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Characterization of global research trends and prospects on sudden coronary death: A literature visualization analysis

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ABSTRACT

Background: Sudden coronary death is a major global public health issue that has a significant impact on both individuals and society. Nowadays, scholars are active in sudden coronary death all over the world. However, no relevant bibliometric studies have been published. Here, we aim to gain a better understanding the current state of research and to explore potential new research directions through bibliometric analysis.

Methods: Articles and reviews on sudden coronary death from 2012 to 2023 were retrieved from the Web of Science Core Collection (WoSCC). The topic search was conducted using the following keywords: (((“sudden cardiac death” OR “sudden death”) AND (coronary OR “myocardial infarction”)) OR “sudden coronary death”). Knowledge maps of authors, countries, institutions, journals, keywords, and citations were conducted by CiteSpace. Publication dynamics, hotspots, and frontiers were analyzed independently by authors.

Results: A total of 2914 articles were identified from January 1, 2012 to June 20, 2023. The USA (n = 972) contributed the greatest absolute productivity and UK (centrality = 0.13) built a robust global collaboration. Harvard University was the institution with the highest number of publications (n = 143). Huikuri HV and Junttila MJ were the most published authors who devoted to searching for biomarkers of sudden coronary death. American Journal of Cardiology was the journal with the most publications, and Circulation was the most cited journal. Left ventricular ejection fraction, society, inflammation, and fractional flow reserve became novel burst words that lasted until 2023. Research on etiology and pathology, role of early risk factors in risk stratification, potential predictive biomarkers and novel measurement methods for the prevention and management of sudden coronary death were identified as the research hotspots and frontiers.

Conclusion: Our knowledge and understanding of sudden coronary death have significantly improved. Ongoing efforts should focus on the various etiologies and pathologies of sudden coronary death. Furthermore, a novel sudden coronary death risk model, large-scale population studies, and the rational use of multiple indicators to individualize the assessment of sudden coronary death and other risk factors are other emerging research trends.

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1. Introduction

Sudden cardiac death (SCD), caused by cardiac alterations, is one of the major global public health issues [1]. According to the 2022 European Society of Cardiology Guidelines, SCD is defined as sudden natural death occurring within an hour of the onset of symptoms in witnessed cases, or within 24 h of last being seen alive when it is unwitnessed due to a cardiac cause [2]. In autopsied cases, SCD presumed to be the natural unexpected death of unknown or cardiac cause [2]. Globally, SCD kills 4–5 million people each year [3], with China having a rate of 41.8 per 100,000 people per year [4]. Although the mortality rate from SCD has declined over the past 40 years, it still accounts for almost 50% of deaths in China [5]. In terms of etiologies, most SCDs are caused by coronary artery diseases (CADs) [1,6], which are known as sudden coronary deaths. CADs are characterized by the existence of atherosclerosis (either obstructive or non-obstructive) in coronary arteries and they can be asymptomatic [7]. Generally, the mechanisms of sudden coronary death are divided into acute plaque complications leading to acute coronary syndrome (ACS) and previous myocardial infarction (MI) scar as a substrate for re-entry arrhythmias [8]. Moreover, scholars are active in the prevention and management of sudden coronary death. Zhang GQ et al. [9]. For example, developed a 21 SNP plex to predict the risk of sudden coronary death. However, no publication exists to systematically evaluate the published related literature.

With the boost of science communication research, the quantification of science is also prospering. Bibliometric analysis, a combination of "data science" and modern science, contributes to delineate a scientific era's comprehensive knowledge system and growing trends in research activity over time. It is an achievable method for qualitative and quantitative assessment of published records on a particular subject, which has been widely used in various fields to compare the contributions of countries, institutions,

