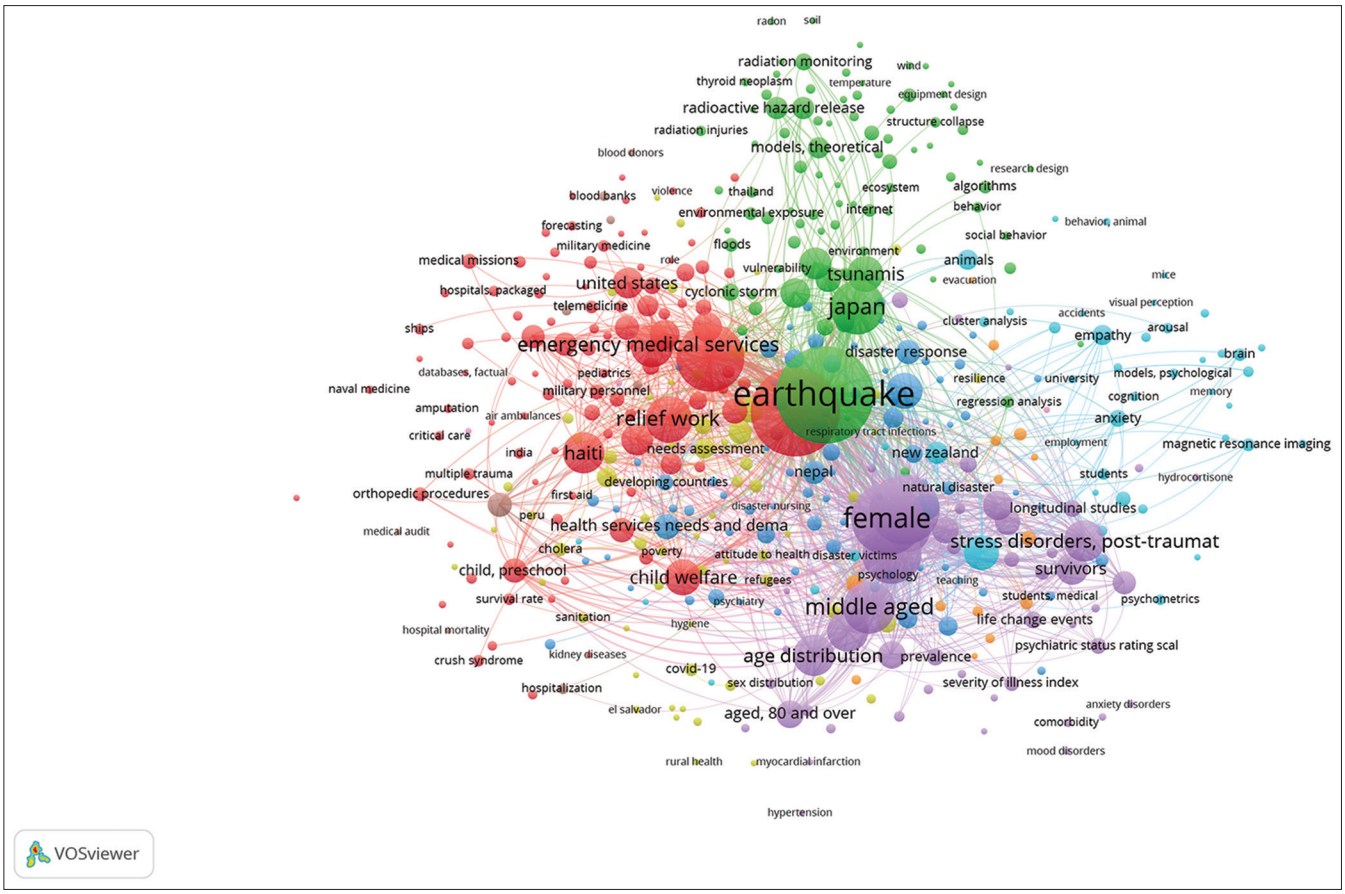


Figure 1: Keyword co-occurrence map

thematic clusters, and the linking lines denote the logical relationships among concepts. The proximity or distance among the clusters indicates their relevance to one another. Moreover, the large size of the nodes shows the higher weight and power of the link among the other clusters, (i.e., the further usage of the concepts in describing scientific words).[8]

Results

In the following sections, each cluster is interpreted under different narrations.

Narration of Cluster 1: Initial response of the health-care system

Cluster 1 encompasses 102 terms, as presented in red in Figure 2.

At the top of this cluster, there are three nodes with strong links: Disasters, disaster planning, and plan evaluation. Regarding its relationship with other terms, this cluster can be entitled 'planning in disasters'. Relief and rescue, emergency medical services, air rescue, hospital services, specialized treatment services for trauma and spinal injury victims, and emergency health measures are the acute-phase responses to earthquakes in Narration 1. People with severe injuries, multiple traumas, tissue and bone injuries, spinal lesions, and patients with acute renal diseases (nephrology), who are prominent in this cluster, should be prioritized for treatment. Accordingly, the treatment wards must be established in field hospitals. Doctors play a pivotal role in this narration. Moreover, attention to the welfare of children, as a prioritized group, is highlighted in this cluster. There is a strong link between health force mobilization, military personnel, military hospital, and military medicine nodes near the USA node. The frequent citation of some regions, including Haiti, the USA, Southeast Asia, India, Indonesia, Pakistan, England, France, and Los Angeles, can suggest these regions' higher vulnerability. The notable point in the first stage of disasters is the cooperation of academic healthcare centers, volunteer groups, the private sector, and international and humanitarian organizations with the affected governments. The necessity of organizing and seeking their support during and after the response phase is emphasized in this cluster.

Narration of Cluster 2: Response to probabilistic risks after the hazard

Cluster 2, presented in green in Figure 3, contains 87 terms.

