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A Visualization Analysis of Hotspots and Frontiers of Cardiovascular Diseases with Frailty Based on CiteSpace

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Abstract

Cardiovascular diseases(CVD) and frailty are common health problems among the elderly. This research aims to investigate the hotspots and frontiers of the field of cardiovascular diseases with frailty. Data of publications between 2000 and 2021 was collected from the Web of Science(WoS) and CiteSpace was used for analysing the hotspots and frontiers of cardiovascular diseases with frailty research from high-impact countries, institutions, authors, cited-references, cited-journals, high-frequency keywords and burst keywords. The results showed that the United States, England and Canada were the leading countries in research of cardiovascular diseases with frailty. Other countries and regions lagged behind these developed countries. There is a need to establish cooperation between developed countries and developing countries. Research hotspots focused on frailty in the elderly with CVD, exercise intervention, assessment for CVD patients with frailty, quality of life and common diseases related to CVD with frailty. The frontier fields include care and intervention of CVD patients with frailty, social frailty and validation of CVD with frailty.

Keywords: Scientometrics, Visualization analysis, Cardiovascular diseases, Frailty

1 Introduction

Frailty is an age-related syndrome, which is characterized by multiple organ decline^[1]. When patients are exposed to frailty, they will be more sensitive to stress and their ability to cope with the stress may also decrease^[1]. As a result, it will lead to adverse events in hospitals, such as fall, disability, and even death. Not only hospitalized patients may suffer from frailty, but also community-dwelling people. Community-dwelling people with frailty have a high risk to suffer from negative events, such as disability, hospitalization, death, and so on^[2]. A study in Spain which consisted of 855 individuals found that prevalence of frailty among community-dwelling people was 26.2%^[3], and this result may connect to the fact that chronic disease patients have frailty in communities. Hence, not be admitted to the hospital should not become a reason of reducing public awareness of frailty. Frailty is a common problem in people aged 70 and above^[4]. With the increase of aged population, there will be more frail people^[5].

Cardiovascular diseases(CVD) is the leading cause of disability and death among the elderly. Meanwhile, it also leads to the rising health care costs. According to the data from Global Burden of Disease (GBD), the number of patients with cardiovascular diseases doubled from 271 million in 1990 to 523 million in 2019 globally, and the case of death increased from 12.1 million in 1990 to 18.6 million in 2019^[6]. Similar to frailty, aging population is the major reasons of the increase in CVD^[6]. Clearly, the main research objective population of CVD with frailty is the elderly.

Nearly one in two adults with heart failure suffers from frailty^[7]. In Chung's research(2010-2013), patients with advanced heart failure and handgrip strength < 25% of body weight had the increased postoperative complications and risk of death after ventricular assist device implantation^[8]. In Fried's frailty phenotype(FP), the decreased grip strength is one of the factors^[9]; therefore, frailty is associated with prognosis and clinical outcome in patients with cardiovascular diseases. Hence, a lot of researchers also identified frailty as a risk factor for cardiovascular diseases. Identifying the frailty of CVD patients help to give the most suitable care to the different types of patients. Research has shown that frailty has different statuses in different diseases, and specific critical value of frailty status in one group of patients may not be applicable in another group, so the author suggested that researchers should define the optimal tool set to measure frailty^[10]. Therefore, researching the frail status in patients with CVD is a high priority.

Frailty is not a disease; instead, it is similar to disability and complications and they all can lead to a high mortality in patients with CVD. CVD with frailty is not only a medical problem, but it is also a public health challenge because both CVD and frailty exist in the elderly population in society widely. For hospitalized CVD patients, discerning early frailty can prevent adverse events, and taking status of frailty into medical and nursing plans also can lead to a better treatment outcome. For community-dwelling people with chronic CVD, screening frail individuals and developing interventions related to lifestyle by community doctors and nurses are effective measures to decrease admission and readmission rate, which can reduce medical costs. Consequently, CVD patients with frailty should get more attention than common CVD patients. Firstly, it is urgent to evaluate the impact of scholarly research in this domain, as well as the impact of countries, authors, journals and institutions. Moreover, exploring the current topics and identifying the problems that can inspire later researchers to have further research to promote public health.

In the existing reviews, more than half the authors focus on the relationship between frailty and CVD. For example, Uchikado expounded the influences of frailty in the common CVD, such as coronary

artery disease, heart failure, aortic stenosis and atrial fibrillation^[11]. Marinus found that frailty is the most common problem among patients with heart failure or aortic valve disease in systematic review^[12]. Most authors discuss CVD with frailty in their traditional literature review. In recent years, some researchers probed prevalence and effect of frailty in CVD patients by systematic review; however, none of them has taken the visualization analysis. In addition, although literature review is a basic measure to understand the development in a specific research area, the authors in the reviews may have certain preferences on some aspects they were previously interested in. As a result, they may ignore some topics and cannot present a complete view sometimes. To obtain further survey of the development of the CVD with frailty roundly and intuitively, and fill a gap of visualization analysis, visualization knowledge map was adopted in this study.

CiteSpace is a widely-used information visualization software established by Professor Chen^[13], and it can intuitively show the hotspots, frontiers and growth of literature in a specified area of academic research. In CiteSpace, research hotspots in this field can be presented through images intuitively, as well as the clear connections among nodes. Thus, CiteSpace was chosen as the tool in this research.

This research aims to discuss the hotspots and frontiers in the CVD with frailty. High-impact countries, institutions, authors, cited-authors, references, journals, high-frequency keywords and burst keywords were shown by CiteSpace to achieve the goal of the research. The analysis on this topic will contribute to new research perspectives in the future.

2 Methods

2.1 Search strategy

The data for this study came from Web of Science (WoS). WoS was chosen for this study because it is a large comprehensive multidisciplinary database which covers 18,000 most influential journals around the world. The search strategy was as follows: (TS=(frailty OR frail) AND TS=("cardiovascular disease")). The type of records was limited to the article and the language was English. The articles published on the WoS from 2000 to 2021 were obtained. Initially, 719 articles were collected from WoS. After reading the titles and abstracts, 133 eligible records were brought into this study.