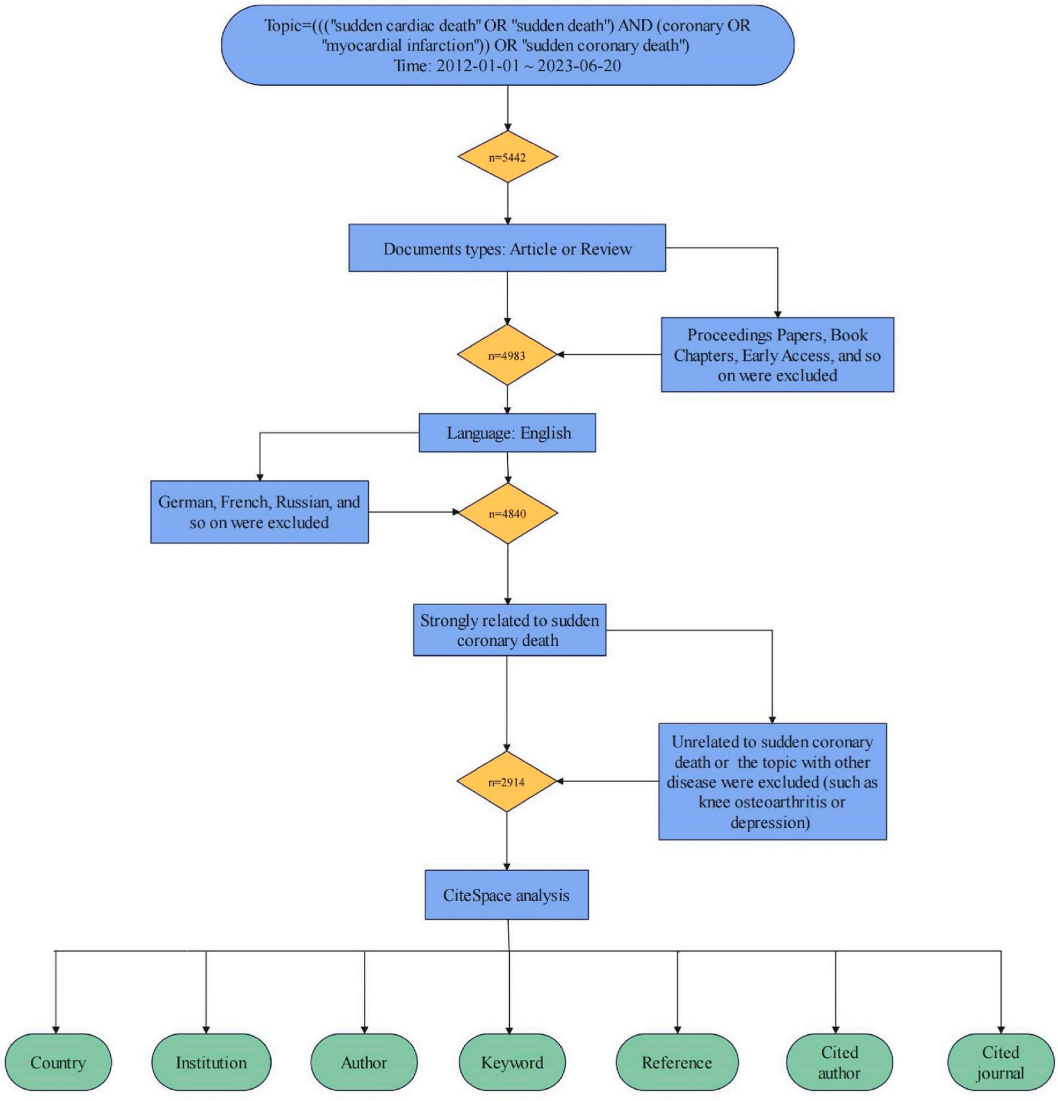

Fig. 1. Flowchart of literature selection.

authors, and so forth. Nowadays, more and more researchers have used this strategy to analyze their respective research domains, for instance, ethical concerns of cerebral organoids [10], colorectal cancer [11], and antipsychotics in schizophrenia [12]. Nevertheless, no specific bibliometric analysis of sudden coronary death knowledge mapping has been conducted to date.

Here, we aim to gain a better understanding of the current research status and to explore potential new research directions on sudden coronary death using CiteSpace, especially from the insights of countries, authors, journals, and keywords.

2. Materials and methods

2.1. Data source and search strategy

Web of science core collection database (WoSCC) is one of the most comprehensive, scientific, and authoritative databases. It is widely used for bibliometric analysis and visualization research. In order to obtain more representative and reliable research information on sudden coronary death, data were extracted from the Science Citation Index Expanded (SCI-Expanded) of WoSCC. The topic search was conducted using the following keywords: ((("sudden cardiac death" OR "sudden death") AND (coronary OR "myocardial infarction")) OR "sudden coronary death"). In addition, the period time was set from January 1, 2012 to June 20, 2023 and language was restricted to English. The literature types defined as "articles" and "reviews" documents were included, while other document types such as letters, meeting abstracts, editorial materials, and corrections were excluded. Subsequently, a total of 4840 articles were collected. Considering the accuracy of publications through this search method was insufficient, two authors independently screened the publications strongly related to sudden coronary death. For example, studies of "Cardiovascular benefits of angiotensin-converting enzyme inhibition plus calcium channel blockade in patients achieving tight blood pressure control and with resistant hypertension" [13], "The elderly at risk: aldosterone as modulator of the immune response to SARS-CoV-2 infection" [14], "Surgical interventions for symptomatic mild to moderate knee osteoarthritis" [15], "Histopathological characterization of intimal lesions and arterial wall calcification in the arteries of the leg of elderly cadavers" [16] related to patients with other diseases were excluded. Additionally, a symposium or another author was required to resolve disagreements between two authors. Following the discussion, a total of 2914 publications were obtained for further analysis. The detailed search strategy was presented in Fig. 1. All documents were exported in the plain text format with "Full Records and Cited References". The data was downloaded within one day to avoid any potential deviation from daily updates.

2.2. Science mapping visualization analysis

The mapping visualization analysis aims at revealing the state of research and leading edge of different fields. CiteSpace is a free Java-based software that analyzes data and visualizes co-citation networks in a research field. The principle of CiteSpace supports