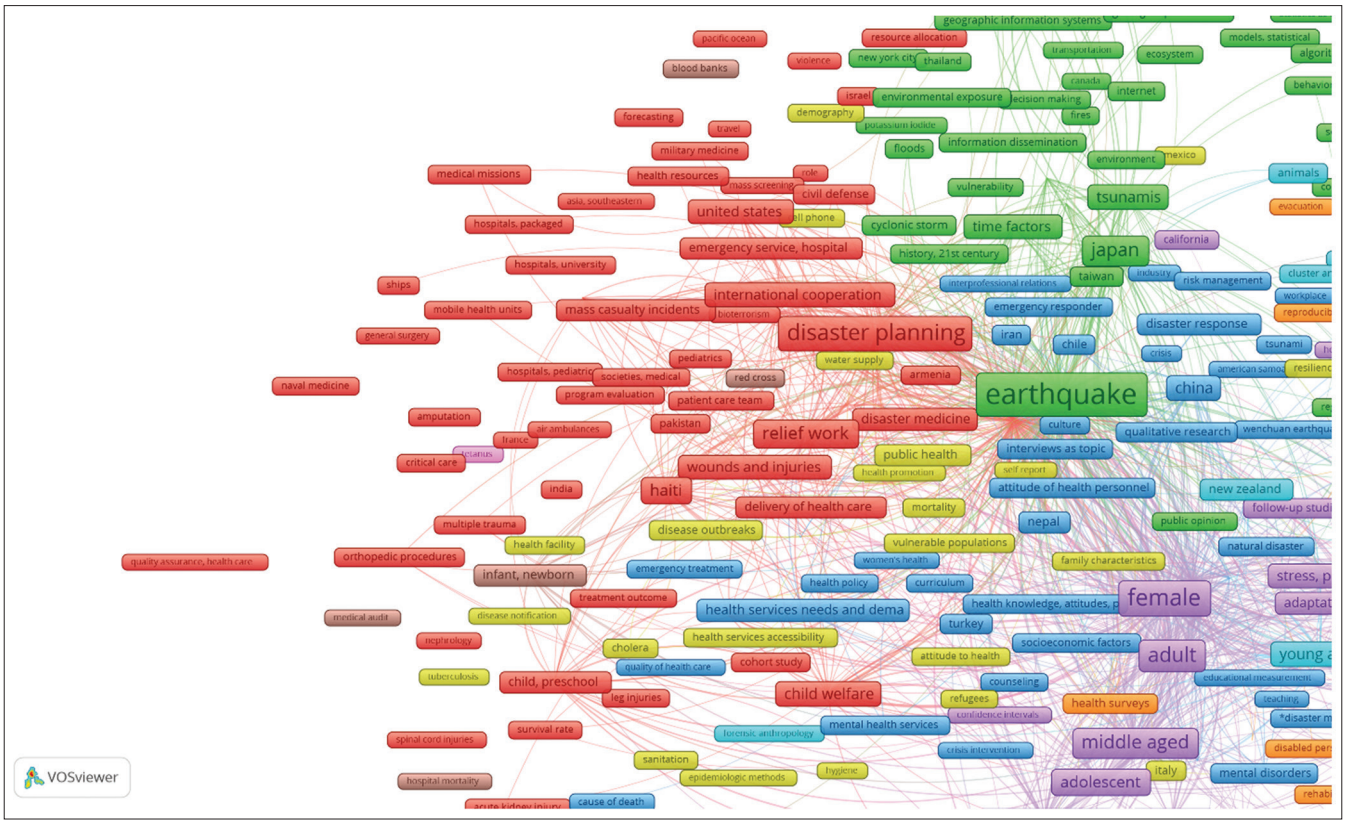


Figure 2: Occurrence of terms in the first cluster

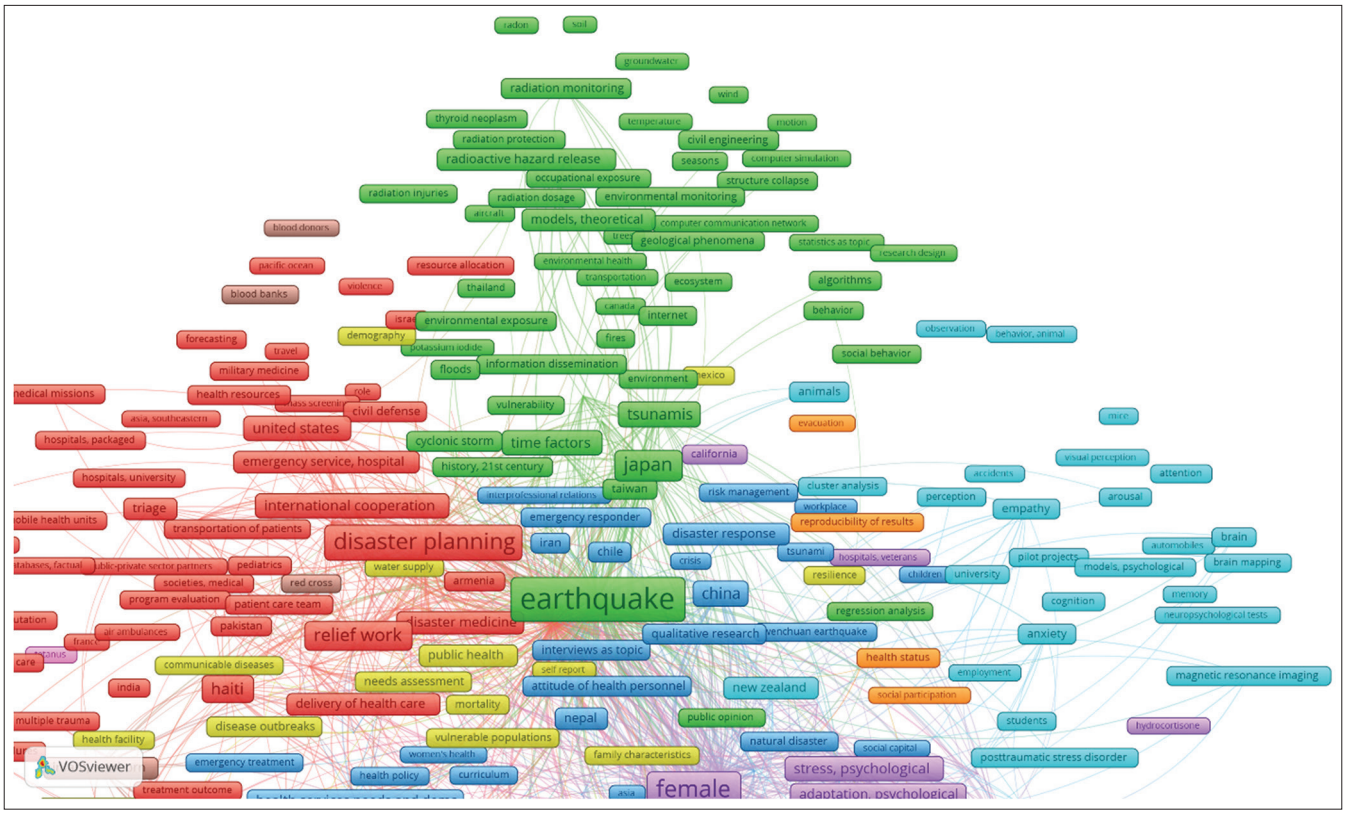


Figure 3: Occurrence of terms in the second cluster

There are several large nodes in this cluster, the largest one being earthquake, which is also the largest node in all the clusters. The prominence of the earthquake was expected as it was among the main keywords of the search strategy. Examining the concepts' weights and frequencies suggests that Cluster 2 primarily discusses postearthquake risks. Publications on this cluster primarily focus on the major geological phenomena, (e.g., tsunami, wind, and whirlwind), the Fukushima Daiichi nuclear disaster, and the risk of radioactivity and nuclear power plants' destruction, especially in Japan. The link between thyroid cancer and temporal factors can indicate the major risk of nuclear power plant accidents. Terms such as soil, trees, agriculture, and groundwater suggest risks following powerful earthquakes, which severely damage the environment and ecosystem. The links among social media, social behavior, and the Internet demonstrate the significance of information and communication management for sending immediate notifications to the public. The link connecting theoretical model provision and computer simulation in Cluster 2 is also remarkable, as these tools are the best instruments for understanding earthquake risks. Civil engineering, structural health monitoring (SHM), and cost-effectiveness analysis are the other prominent terms in this cluster. Moreover, the link between new organizations (e.g., the SHM organization and time factors) saves time and costs imposed on inspecting structural elements. Japan, Fukushima, Canada, Taiwan, and New York are among the regions receiving attention from researchers due to the severity of post-earthquake events.

Narration of Cluster 3: Response to mental health and community resilience

Cluster 3 contains 82 terms, presented dark blue in Figure 4.

China is the largest linked node in Cluster 3. This cluster mainly focuses on response to disasters in the fields of mental health, psychological disorders, and emergency psychological services. Resilience and community resilience in disasters linked to psychological theories are the notable concepts in Cluster 3. The terms "students" and "schools" indicate the necessity of adopting measures to prepare schools to face earthquakes and other crises. Regarding the links among the concepts, empathy and disaster relief are bold nodes in this cluster, linked to other nodes of Cluster 4 (i.e., women and the middle-aged groups). They express the necessity of providing immediate counseling services to these groups. Nurses play a crucial role in this cluster, and the qualitative method, group interviews, and focus groups are the other prominent nodes in terms of earthquakes. The proximity of developing and Asian countries such as Nepal, Iran, Turkey, and China to the central node (i.e.,