2.2 Data and analysis

The 133 records were imported into CiteSpace for further analysis. Top 50 levels and g-index(k=25) of most citations from each year were selected in this study. Co-occurrence and cluster views were chosen

to present the images. Then, CiteSpace was used to analyse the hotspots and frontiers from high-impact countries, institutions, authors, cited-references, cited-journals, high-frequency keywords and burst terms. In the tables, influences of countries, institutions and authors are presented from frequency and centrality two viewpoints. In the figures, sizes and colors of nodes are key points. Figure 1 shows this process as follows.

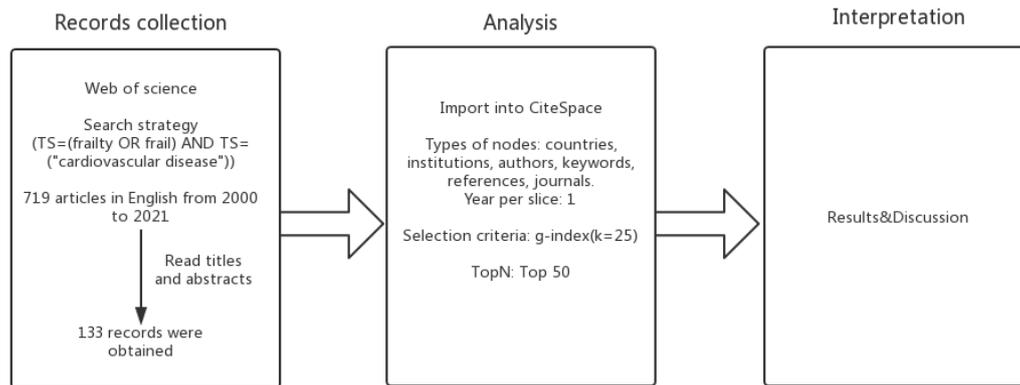


Fig. 1 Overview of the study protocol

3 Results

Included in this study were 133 publications from 2000 to 2021.

3.1 Analysis of country, institutions and authors

Table 1, Fig. 2, Fig. 3 and Fig. 4 show the top ten countries, institutions and authors according to the number of publications in CVD with frailty. Figure 2 consists of 39 nodes and 131 collaboration links. The USA has the largest number of articles(n=41), the second is Canada(n=17), and the third is England(n=14). Though USA is way ahead of the other countries in numbers, its centrality is not the highest. High centrality means that the node plays an important role in the specific field. Based on centrality, the top three countries are England, Spain and Canada, which means these countries are the most influential in the research domain of CVD with frailty. In addition, although the number of articles of France is less than eight other countries, its centrality is at a high level (0.25), which indicates that the quality of the articles is high. The purple circle of nodes in figure 2 is the key marker, and it means that the centrality of the country was high, which indicates that these countries play an important role in this field. These countries are USA, England, Spain, Canada and France. Fig. 3 consists of 359 nodes and 1081 collaboration links. The top three institutions based on frequency are Harvard Medical School, Tel

Aviv University and University of Pittsburgh, and two of them are in USA. The top three institutions based on centrality are NIA (National Institute on Aging), McGill University and University of Pittsburgh. Both the number and the centrality of publications of University of Pittsburgh are in the top three in the world. In figure 3, the nodes of NIA (National Institute on Aging) and McGill University are surrounded by purple circle, indicating that these two institutions have greatly contributed to CVD with frailty research. Fig. 4 consists of 903 nodes and 2826 collaboration links. Given that the nodes of authors are dispersive in the map, a part of concentrated distribution of the whole map is shown in this research. Nine prolific authors come from Israel and China.

Table 1 Top ten countries, institutions and authors according to the frequency of articles related to CVD with frailty

Country	n	Centrality	Institution	n	Centrality	Author	n	Centrality
USA	41	0.13	Harvard Medical School, USA	6	0	Uri Goldbourt, Israel	5	0
Canada	17	0.28	Tel Aviv University, Israel	6	0.04	Galit Weinstein, Israel	4	0
England	14	0.56	University of Pittsburgh, USA	6	0.11	Peipei Zhang, China	4	0
Spain	14	0.34	University College London, England	5	0.09	Jiefu Yang, China	4	0
Italy	11	0.09	McGill University, Canada	5	0.27	Hua Wang, China	4	0
China	10	0	NIA(National Institute on Aging), USA	5	0.31	Nicola Veronese, Italy	4	0
Brazil	10	0	University of Haifa, Israel	4	0	David Tanne, Israel	4	0
Japan	9	0	University of California, San Francisco, USA	4	0.02	Miri Lutski, Israel	4	0
France	8	0.25	Chinese Medical Association, China	4	0.02	Simin Yao, China	4	0
Poland	8	0	Columbia University, USA	4	0.03	Daniel E Forman, USA	3	0