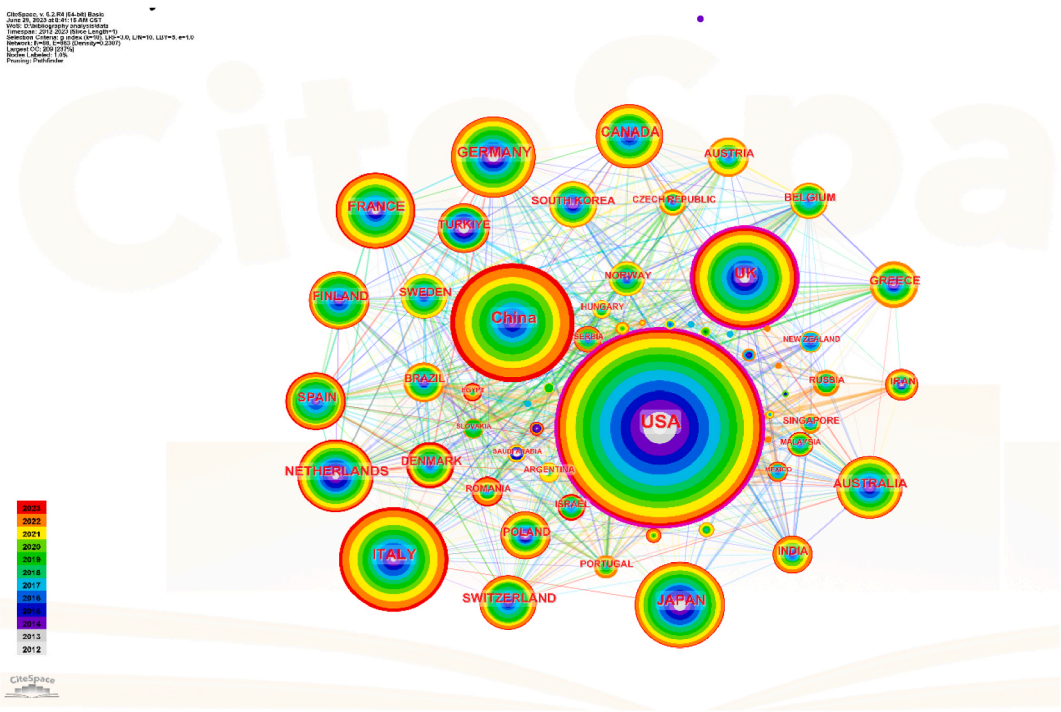

Fig. 2. Distribution of publications from different countries.

structural and temporal analysis of a variety of networks, including co-occurrence, keywords, and co-citation networks [17]. Moreover, CiteSpace can present the strongest burst citation of keywords and draw a dual-map overlay for journals. Therefore, our knowledge and understanding of sudden coronary death will be significantly improved. In this study, CiteSpace was applied to analyze and visualize the co-authors, co-countries, co-institutions, timeline view of keywords, the keywords bursts, reference co-citation, and so on.

3. Results

3.1. Contributions of countries

In total, 2914 articles from 88 countries were published. The node in the visualizations represents a country, and the size of the node indicates the country's publication outputs. Therefore, the larger the node, the more articles published by the country. As can be seen from Fig. 2, the majority of the articles about sudden coronary death were published in the USA, China, and Italy. Moreover, the line width between two nodes indicates the intensity of collaboration. There were only a few countries that put up active cooperations (such as Denmark and Netherlands), whereas most countries lacked cooperation and exchanges. Subsequently, the top 10 countries were extracted (Table 1). The USA published the most articles (n = 972), followed by China (n = 402), Italy (n = 296), and UK (n = 268). From the perspective of the cooperative network, centrality over 0.1 is usually regarded as a significant turning point that may lead to transformative discoveries and act as a bridge. Among the top 10 countries, the centrality of UK and USA were 0.13 and 0.11, indicating that they played an intermediary role all over the world.

3.2. Contributions of institutions

The top 10 institutions were presented in Table 1. Harvard University contributed the most publications (n = 143), followed by Oulu University (n = 66), Washington University (n = 66), and Brigham & Women's Hospital (n = 56). Notably, Padua University (0.39) and Copenhagen University (0.32) had highest centralities, indicating a good mediating effect between different institutions. It can be found that collaboration between institutions was tighter than collaboration between countries (Fig. 3).

3.3. Authors and cited authors analysis

As shown in the author collaboration network map (Fig. 4), Huikuri HV (the largest node) had a close cooperative relationship with Junttila MJ (the second largest). Table 2 summarized the top 10 authors. Huikuri HV from the Oulu University was the most prolific author (n = 56), followed by Junttila MJ (n = 39), Chugh SS (n = 22), Albert CM (n = 20), and Molossi S (n = 19).

Co-cited authors are two or more authors who are simultaneously cited by another or more publications, and these two or more authors form a co-cited relationship. Observing Supplementary Fig. 1, a close co-occurrence relationship between prolific authors and co-cited authors was observed. For example, Myerburg RJ and Moss AJ both cited the articles from Zipes DP. Among the top 10 co-citation authors (Table 3), Maron BJ from Tufts Medical Center in USA ranked first with 386 publications, followed by Basso C (n = 351), and Priori SG (n = 310).

3.4. Journals and cited journals analysis

A total of 762 journals published articles on sudden coronary death. We ranked the top 10 journals by the number of publications (Table 4). American Journal of Cardiology published the most papers (n = 98), followed by International Journal of Cardiology (n = 74), Journal of The American Heart Association (n = 60), and European Heart Journal (n = 50). The impact factor (IF) of the top 10 journals ranged from 2.8 to 39.3 (mean = 13.17). Among the journals contributing publications with IF greater than 20, European Heart Journal (n = 50) had the highest IF (IF 2023 = 39.3), followed by Circulation (n = 38, IF 2023 = 37.8) and Journal of The American College of Cardiology (n = 46, IF 2023 = 24). According to the 2023 Journal citation reports (JCR), 40% of journals were classified as Q1, 50% as Q2, and 10% as Q3.

Table 1
Top 10 countries and institutions related to sudden coronary death.