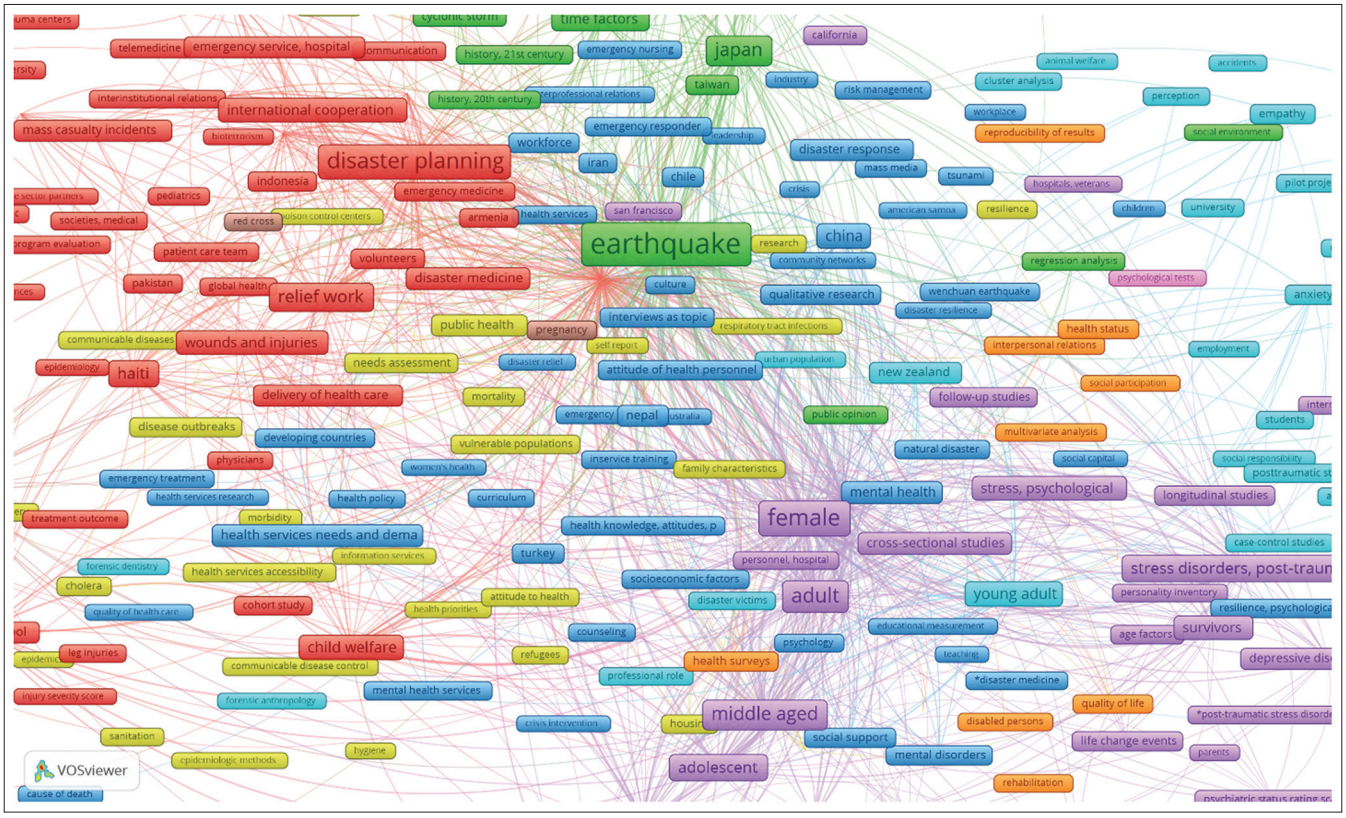


Figure 4: Occurrence of terms in the third cluster

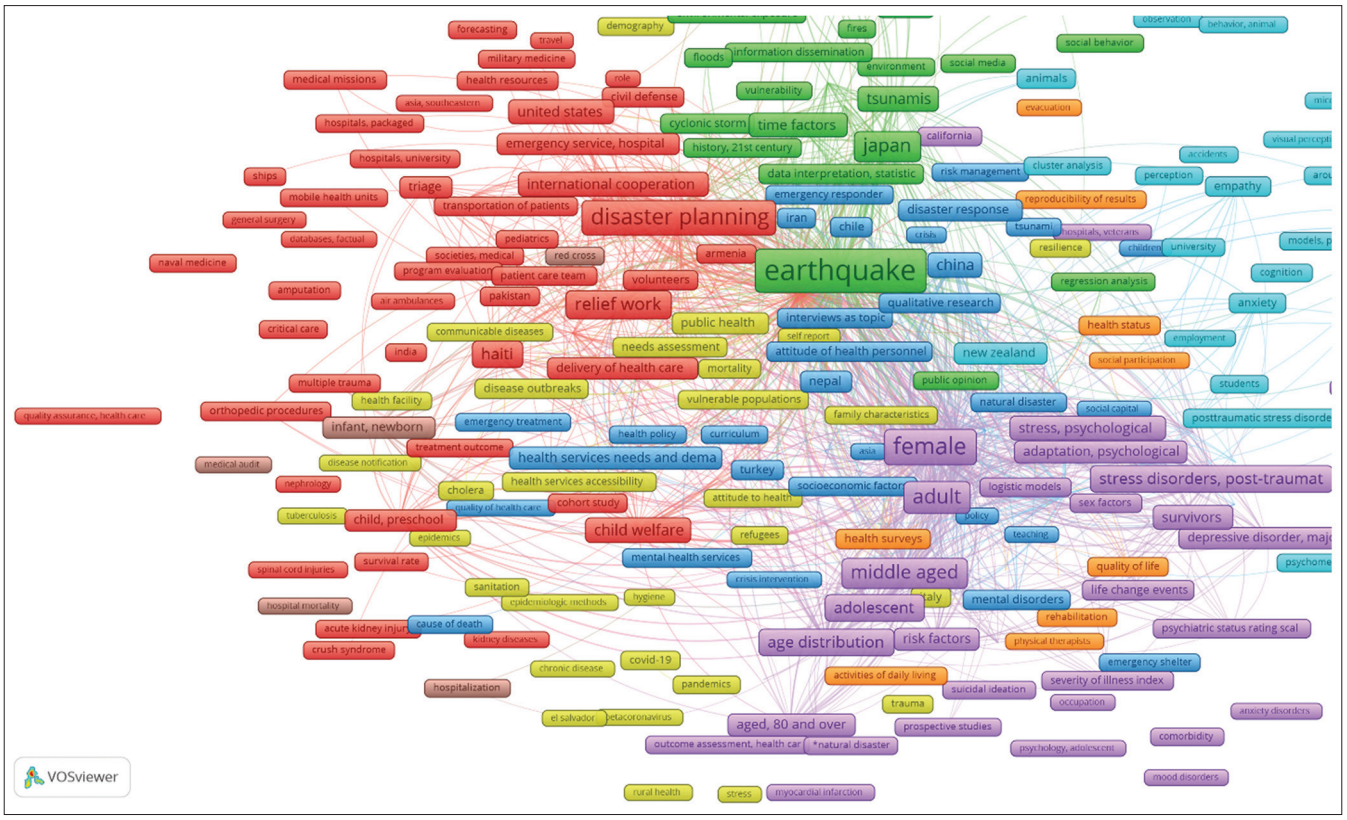


Figure 5: Occurrence of terms in the fourth cluster

earthquake) suggests the earthquake-prone nature of these regions and the authors' attention to the risks. The 2008 Wenchuan earthquake in China is a central node, indicating the magnitude of this earthquake and its casualties and losses. The weight and power of the link between the US and Australia may be due to the development of national plans in these countries.

Narration of Cluster 4: Response to public health

Cluster 4 (presented in yellow) contains 65 terms, headed by emergencies with 368 links [Figure 5].

In this scenario, researchers mainly focus on the management of public health emergency conditions postearthquake. The outbreak of communicable (e.g., influenza, measles, COVID-19) and noncommunicable (cholera, tuberculosis, pneumonia, beta coronavirus) diseases is a predicted postdisaster risk. Moreover, chronic diabetes, cardiovascular diseases, and hypertension need specialized follow-up treatment in the 1st postearthquake days due to symptom exacerbation. The presence of terms such as "epidemics," "pandemics,' and "notification about coronavirus diseases" demonstrate that the authors have focused on the consequences of COVID-19 outbreak in disasters since 2019. Needs assessment, food and drinking water provision, and volunteer services indicate the significance of food management and supervision during earthquakes. Thus, this cluster is linked to the control and treatment of toxicities resulting from nonobservance of hygiene. The terms "rural populations" and "rural health" indicate the vulnerable groups in this cluster. Moreover, terms such as "sanitation" can indicate the significance of health facilities postearthquake. In general, the strong node of the needs analysis in this cluster suggests the significance of assessing the affected regions in the first stages of earthquake response, with the help of the development and support sector. Compared to Mexico, Peru, and Tokyo, Italy has a higher weight and frequency in this cluster. The link between Italy and COVID-19 could be due to researchers' concerns about its earthquake-prone nature and its need for planning to prevent and control this disease during earthquakes.