Fig. 2 Map of countries related to CVD with frailty

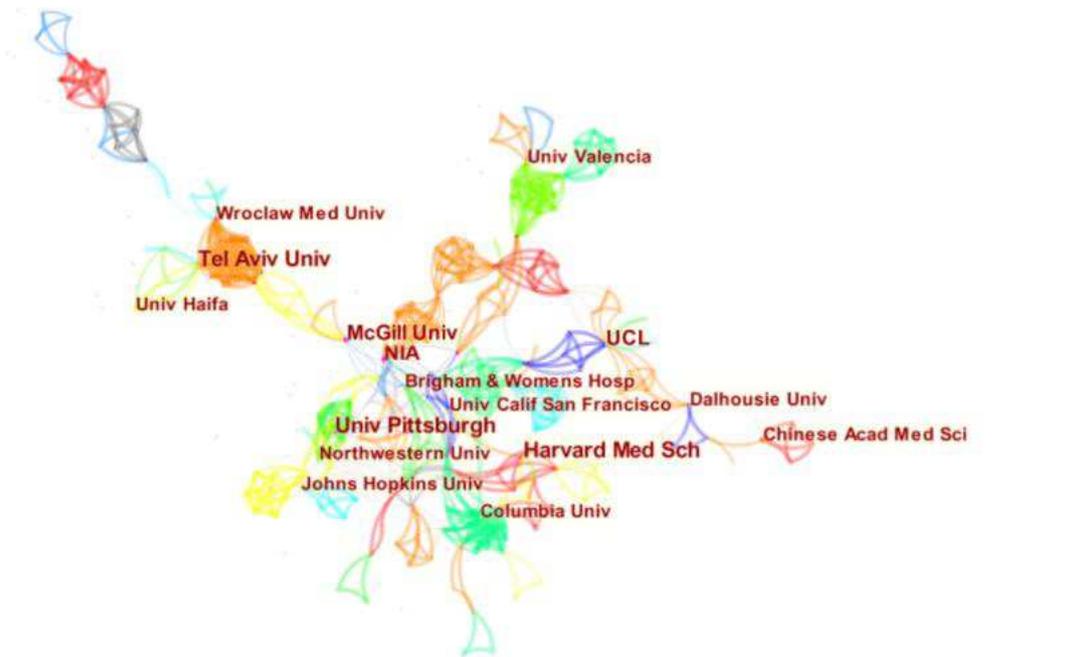


Fig. 3 Map of institutions related to CVD with frailty



Fig. 4 Map of authors related to CVD with frailty

3.2 Analysis of cited authors, references and journals

Co-citation analysis is the unique advantage of CiteSpace which not only explores the influential authors, references or journals, but also assists the hotspots in a specific study area. The co-citation explores in this research used g-index(k=25) for analysis. Table 2 shows that the cited authors, references and journals that are related to CVD with frailty.

Professor Fried LP, who come from an authoritative institution for CVD with frailty, is the most cited author related to CVD with frailty(n=104). Professor Afilalo J of McGill University is the second most cited author related to frailty with CVD and three of his articles were the top ten cited references related to CVD with frailty. In addition, Rockwood K from Dalhousie University and Cacciatore F from Institute of Care and Scientific Research of Italy has the highest centrality. The cited references reflects the long-term hotspots in specific field^[14], hence, clusters map of cited-references related to CVD with frailty are presented in Fig. 5, where the software works out 33 clusters. After limiting the cluters automatically by the software, there are 14 significant clusters in total. The result of cluster map is convincing because the map shows that $Q=0.85 > 0.3$, $S=0.95 > 0.5$ ^[13]. The top five clusters are #0 elderly, #1 arterial stiffness, #2 frailty elderly, #3 cytokines and #4 physical performance-based measures. The top ten cited journals are medical journals, with geriatrics and cardiovascular journals dominating. These journals can be called the “core journals” in this field. The publishing countries are all developed countries, and the UK has the most cited journals among the top ten journals related to CVD with frailty. The American Journal of Medicine has the highest frequency and centrality simultaneously.

Table 2 Cited authors, references and journals related to CVD with frailty

Cited	Count	Centrality	Cited	Count	Centrality	Cited	Count	Centrality
-------	-------	------------	-------	-------	------------	-------	-------	------------

authors			references			journals		y
Fried LP, Columbia University, USA	104	0.09	Afilalo J ^[15]	22	0.25	The American Journal of Medicine, USA	30	0.23
Afilalo J, McGill University, Canada	73	0.13	Clegg A ^[16]	20	0.06	Circulation- Cardiovascular Quality and Outcomes, USA	29	0.03
Newman AB, The University of Pittsburgh, USA	54	0.07	Singh M ^[17]	15	0.15	International Journal of Cardiology, Netherlands	28	0.03
Clegg A, University Leeds, England	48	0.12	Sergj G ^[18]	15	0.07	Clinics in Geriatric Medicine, England	28	0.09
Rockwood K, Dalhousie University, Canada; Xuanwu Hospital, China	48	0.15	Veronese N ^[19]	10	0.08	BMJ-British Medical Journal, England	26	0.1
Singh M	30	0.07	Afilalo J ^[20]	10	0.08	Clinical Interventions in Aging, England	23	0.01
Walston J, The John Hopkins Medical Institutions, USA	23	0.06	Afilalo J ^[21]	9	0.1	European Journal of Clinical Investigation, England	23	0.02
Cacciatore F, Salvatore Maugeri Foundation, Institute of Care and Scientific Research, Italy	22	0.15	Ekerstad N ^[22]	9	0.17	Aging Clinical and Experimental Research, Germany	22	0.7
Purser JL, Center for the Study of Aging and Human Development, USA	19	0.02	Soysal P ^[32]	8	0.01	BMC Medicine, England	20	0.01
Lee DH, Canadian Cardiovascular Outcomes Research Team, Canada	19	0.06	Singh M ^[24]	8	0.03	Journal of Clinical Epidemiology, Netherlands	20	0.01
-	-	-	-	-	-	BMJ Open,	19	0.01