Rank	Countries	Year	Centrality	Count	Institutions (country)	Year	Centrality	Count
1	USA	2012	0.11	972	Harvard University (USA)	2012	0.27	143
2	China	2012	0.02	402	Oulu University (Finland)	2012	0.18	66
3	Italy	2012	0.08	296	Washington University (USA)	2012	0.05	66
4	UK	2012	0.13	268	Brigham & Women's Hospital (USA)	2012	0.23	56
5	Japan	2012	0.02	196	Mayo Clinic (USA)	2012	0.00	49
6	Germany	2012	0.04	185	Cedars Sinai Medical Ctnter (USA)	2012	0.06	44
7	Netherlands	2012	0.07	144	Copenhagen University (Denmark)	2013	0.32	43
8	France	2012	0.05	144	Oregon Health & Science University (USA)	2013	0.04	39
9	Canada	2012	0.07	133	Padua University (Italy)	2016	0.39	36
10	Finland	2012	0.06	117	Pennsylvania University (USA)	2012	0.16	36

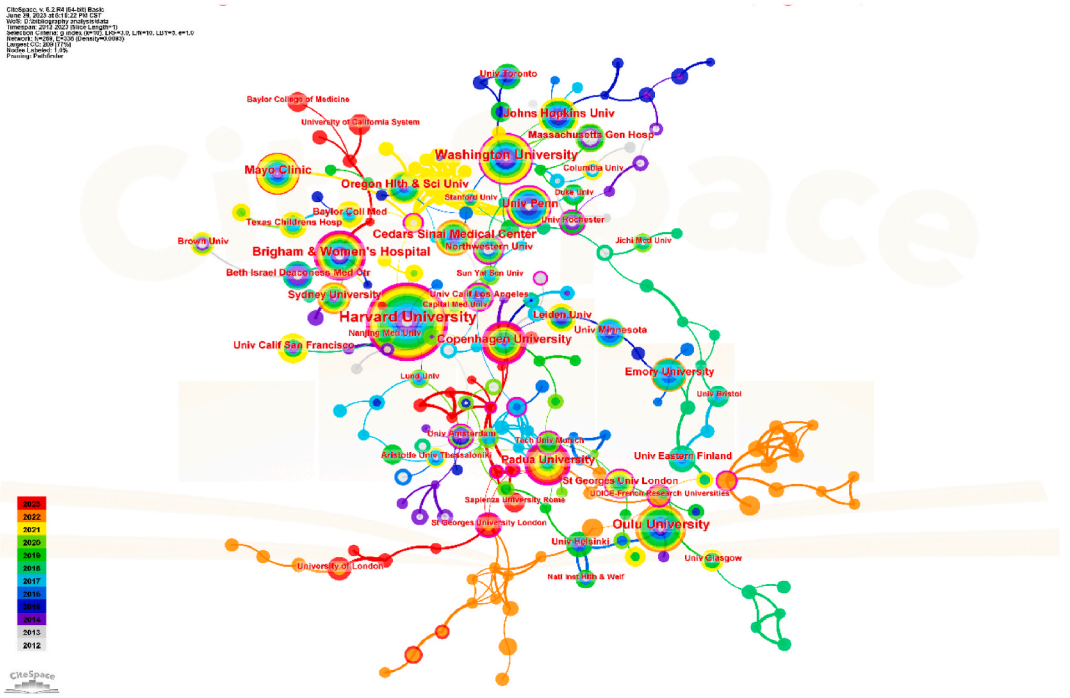

Fig. 3. Distribution of publications from different institutions.

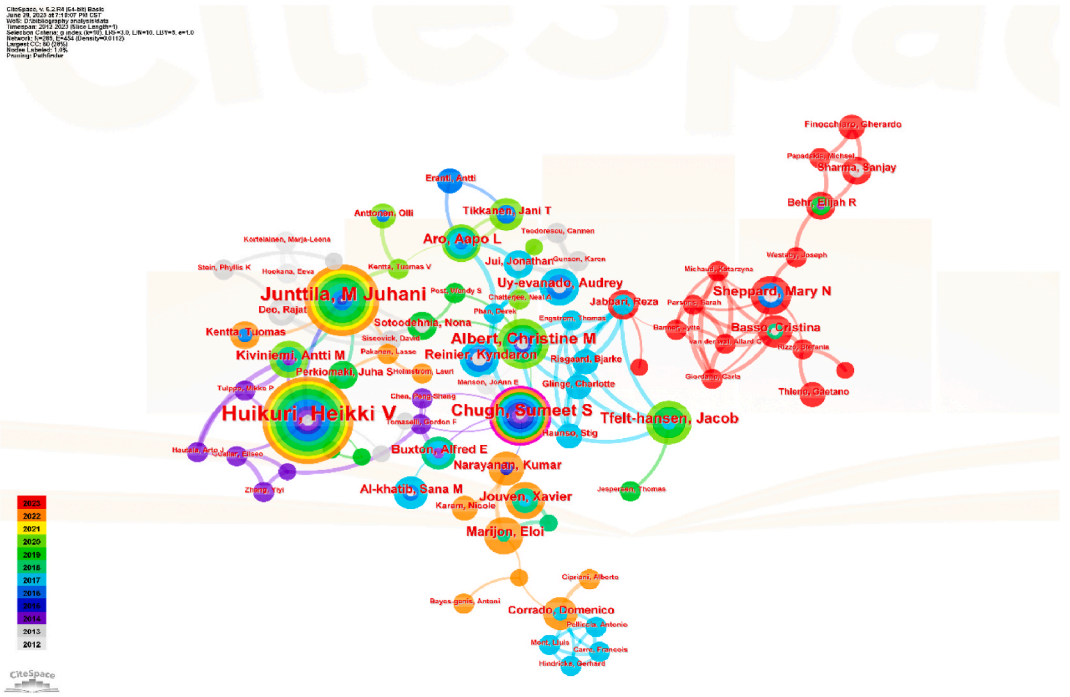

Fig. 4. CiteSpace visualization map of authors involved in sudden coronary death.