Narration of Cluster 5: Response to Post Traumatic Stress Disorder

Cluster 5 (purple) shown in Figure 6 contains 53 terms. The keyword "women" has the strongest link and highest frequency.

There are prominent links between "stress" and "mood disorders", "depression," "anxiety," "comorbidity," "suicidal thoughts," "grief and mourning," "occupational diseases," and "job creation," with the survivors' lifestyle change. The node "survey research method and self-report

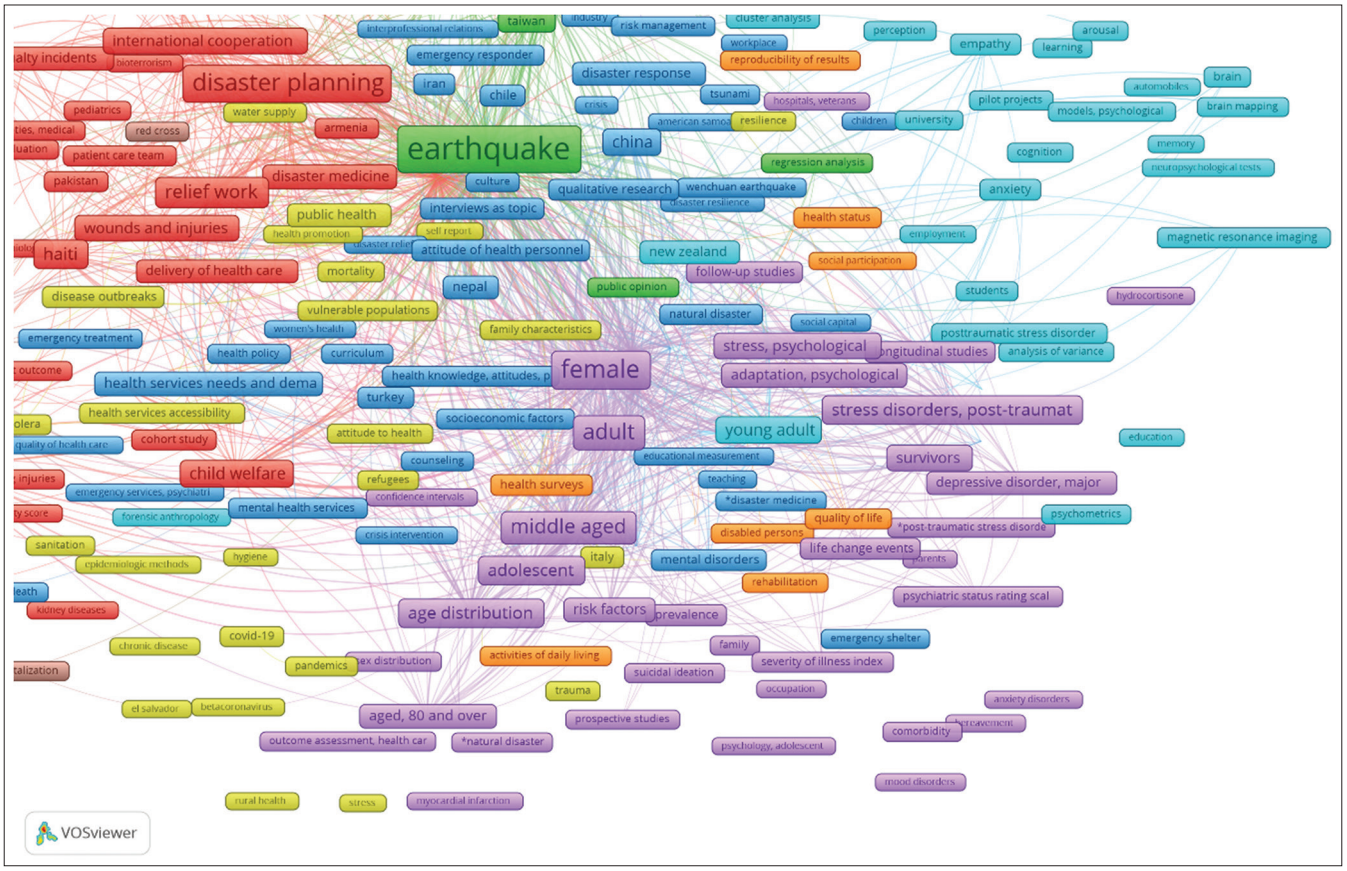


Figure 6: Occurrence of fifth cluster terms

personality questionnaires" (with 1698 links and a frequency of 149), followed by cross-sectional studies (632 links and a frequency of 54), follow-up studies (306 links and a frequency of 23), longitudinal studies (288 links and a frequency of 23), and prospective studies (125 links and a frequency of 57) are the frequent research methods adopted by researchers. Nodes such as gender factors, gender distribution (female, male, adult, middle-aged, adolescent), and age distribution (>80 years) suggest that the authors distinguished the level of resilience and needs of victims of different genders and age groups and focused on each group separately. The use of psychiatric status rating scales is another prominent node, in contrast with different gender distributions at the time of disasters. Doctors may use these scales to measure psychiatric symptoms such as stress, anxiety, and abnormal behaviors. The strong link between posttraumatic stress disorder (PTSD) and women shows this group's high sensitivity and vulnerability, which necessitates effective psychotherapy measures for PTSD prevention and treatment. The term 'hydrocortisone' is prominent in this cluster as an emergency medication for patients with pulmonary and respiratory diseases and allergies. Another notable point is mentioning multiple and severe earthquakes in California and San Francisco since the 20th century in this cluster.

Narration of Cluster 6: Staff response to the needs assessment and continuity of diagnostic treatment services

Clusters 6, 7, 8, and 9 were merged into Cluster 6.