England
 Geriatrics & Gerontology
 International,
 England

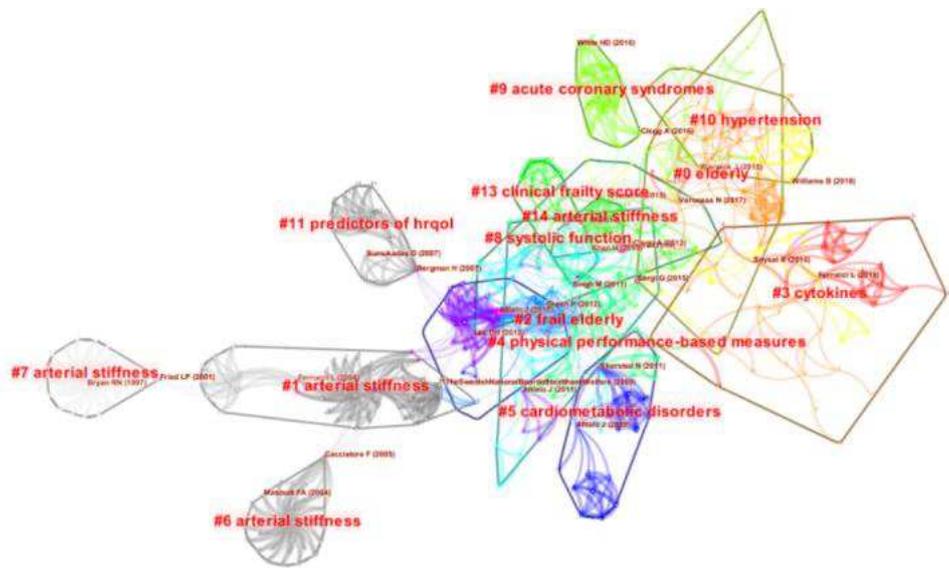


Fig. 5 Clusters of cited references related to CVD with frailty

3.3 Analysis of keywords

The researchers merged the keywords that share the same meaning, and graphed the visual figure of the keywords related to CVD with frailty (Fig. 6). Fig. 6 consists of 480 nodes and 2506 collaboration links. According to frequency, top ten high frequency keywords in this field were sorted in Table 3. The top five high frequency keywords are “frailty”, “cardiovascular disease”, “older adult”, “mortality” and “health”. The top three high centrality keywords are “cardiovascular disease”, “mortality” and “disability”. The nodes are bigger than the others in Fig. 6, and the frequency of keywords are higher than the others, which means they are the hotspots in this field. Then, clusters map of keywords related to CVD with frailty was graphed in Fig. 7, and 23 clusters were presented in total. The result of cluster map is convincing because the map shows that $Q=0.69 > 0.3$, $S=0.90 > 0.5$ ^[13]. Top ten clusters related to size were selected to make the cluster map clear in figure 7. The top five clusters are #0 frailty syndrome, #1 atherosclerosis, #2 arterial vascular surgery, #3 health-related quality of life and #4 mobility limitation.

Table 3 Top high frequency keywords related to CVD with frailty

Keywords	Count	Centrality	Year
frailty	85	0.01	2008
cardiovascular disease	80	0.13	2008

older adult	66	0	2009
mortality	57	0.07	2001
health	28	0.05	2001
heart failure	27	0.01	2008
risk	26	0	2014
association	24	0.04	2013
outcome	23	0.04	2012
disability	20	0.06	2005

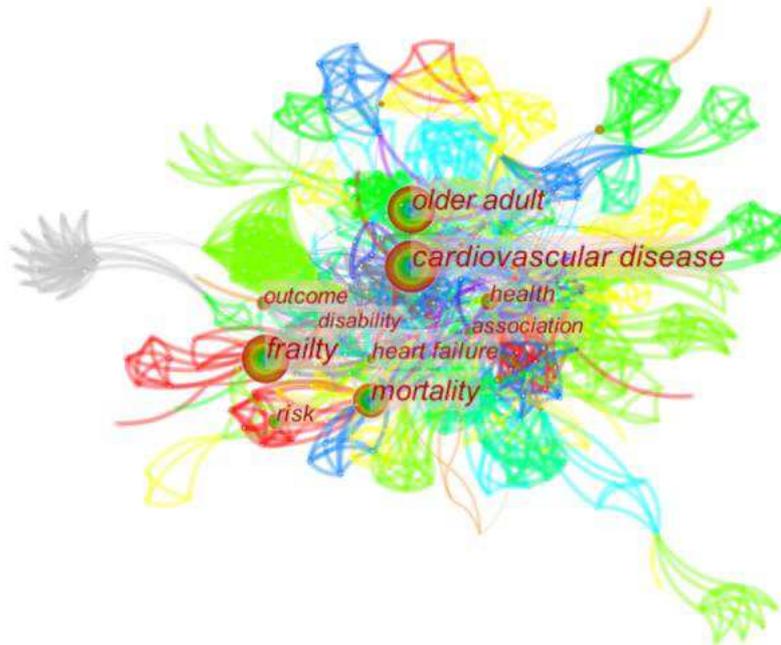


Fig. 6 Map of keywords related to CVD with frailty

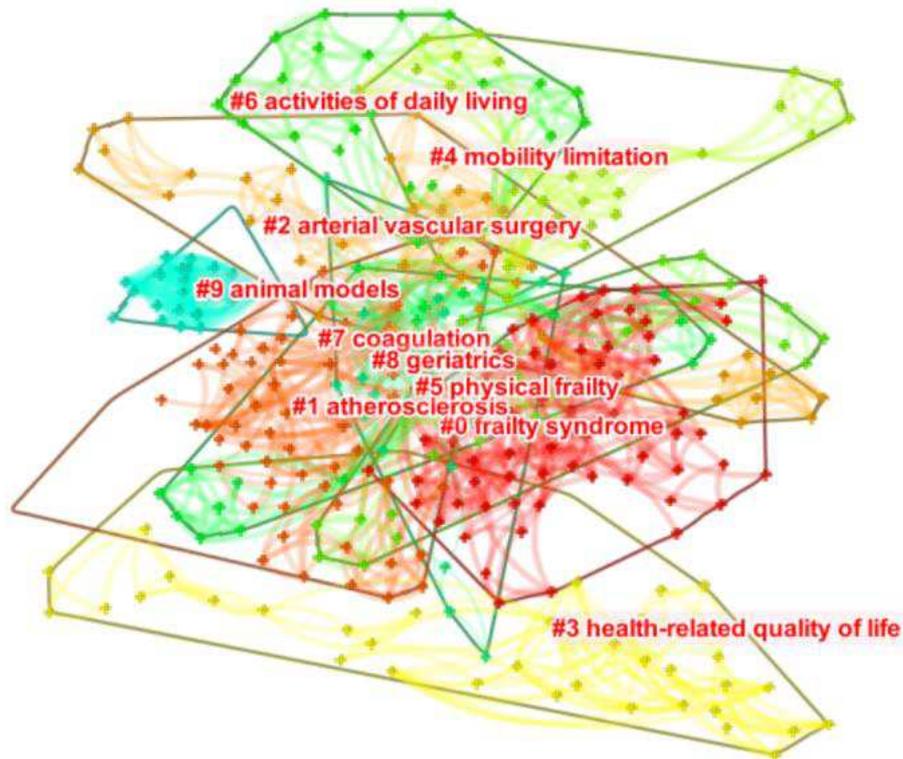


Fig. 7 Clusters of keywords related to CVD with frailty

3.4 Analysis of keywords of bursts

15 keywords of bursts are shown in Fig. 8, and the minimum duration is 1 year and $\gamma=0.5$. The top three strongest bursts were “women health (2.21)”, “age (2.12)” and “complication (2.03)”. There are more bursts in 2020 than in other years. There are nine keywords of bursts in nearly two years, and seven keywords have high strength in 2020. They are “validation”, “health”, “cardiac rehabilitation”, “care”, “frailty”, “coronary artery disease” and “adult”.