The power of journals is highly dependent on the number of times they are co-cited, which indicates whether the journal has a significant influence on a specific research field. The top 10 productive journals were presented in Table 4. Eight of the top 10 co-cited academic journals had been cited more than 1000 times. Circulation had the most publications (n = 2584), followed by Journal of the American College of Cardiology (n = 2254), and The New England Journal of Medicine (n = 1694). Furthermore, almost all the co-

Table 2
Top 10 authors related to sudden coronary death.

Rank	Authors	Count	Country	Institution	Centrality	Year
1	Huikuri HV	56	Finland	Oulu University	0.02	2012
2	Junttila MJ	39	Finland	Oulu University	0.05	2012
4	Chugh SS	22	USA	Cedars Sinai Medical Center	0.11	2013
3	Albert CM	20	USA	Harvard University	0.09	2012
6	Molossi S	19	USA	Baylor College of Medicine	0.00	2017
5	Tfelt-Hansen J	14	Denmark	European Heart Rhythm Association	0.00	2017
7	Laukkanen JA	13	Finland	University of Jyvaskyla	0.00	2016
8	Mery CM	12	USA	University of Texas Austin	0.00	2017
9	Sheppard MN	11	USA	St Georges University	0.02	2012
10	Aro AL	11	Finland	Meilahti Tower Hospital	0.06	2016

Table 3
Top 10 co-cited authors related to sudden coronary death.

Rank	Co-cited authors	Count	Country	Institution	Centrality	Year
1	Maron BJ	386	USA	Tufts Medical Center Hypertroph Cardiomyopathy Center	0.32	2012
2	Basso C	351	Spain	Lozano Blesa University Clinical Hospital	0.01	2012
3	Priori SG	310	Italy	University of Pavia	0.01	2012
4	Moss AJ	286	England	University of Leicester	0.08	2012
5	Myerburg RJ	265	USA	University of Miami	0.19	2012
6	Angelini P	261	USA	Texas Heart Institute	0.04	2012
7	Zipes DP	251	USA	Indiana University System	0.00	2012
8	Chugh SS	236	USA	Cedars Sinai Medical Center	0.14	2012
9	Corrado D	216	Italy	University of Padua	0.08	2012
10	Albert CM	214	USA	Harvard University	0.00	2012

Table 4
Top 10 journals and co-cited journals related to sudden coronary death.

Rank	Journal	Count	IF (2023)	JCR	Co-cited journal	Citation	IF (2023)	JCR
1	American Journal of Cardiology	98	2.8	Q3	Circulation	2584	37.8	Q1
2	International Journal of Cardiology	74	3.5	Q2	Journal of The American College of Cardiology	2254	24	Q1
3	Journal of The American Heart Association	60	5.4	Q2	New England Journal of Medicine	1694	158.5	Q1
4	European Heart Journal	50	39.3	Q1	European Heart Journal	1678	39.3	Q1
5	Europace	47	6.1	Q1	American Journal of Cardiology	1519	2.8	Q3
6	Journal of The American College of Cardiology	46	24	Q1	American Heart Journal	1165	4.8	Q2
7	Plos One	45	3.7	Q2	International Journal of Cardiology	1076	3.5	Q2
8	Heart Rhythm	42	5.5	Q2	JAMA-Journal of The American Medical Association	1067	120.7	Q1
9	Frontiers in cardiovascular medicine	39	3.6	Q2	Lancet	995	168.9	Q1
10	Circulation	38	37.8	Q1	Heart	906	5.7	Q2

cited journals belong to Q1/Q2 except for The American Journal of Cardiology and American Heart Journal.

The dual map of journals presents contributions and connections among journals. The labels represent different disciplines covered by the journals. The left side of the map shows citing journals, while the right side shows cited journals. From left to right, the colored paths portray the citation route between citing and cited journals. Three distinct citation paths existed (Fig. 5). Two green citation paths suggested that publications from medicine/medical/clinical journals were frequently cited from publications in health/nursing/medicine and molecular/biology/genetics. An orange path indicated that publications from molecular/biology/immunology were frequently cited from publications in molecular/biology/genetics.

3.5. Co-cited references analysis

References are essential parts of publications. The top 14 clusters labeled by the keywords of cited articles were obtained (Fig. 6). Clusters #2 (cardiac imaging), #3 (tachycardia), #4 (early repolarization), #7 (congenital heart disease), #8 (cardiovascular disease), #9 (wearable cardioverter-defibrillator), #10 (electrophysiology), and #11 (athletes heart) remained active until 2016. Clusters #0 (heart failure), #1 (anomalous aortic origin of a coronary artery), #5 (sports), #6 (sudden cardiac death), #12 (deep learning) and #13 (cardiovascular magnetic resonance imaging) have been active until now. Meanwhile, the top 10 cited references were listed in