Due to the small number of the terms (n = 71) included in those clusters. Clusters 6, 7, 8, and 9 are displayed in Figure 7 in light blue, orange, and black, respectively. In narration 6, the disintegration of social and healthcare structures in the affected region seems to bring about its multi-dimensional impacts on managerial, incident command system, and other domains; therefore, the specialized functions in this domain should be promoted. This cluster focuses on the logistic services and has described the role of social groups and social responsibilities of volunteers such as the Red Crescent Organization in promoting health and quality of life and returning to normal conditions postearthquake. Diagnostic measures are a strong node (133 strong links), including earthquake-induced brain damage, neurological and brain disorders, and seizures. Diagnostic measures such as magnetic resonance imaging imaging, brain mapping, and electrocardiography should be considered. Delivery facilities and relevant supports should be provided for vulnerable groups, including pregnant women, infants, and the disabled.

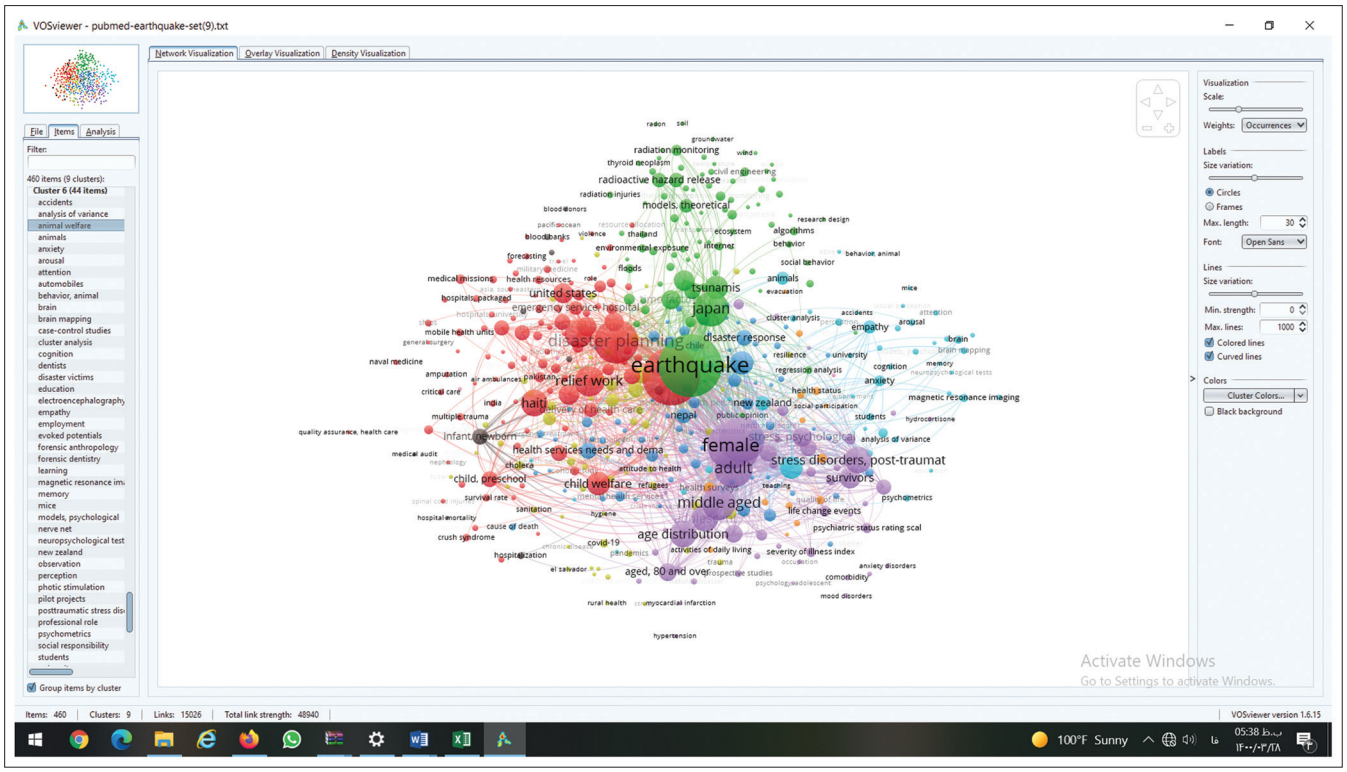


Figure 7: Occurrence of sixth cluster terms

Moreover, the terms "animals," "animal welfare," and "treating animals" were prominent nodes in this cluster, with 247 links. The role of veterinary organizations, the department of environment, and animal protection organizations with regard to the animals' injuries, health, and welfare should be of concern. The prevention and control of communicable diseases (tetanus, rabies, plague) between humans and rodents such as mice (27 strong links) suggest the significance of this topic. The terms "tooth" (39 strong links), "dentistry jurisprudence" (17 strong links), and "medial jurisprudence anthropology" (24 strong links) are important in the domain of health in disasters to identify the deceased individuals. Blood banks, blood donors, and blood infusions are the other relevant nodes for supplying blood to hospitalized patients. "Rehabilitation" (74 strong links) expresses the significance of rehabilitation-phase measures in the concerned studies. Due to the large number of casualties and losses in 2011, New Zealand was a major research trend in this cluster.

The examination of the earthquake response scientific publications led to the identification of six thematic clusters. The overall framework of the extracted content is displayed as a flowchart [Flowchart 1].

Figure 8 presents the co-author relationships, and Table 1 lists the top 10 authors by different indices.

According to the co-authorship results, Nagamine (Division of Behavioral Science, National Defense Medical College Research Institute, Tokorozawa City, Japan) and Zhang (Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China) have the highest degree index calculated by counting the nodes or the lines entering/exiting a specific node. They primarily serve as the centers of excellence in the network with adequate independence, little dependence on other authors, and their more remarkable roles. In other words, they have unique and valuable publications on specific topics. Moreover, Suzuki (Department of Public Health, Fukushima Medical University School of Medicine, Fukushima 960–1295, Japan and National Center of Neurology and Psychiatry, Department of Mental Health Policy, National Institute of Mental Health, Tokyo 187–8553, Japan) and Tomita (Department of Disaster Psychiatry, Tohoku University Graduate School of Medicine, Sendai, Japan) have the highest closeness index. In other words, they have closer cooperation with other authors and achieved the highest degree of visibility with minimum intervention. The betweenness index is another main centrality index in social network analysis. In this regard, Suzuki (Japanese affiliation) and Tsuji (Department of Epidemiology, Tohoku University Graduate School of Medicine, Sendai, Japan) have the maximum betweenness index. This means that they linked the other researchers, without whom the communications in the co-author network would be disrupted.