Top 15 Keywords with the Strongest Citation Bursts

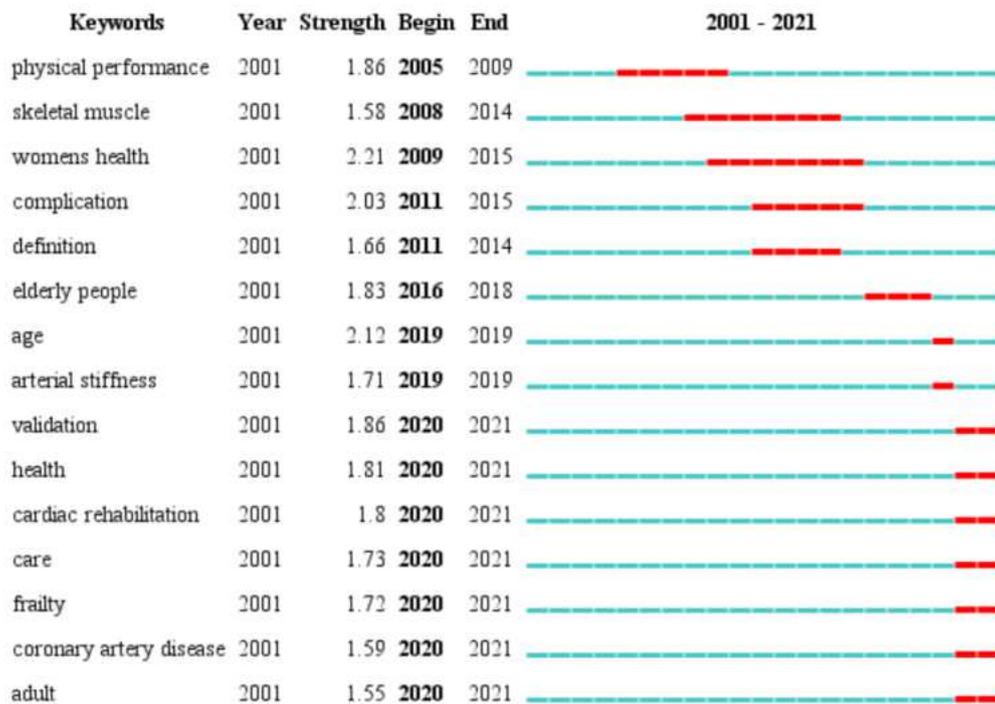


Fig. 8 Top 15 keywords of bursts related to CVD with frailty

4 Discussion

In this research area, the USA, England and Canada are the leading countries. Although some developing countries such as Israel and China have been paying great attention to CVD with frailty, they continue to show deficiencies in the quality of studies. The study highlighted the hotspots and frontiers and presented several clusters in the research area of CVD with frailty. Older adults with CVD, exercise intervention, assessment for CVD patients with frailty, quality of life, common diseases related to CVD with frailty are concerns among authors in this research domain. In recent years, researchers turn their attention to interventions of CVD patients with frailty. Moreover, care and intervention of CVD patients with frailty, social frailty, validation of CVD with frailty will be the trending research topics in the future.

4.1 Development of top ten countries

England and Canada lead the world in the domain of CVD with frailty by synthesizing the number of articles and centrality. The top five countries by the number of publications in CVD with frailty are developed countries. This may be due to a faster increase in aging population compared to other developing countries. Though population aging is a global phenomenon, the situation differs among countries and regions^[25]. There are two Asian countries in the top ten prolific countries in CVD with

frailty. It is mostly developing countries in Asia, indeed, the medical resources and environments in developing countries are not at a high level. Doctors and nurses may ignore the accompanying symptoms which is not obvious like unintentional weight loss, weakness, etc sometimes, because they focus on the disease therapy more. Generally, the frailty of CVD patients is ignored in Asian countries. Besides, figure 2 shows that cooperative relationship in this field was limited to only a few countries, thus cooperation between countries should be strengthened in the future.

4.2 Contribution of institutions

According to Fig. 3, close cooperation exists between various institutions. Universities made up the majority among the top ten institutions, and most of these institutions are from developed countries—half of them belonging to the USA, which is in accord with the top ten countries (Table 1). NIA (National Institute on Aging) and McGill University are also influential in CVD with frailty. The analysis of institutions provides the basis for talent introduction and further study.

4.3 Contribution of individuals

As shown in Table 2 and Fig. 4, most of the top ten authors by the number of articles related to CVD with frailty are from Israel and China, which indicates that some Asian countries pay attention to CVD with frailty. The number of prolific authors' publications are similar among the top ten authors by the number of articles, and several of these authors come from the same institutions. The authors prefer to first collaborate with a prolific author, and form a co-author cluster afterwards. Besides, in terms of country and institution, it is the European and American countries that had the advantage on the numbers of articles. That is to say that Asian countries were in their preliminary stage in this field and do not have influential and leading experts or teams. Asian countries should establish multicentric cooperation with developed countries to guide their research of the CVD with frailty.