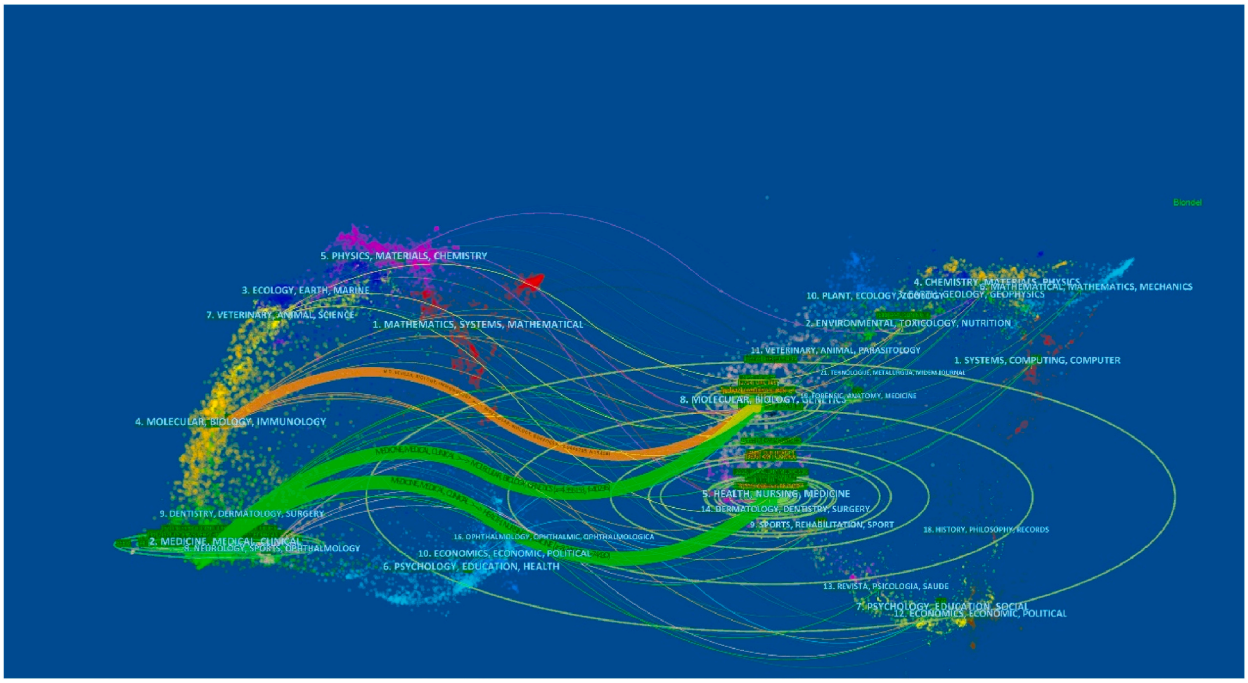

Fig. 5. The dual-map overlay of journals on sudden coronary death.

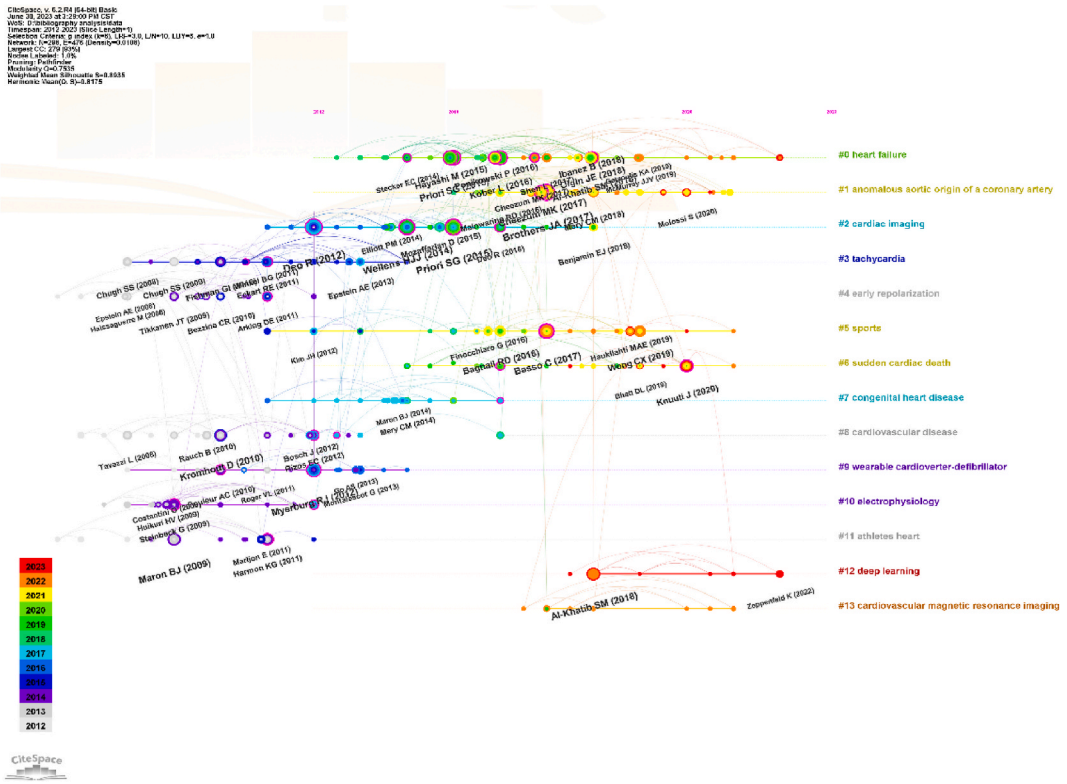

Fig. 6. Timeline view of co-cited references related to sudden coronary death.