Table 1: Top authors by centrality metrics

Authors	Degree	Authors	Closeness	Authors	Betweenness
Nagamine, Masanori	9.000	Suzuki, Yuriko	1.714	Suzuki, yuriko	573.304
Zhang, Kan	9.000	Tomita, Hiroaki	1.711	Tsuji, ichiro	372.500
Bar-on, Elhanan	8.000	Yasumura, Seiji	1.710	Tomita, hiroaki	217.125
Catalucci, Alessia	8.000	Tsuji, Ichiro	1.709	Yasumura, seiji	208.495
Goto, Aya	8.000	Yabe, Hirooki	1.708	Usami, masahide	156.000
Lui, Su	8.000	Abe, Masafumi	1.707	Ushijima, Hirokage	156.000
Marmar, C. R.	8.000	Kamiya, Kenji	1.706	Akashi, Makoto	135.000
Mazza, Monica	8.000	Fukasawa, Maiko	1.706	Kondo, Hisayoshi	92.000
Metzler, t j	8.000	Sakata, Kiyomi	1.706	Abe, Masafumi	58.694
Peleg, Kobi	8.000	Ohira, Tetsuya	1.705	Kamiya, Kenji	38.750

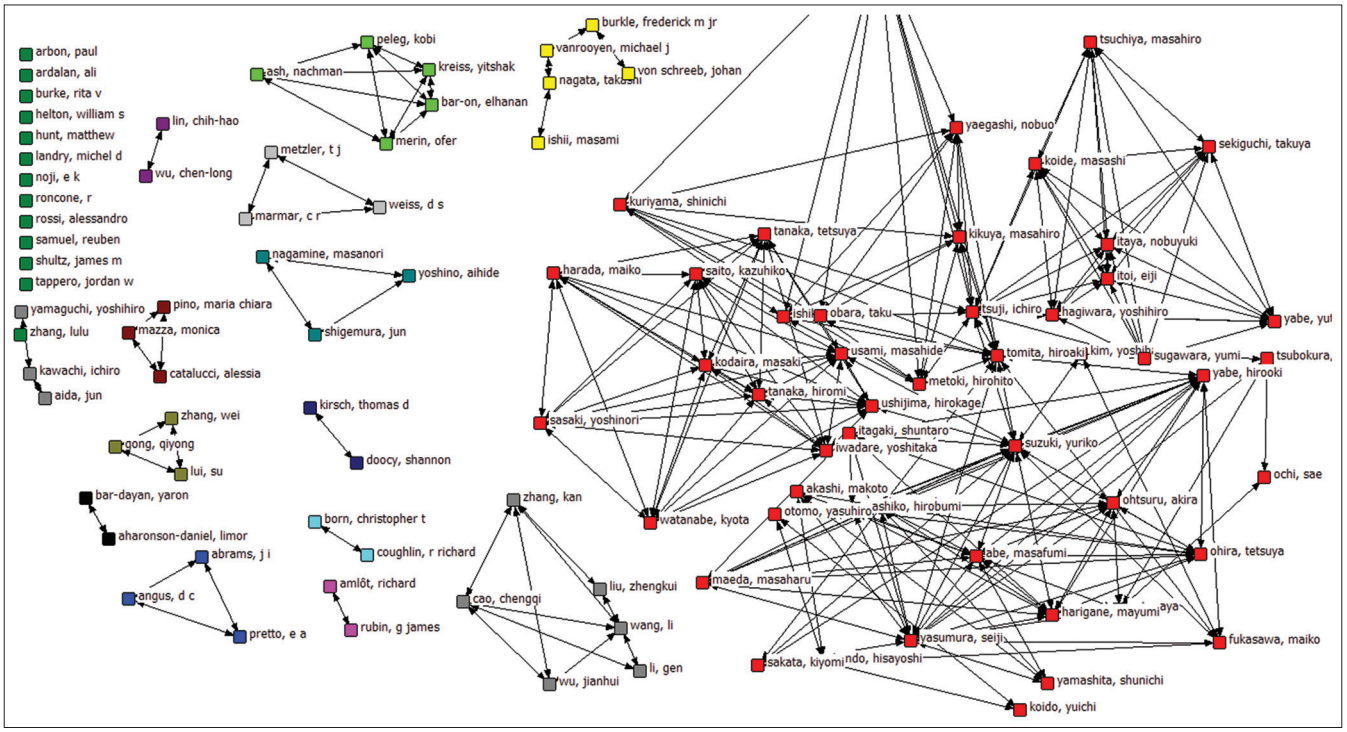
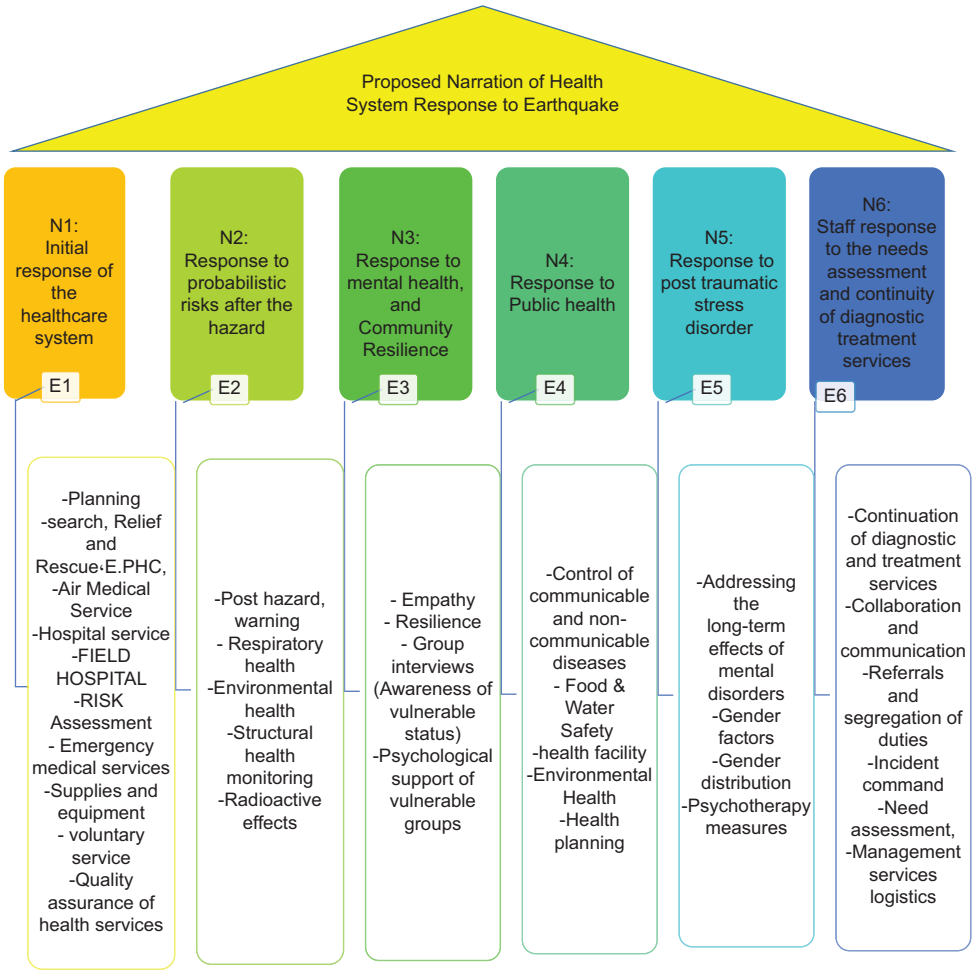