4.4 Co-citation analysis

Fried LP from Columbia University is the most cited author (Table 2), and he put forward Frailty phenotype (FP) based on data from the Cardiovascular Health Study in 2001 that is used widely. FP is a diagnosis criteria of frailty including five items: unintentional weight loss, self-reported exhaustion, weakness (grip strength), slow walking speed and low physical activity^[9]. People who have clinical syndrome in three or more of the mentioned criteria are diagnosed as frailty. FP is an easy and convenient clinical assessment tool for frailty; however, it only has five items which is inadequate to assessments of the potential frail patients. Meanwhile, it is because of the simplicity and feasibility of the assessment

criteria that contribute to its widespread use in the primary clinical screening for frailty. Professor Rockwood K from Dalhousie University has the highest centrality among the top ten most cited authors (Table 2). In 2001, he developed a method for appraising health status in the elderly: frailty index (FI), consisting of 92 items that include symptoms, abnormal laboratory values, disease classifications, and disabilities^[26]. FI is more comprehensive compared with FP. It is because it includes more items that lead to a more all-sided prediction for frail adverse outcomes, meanwhile, it limits the use of FI in the clinic practice. In general, both authors contributed to frailty assessment. Besides, Professor Rockwood K established academic cooperation with Xuanwu Hospital of China to promote the in-depth cooperation between China and Canada. In addition, Professor Afilalo J of McGill University contributes to the basic theory review about CVD with frailty in all aspects.

What researchers focus on can be presented by cited references, and this content will be discussed in detail in the 4.5 Hotspots in the CVD with frailty.

There are three geriatric journals among the top ten cited journals (Table 2), which indicates that researchers attached great importance on the elderly CVD patients with frailty. In other words, it is because CVD with frailty is common among the elderly that researchers focus on geriatric journals. One of the most influential journal, the American Journal of Medicine, is the official journal of the Alliance for Academic Internal Medicine that is a group comprising internal medicine department chairs at more than 125 medical schools across the USA. Its impact factor is 4.529 in June 2020. Frailty should be viewed as a reason of nursing in a more patient-centered fashion^[15]. As shown in Table 2, there is no nursing journals among the top 10 cited journals. However, frailty should be included during the whole process of nursing; optimal nursing pathways can relieve frailty. In the future, what nurses can do for the CVD patients with frailty should be taken into consideration, and then conduct researches from the nursing point of view.

4.5 Hotspots in the CVD with frailty

The hotspots in a specific field are determined by co-occurrence figures, high-frequency keywords and high-centrality keywords. To focus on the major topics, the contents in Table 3, Fig. 5, Fig. 6 and Fig. 7 were summarized into 5 aspects as follow.

4.5.1 Frailty in the elder adults with CVD

The relevant keywords are “elderly” (Fig. 5) “frail elderly” (Fig. 5) “older adult” (Table 3) “geriatrics” (Fig. 7). The elder adults have been the focus of frailty and CVD. Nearly one third of elderly inpatients

have frailty, which is related to the length of hospital stay. The longer time of hospital stay, the higher possibility for the patient to have frailty^[27]. Most geriatric cardiovascular diseases are chronic, and most of the elderly with CVD have to remain hospitalized for a long time. It follows that the elderly with CVD are more probable to have frail than other populations. It is necessary to attach more importance to the elder adults with CVD, and elderly CVD patients with frailty will be a long-term hot research topic in the future.

4.5.2 Exercise intervention for CVD patients with frailty

The relevant keywords are “activities of daily living” (Fig. 7) and “mobility limitation” (Fig. 7). Cesari found that regular physical activity may reduce frailty, especially in individuals at higher risk of disability^[28]. Dustin discovered that insufficient physical activity and prolonged sedentary time were detrimental despite CVD status^[29]. In other words, physical activities are beneficial to improve the remission situation of frailty and CVD. It will be a tendency to make a specific physical activity plan for the CVD patients with frailty. Suitable physical activities are the effective ways to improve the physical status to CVD patients with frailty, but specific details of the physical activities, such as time, frequency and types are unknown. Therefore, it is needed to consider frailty and CVD simultaneously, making appropriate activity plans for this type of patients is intractable research.

4.5.3 Assessment for CVD patients with frailty

The relevant keywords are “physical performance-based measures” (Fig. 5), “clinical frailty score” (Fig. 5) and “frailty syndrome” (Fig. 7). There are many assessment tools for CVD patients with frailty in the clinical practice, and the common tools are Frailty Phenotype (FP), Frailty Index (FI), Clinic Frail Score (CFS), Tilburg Frailty Indicator (TFI), FRAIL, SHARE-FI, and so on. FP is one of the most widely used tools, and it works efficiently in primary clinical screening for frailty. FI is another common tool for frailty assessment^[26]; however, time investment to finish 92 items of FI may limit its use in busy clinical practice. Being based on the FP and FI, FRAIL^[30] gives a score according to specific symptoms, then assess patients’ frailty situation according to scores. Clinical frail scale (CFS)^[31] determines patients’ frail status according to the subjective judgement of evaluators. Tilburg frailty indicator(TFI)^[32] is a self-reported tool to screening the frail population in the community. It is a long-term therapy process for CVD patients with frailty, therefore, working out a settled assessment measure that can be used in daily clinical assessment is in greater need. Besides, in FP, only the options of “yes” and “no” are available for patients, and the condition of CVD patients with frailty is always complicated, so screen frailty according

to a score will be a better choice for CVD patients. In order to recognize frailty accurately, both subjective and objective information should be obtained during the assessment process. However, spending too much time may become a limitation for clinic practice. Researchers use different instruments in studies about CVD patients with frailty at present, but it is convenient to evaluate frailty status for CVD patients if a tool which can be called the “golden standard” will be developed in this field. Developing a more suitable instrument and selecting an applicative tool to discern frailty for different CVD patients have been brought into focus in this domain.

4.5.4 Quality of life of CVD patients with frailty

The relevant keywords are “predictors of HRQOL” (Fig. 5) “health” (Table 3) and “health-related quality of life” (Fig. 7). A cross sectional, observational study suggested that frailty was independently associated with decreased quality of life ($p < 0.0001$) in the population with CVD^[33]. A good quality of life is the ultimate goal of medical and nursing care, but both CVD and frailty are two of the risk factors of decreased quality of life. To achieve the nursing care goal, it is necessary to concern about the frailty of CVD patients. The assessment tools of quality of life are unambiguous; therefore, determining whether frailty situation is improved by evaluating quality of life is available.