Supplementary Table 1. The most frequently cited reference was "2015 ESC Guidelines for The Management of Patients with Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death" by Schwartz PJ, with a co-citation number of 50 from European Heart Journal (IF 2023 = 39.3, Q1). The second most cited paper was "Epidemiology and Genetics of Sudden Cardiac Death" by Albert CM, which received a co-citation number of 48 from Circulation (IF 2023 = 37.8, Q1) and the third most cited paper was "Anomalous Aortic Origin of a Coronary Artery-American Association for Thoracic Surgery Clinical Practice Guidelines" by Tweddell JS with a co-citation number of 47 from Journal of Thoracic and Cardiovascular Surgery (IF 2023 = 6, Q1).

3.6. Keywords analysis

Keywords indicate the core content of articles, which can further determine the edge advance in the specific field. CiteSpace was used to generate keywords co-occurrence map, keywords timeline view, and burst keywords, which could acquire hotspots and frontiers of sudden coronary death.

As shown in the keywords co-occurrence map (Fig. 7), sudden cardiac death was often associated with mortality, myocardial infarction, ventricular tachycardia, risk, and coronary artery disease. In addition to sudden cardiac death and risk, myocardial infarction also occurred with ventricular arrhythmia. For the sudden death, it interacted with coronary artery anomalies. The top twenty keywords with the most frequent occurrences were presented in Table 5. Sudden cardiac death with the count of 1210 times were the maximum, followed by myocardial infarction (n = 1194), risk (n = 849), and sudden death (n = 644). All keywords could be classified into 8 clusters (Supplementary Fig. 2), including treatment-related (#0 implantable cardioverter defibrillator, #6 percutaneous coronary intervention, and #5 scientific statement), outcome (#1 sudden coronary death and #7 sudden death), etiology (#2 cardiovascular disease and #3 coronary artery), and pathology (#4 ventricular fibrillation). As shown in the timeline view, Clusters #1, #2, and #6 were always existed up to now. The burst detection results revealed some articles that have attracted the attention of fellow scientists. As shown in the top 25 keywords with the strongest citation bursts (Fig. 8), guideline (9.49) showed the strongest burst strength, followed by outcome (7.76), and society (6.71). Polyunsaturated fatty acids, genome wide association, and heart rate first appeared in 2012 but lasted only 3 years. Recently, left ventricular ejection fraction (5.26), society, inflammation, and fractional flow reserve had become novel burst words that lasted until 2023. The results demonstrated that these words would be the focus of future research direction.

4. Discussion

This paper analyzed the spatial-temporal distribution, research collaborations, current hotpots, and frontier trends in sudden coronary death from 2012 to 2023 using bibliometrics and information visualization (CiteSpace). A total of 2914 articles were

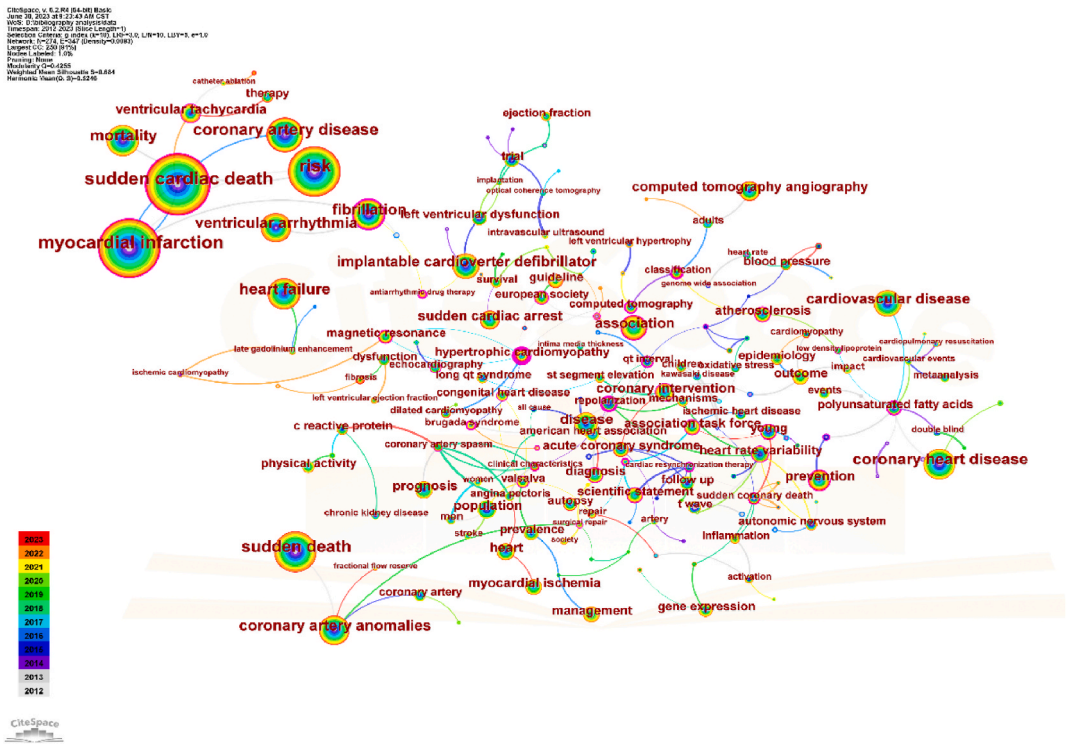

Fig. 7. CiteSpace visualization map of keywords related to sudden coronary death.

Table 5
Top 20 keywords related to sudden coronary death.