Figure 8: Co-authorship social network based on centrality

Discussion

The clusters' bibliographic results can reveal the fields of research interest and subject gaps. The first response of the healthcare system to earthquakes is the timely evaluation and planning for saving the victims and provision of health-care services, which is in line with other studies.[1,12,13,19-24] However, a disregarded topic in this cluster is developing an application and disaster simulation, health-care quality assurance, and regional-local treatments, especially for chronic diseases. Moreover, few studies have discussed the application of modern technologies such as drones to provide food and drug services in emergencies, especially in far-away regions,[25] which was not displayed due to little word co-occurrence in the clusters. The strong link between health force mobilization, military personnel, military hospital, and military medicine nodes near the USA node can indicate the significance of this country's support before, during, and after disasters. Narration 2 discusses the significance of secondary risks resulting from earthquakes, which can have extensive health-related, environmental, economic, and socio-political impacts, as mentioned in several studies.[26-30] According to the Sendai framework for disaster risk reduction, raising public awareness can be effective for promoting participation in earthquake response and returning to the initial state.[31] A research gap in this narration is to plan for deployment and establish level-3 and level-4 laboratory infrastructure, detectability of toxic agents, probabilistic risks such as cyber-attacks on health infrastructure, and the absence of comprehensive programs for dealing with tsunamis (multi-hazard disasters). Narrations 3 and 4 mainly focus on boosting resilience and consider PTSD while prioritizing different groups. Based on the evidence, low- and middle-income



Flowchart 1: Response plan to earthquake extracted from the keywords co-occurrence

countries have feeble mental health systems and cannot meet their societies' compelling mental health needs.[32-36] Disaster health literacy and psychological self-care in disasters are novel topics disregarded in these papers. Narration 4 expresses various dimensions of public health postearthquake, and numerous publications have noted the necessity of prevention services, vaccination for communicable and noncommunicable diseases, preparation of a medicine packages for chronic patients, especially diabetics, and enhancing health-care facilities' capacity (environment, clean water, and nutrition) to prevent disease outbreaks.[37-44] A noticeable research gap in this narration is bio-terrorist attack control and prevention, which may occur even by humanitarian food aids with an aggressive approach (e.g., advertisement or human and environment contamination). Another issue is the absence of technology-based plans for tracking services (equitable distribution of food, drugs, health products, clothes, etc.). In narration 6, studies focused on the significance of integrated command and communication, rehabilitation care, preparing healthcare service packages for vulnerable groups,[24,45-47] health planning for controlling zoonotic diseases,[48,49] management of bodies, and referral to medical and dental jurisprudence.[50-52] A weakness of studies, in this case, is the management of large masses and the use of quadcopters. A significant relationship between earthquakes and the level of scientific publications in earthquake-prone countries has been reported, which is consistent with the findings proposed by Ahmadi, Osareh, and Soheili (2014). The main keywords in this study significantly differ from those extracted by Liu *et al*., because their study primarily focused on land and fault structure. The social network analysis suggests that Japanese and Chinese institutes and authors (Fukushima Medical University, key laboratory of mental health, institute of psychology, Chinese Academy of Sciences, Beijing, China) and Taiwanese authors (Department of emergency medicine, national Chang Kung university hospital, college of medicine, national Cheng Kung University, Tainan, Taiwan) have the most significant influence in terms of scientific publications. However, in Sweileh and Emer's study, American authors had the most publications on health in natural disasters.[4,15] This study only examined the research presented in the PubMed database, while some aspects of the health field

in gray resources may have been investigated from the point of view of experts, which has not been retrieved in the data of the present study because the scientometrics software supports bibliographic database files from Web of Science, Scopus, Dimensions, and PubMed, not others dataset.

Conclusion

The results identified the research strengths and weaknesses. The extraction plan can thus be used to change the patterns of applied research. Scholars could differently prioritize the interpretations extracted from the clusters in terms of service providers and organizations. Moreover, decision-makers in the domain of healthcare earthquake response can use them as a guideline to develop a general framework to design an integrated response plan and, thus, promote the function of the healthcare system. Based on the results, it is expected that other issues such as how to deal with tsunamis and cybersecurity, factors Chemical, Biological, Radiological, and Nuclear (CRNE) defense caused by secondary effects, use of aerial operations, and introduction of modern technologies also be included. Finally, attention to the cultural and indigenous factors of the regions at different global and national levels should be given special attention in designing the plan. Other countries, especially underdeveloped and developing countries, must expand their scientific productions on this topic and publish them on global databases. In this way, a complete joint global framework can be developed and shared since specific functions in different domains of earthquake health system response plan design cannot be implemented without needs assessment in vulnerable societies.

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Conflicts of interest

There are no conflicts of interest.

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