4.5.5 Diseases related to CVD with frailty

The relevant keywords are “acute coronary syndromes” (Fig. 5), “hypertension” (Fig. 5), “cardiometabolic disorders” (Fig. 5), “heart failure” (Table 3) and “atherosclerosis” (Fig. 7). Many research found that frailty was common in older heart failure inpatients and it should be considered as a prediction factor to help identify individuals with an increased risk of mortality or readmission^[34-35]. Some CVD may transform into heart failure eventually; hence, patients with heart failure are common among the patients with CVD. Therefore, heart failure is a research hotpot in this field. The most cited author, Afilalo J, expounded the relationship between common CVD and frailty^[15]. During the whole process of therapy, although frailty is not a kind of disease, it is a key factor influencing the clinical outcome, which can lead to adverse events. Frailty should not be ignored no matter which kind of CVD patients have.

4.6 Frontiers in the CVD with frailty

As shown in Fig. 7, 15 burst keywords were considered as indicators of research frontiers. In terms of the time evolution of these keywords, the transformation of research frontiers can be summarized as follows: performance and definition of frailty (2005-2015), such as keywords “physical performance”,

“skeletal muscle”, “complication” and “definition”, care and intervention of CVD patients with frailty (2020-), keywords such as “health”, “cardiac rehabilitation” and “care”.

In addition, Lien T . Quach et al. put forward the importance of social frailty in older adults^[36]; moreover, social frailty can be defined as a continuum of being at risk of losing or having lost social and general resources, activities, or abilities that are important for fulfilling one or more basic social needs during daily life in S. Bunt’s paper^[37]. Although there are social factors during the process of assessment of frailty, it is not enough to recognize social frailty and clinical tools for identifying social frailty remain unclear. Most of the time, geriatric cardiovascular diseases need a long time for therapy; thus, it is easy to have social frailty problems for older adults. However, the incorporation of another assessment into an already busy clinical practice should also be considered^[36]. As is shown in Fig. 7, physical frailty is a hot topic in this field; however, with the gradual attention to humanistic care of CVD patients with frailty, social frailty will be a concern.

In other words, after synthesizing information in Fig. 7, the CVD with frailty research frontiers are summarized as follows: care and intervention of CVD patients with frailty, social frailty, and validation of CVD with frailty.

5 Conclusions

This study aims to conduct a scientometric analysis of CVD with frailty. It mainly included the contributory countries, institutions and authors, as well as the most cited authors, references and journals, hotspots and frontiers in this field. England and Canada led the world in the field of CVD with frailty. NIA (National Institute on Aging) and McGill University were influential in frailty with CVD. Although Asian authors were prolific, the European and American authors still played a lead role; therefore, cooperation between countries should be established. Hotspots in the CVD with frailty have been summarized, they were frailty in the elderly with CVD, exercise intervention, assessment for CVD patients with frailty, quality of life, common diseases related to CVD with frailty. Frontiers in the CVD with frailty have been summarized as care and intervention of CVD patients with frailty, social frailty, validation of CVD with frailty.

This study shows that there is a gap of the quality of research about CVD with frailty between developed countries and developing countries. It is needed to establish long-term and in-depth international medial cooperation. This will contribute to the sustainable development of this research domain in developing countries, thereby putting more attention on CVD patients with frailty can improve

outcomes. Screening the pre-frailty dwellers and taking some simple interventions are effective measures to reduce medical cost. Most importantly, world public health will benefit from establishing a good cooperation.

There are hardly any researchers who will focus on the frailty of young people or children. In fact, some risk factors related to frailty may occur on the young people or children, such as disability, obesity, inflammation, or some other chronic diseases. As the lifestyle and living environment changed, CVD is gradually becoming more common among young people. However, in the existing studies, most studies focus on elderly, but young CVD patients with frailty also should get attention. For example, at-risk adolescent and young adult (AYA) is a population who needs attention. The survivors of childhood severe diseases or patients who previously accepted radiotherapy or chemotherapy may probably be exposed to frailty. Compare to their siblings, childhood cancer survivors were more likely to have adverse health status^[38]. Krnavek found that childhood cancer survivors were more likely to be pre-frail than people without cancer history^[39]. It is possible to have CVD and frailty for these special children when they grow up. Thus, it is necessary to explore the relationship between childhood adverse events and CVD with frailty, then decide whether to perceive childhood adverse events as a crucial risk factor of CVD with frailty. In the future, association between at-risk adolescent and young adult (AYA) with CVD and frailty may become a new research orientation.

CVD with frailty will be a hot topic for a long time, and more comprehensive research in this domain will help patients and medical staffs to cope with it. In the future, a more detailed visualization analysis should be available, for example, analysis of articles in other languages like Chinese, Spanish and German, etc. Besides, frailty in the different CVD patient population is also an aspect worth exploring, such as women, disability, cognitive impairment, and so on.

6 List of abbreviations

Abbreviations	Full name
CVD	Cardiovascular diseases
WoS	Web of Science
NIA	National Institute on Aging
FP	Frailty phenotype
FI	Frailty index

CFS	Clinic Frail Score
TFI	Tilburg Frailty Indicator
AYA	At-risk adolescent and young adult

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Xuping Bao, Loretta Yuet Foon, CHUNG and Yujie Wen made substantial contributions to the conception and design of the research.

Qiyu Sun operated the CiteSpace software.

Yi Wang and Yifei Du searched database and collected the records that meet criteria.

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8 References

[1] Dent E, et al. (2019). Management of frailty: opportunities, challenges, and future directions. *Lancet*,

394(10206):1376-1386.

[2] Cesari M, Calvani R, Marzetti E. (2017). Frailty in Older Persons. *Clin Geriatr Med*, 33(3):293-303.

[3] Rivas-Ruiz F, et al. (2019). Prevalence of frailty among community-dwelling elderly persons in Spain and factors associated with it. *Eur J Gen Pract*, 25(4):190-196.

[4] Arai H, Satake S, Kozaki K. (2018) Cognitive Frailty in Geriatrics. *Clin Geriatr Med*, 34(4):667-675.

[5] ZHANG Weiyi, et al. (2020) Analysis of hotspots and frontiers of frailty research: a visualization analysis based on CiteSpace. *Chinese Journal of Evidence-Based Medicine*, 20(11):1308-1315.

[6] Roth GA, et al. (2020) Global Burden of Cardiovascular Diseases and Risk Factors, 1990-2019: Update From the GBD 2019 Study. *J Am Coll Cardiol*, 76(25):2982-3021.

[7] Denfeld QE, et al. (2017) The prevalence of frailty in heart failure: A systematic review and meta-analysis. *Int J Cardiol*, 236:283-289.

[8] Chung CJ, et al. (2014) Reduced handgrip strength as a marker of frailty predicts clinical outcomes in patients with heart failure undergoing ventricular assist device placement. *J Card Fail*, 20(5):310-5.

[9] Fried LP, et al. (2001) Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*, 56(3):M146-56.

[10] Estabrooks CA, Winther C, Derksen L. (2004) Mapping the field: a bibliometric analysis of the research utilization literature in nursing. *Nurs Res*, 53(5):293-303.

[11] Uchikado Y, Ikeda Y, Ohishi M. (2020) Current Understanding of the Role of Frailty in Cardiovascular Disease. *Circ J*, 84(11):1903-1908.

[12] Marinus N, et al. (2021) Frailty is highly prevalent in specific cardiovascular diseases and females, but significantly worsens prognosis in all affected patients: A systematic review. *Ageing Res Rev*, 66:101233.

[13] Chen, C. (2006) CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *JASIST*, 57(3), 359-377.

[14] Yuran Jin, et al. (2017) A scientometric review of hotspots and emerging trends in additive manufacturing, *Journal of Manufacturing Technology Management*, Vol. 28 Iss 1 pp.

[15] Afilalo J, et al. (2014) Frailty assessment in the cardiovascular care of older adults. *J Am Coll Cardiol*, 63(8):747-62.

[16] Clegg A, et al. (2013) Frailty in elderly people. *Lancet*, 381(9868):752-62.

[17] Singh M, Stewart R, White H. (2014) Importance of frailty in patients with cardiovascular disease.

Eur Heart J, 35(26):1726-31.

[18] Sergi G, et al. (2015) Pre-frailty and risk of cardiovascular disease in elderly men and women: the Pro.V.A. study. *J Am Coll Cardiol*, 65(10):976-83.

[19] Veronese N, et al. (2017) Risk of cardiovascular disease morbidity and mortality in frail and pre-frail older adults: Results from a meta-analysis and exploratory meta-regression analysis. *Ageing Res Rev*, 35:63-73.

[20] Afilalo J, et al. (2009) Role of frailty in patients with cardiovascular disease. *Am J Cardiol*, 103(11):1616-21.

[21] Afilalo J. (2011) Frailty in Patients with Cardiovascular Disease: Why, When, and How to Measure. *Curr Cardiovasc Risk Rep*, 5(5):467-472.

[22] Ekerstad N, et al. (2011) Frailty is independently associated with short-term outcomes for elderly patients with non-ST-segment elevation myocardial infarction. *Circulation*, 124(22):2397-404.

[23] Soysal P, et al. (2016) Inflammation and frailty in the elderly: A systematic review and meta-analysis. *Ageing Res Rev*, 31:1-8.

[24] Singh M, et al. (2011) Influence of frailty and health status on outcomes in patients with coronary disease undergoing percutaneous revascularization. *Circ Cardiovasc Qual Outcomes*, 4(5):496-502.

[25] Wang S. (2020) Spatial patterns and social-economic influential factors of population aging: A global assessment from 1990 to 2010. *Soc Sci Med*, 253:112963.

[26] Mitnitski AB, Mogilner AJ, Rockwood K. (2001) Accumulation of deficits as a proxy measure of aging. *ScientificWorldJournal*, 1:323-36.

[27] Khandelwal D, et al. (2012) Frailty is associated with longer hospital stay and increased mortality in hospitalized older patients. *J Nutr Health Aging*, 16(8):732-5.

[28] Cesari M, et al. (2015) A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P study. *J Gerontol A Biol Sci Med Sci*, 70(2):216-22.

[29] Kehler DS, et al. (2019) The association between patterns of physical activity and sedentary time with frailty in relation to cardiovascular disease. *Ageing Med (Milton)*, 2(1):18-26.

[30] Morley JE, Malmstrom TK, Miller DK. (2012) A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. *J Nutr Health Aging*, 16(7):601-8.

[31] Rockwood K, et al. (2005) A global clinical measure of fitness and frailty in elderly people. *CMAJ*, 173(5):489-95.

- [32] Gobbens RJ, et al. (2010) The Tilburg Frailty Indicator: psychometric properties. *J Am Med Dir Assoc*, 11(5):344-55.
- [33] Lilamand M, et al. (2020) Quality of life, physical performance and nutritional status in older patients hospitalized in a cardiology department. *J Geriatr Cardiol*, 17(7):410-416.
- [34] Goyal P, et al. (2021) Frailty and Post-hospitalization Outcomes in Patients With Heart Failure With Preserved Ejection Fraction. *Am J Cardiol*, S0002-9149(21)00194-6.
- [35] Zheng PP, et al. (2021) Frailty related all-cause mortality or hospital readmission among adults aged 65 and older with stage-B heart failure inpatients. *BMC Geriatr*, 21(1):125.
- [36] Quach LT, et al. (2021) The Intersection of Physical and Social Frailty in Older Adults. *R I Med J*, 104(4):16-19.
- [37] Bunt S, et al. (2017) Social frailty in older adults: a scoping review. *Eur J Ageing*, 14(3):323-334.
- [38] Hudson MM, et al. Age-dependent changes in health status in the Childhood Cancer Survivor cohort. *J Clin Oncol*, 33(5):479-91.
- [39] Krnavek NJ, et al. (2021) Sensor-Based Frailty Assessment in Survivors of Childhood Cancer: A Pilot Study. *J Frailty Aging*, 10(2):176-181.