Rank	Keywords	Count	Centrality	Rank	Keywords	Count	Centrality
1	sudden cardiac death	1210	0.13	11	fibrillation	304	0.24
2	myocardial infarction	1194	0.18	12	cardiovascular disease	297	0.00
3	risk	849	0.03	13	implantable cardioverter defibrillator	282	0.10
4	sudden death	644	0.00	14	association	232	0.10
5	coronary artery disease	470	0.00	15	disease	227	0.01
6	heart failure	405	0.01	16	prevention	199	0.15
7	mortality	392	0.01	17	computed tomography angiography	175	0.00
8	coronary heart disease	377	0.09	18	ventricular tachycardia	168	0.10
9	coronary artery anomalies	347	0.07	19	sudden cardiac arrest	165	0.07
10	ventricular arrhythmia	331	0.01	20	population	157	0.05

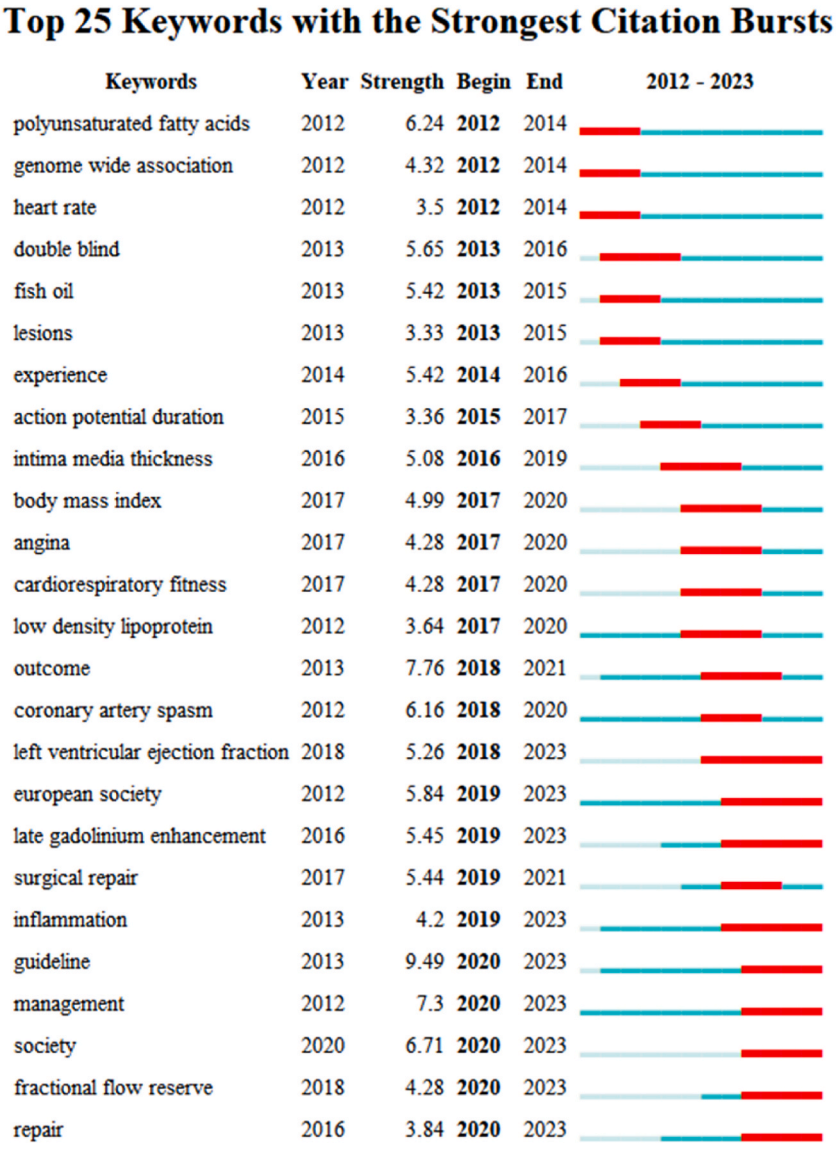

Fig. 8. Top 25 keywords with the strongest citation bursts involved in sudden coronary death.

identified, the annual publication output increased steadily, indicating that this question was still the focus of scholars (Supplementary Fig. 3).

4.1. General information

USA has the highest absolute productivity, with seven of the top 10 most productive institutions based there. Harvard University published 143 articles who had a jump on sudden coronary death. This indicated that the USA was the dominant country in sudden coronary death. Taken together, we thought that the reasons were as follows. Firstly, the USA is a highly developed country and continuously ranks high in measures of socioeconomic. Secondly, sudden coronary death is a major problem in the USA. Thirdly, the USA constructs American Heart Association, the world's leading professional and technical society for cardiology. Although China was the second-largest contributor, no author was at the top of the list. It was possible because China had only conducted a limited number of studies on sudden coronary death in the past 3 years, requiring more time and experiments to demonstrate. Huikuri HV, Junttila MJ, Chugh SS, and Albert CM were the top 4 most published authors. Huikuri HV and Junttila MJ worked together to search for biomarkers of sudden coronary death and to explore the relationship between diabetes and CAD [18, 19]. Chugh SS[20] proposed that integrating multiple widely available echocardiography parameters into the cumulative risk score could significantly improve SCD risk prediction. Albert CM focused on the epidemiological investigation and the risk of SCD[4, 21]), who indicated that higher magnesium intake and smoking cessation were associated with a lower risk of fatal CHD among women [22,23].

American Journal of Cardiology, in particular, published the most article, indicating that his journal was the most popular journal for scholars who studied the field of sudden coronary death. The journal with the most citations was Circulation, followed by Journal of the American College of Cardiology and New England Journal of Medicine. All these journals belong to Q1, suggesting that research on sudden coronary death was highly valued in the global academic field. Furthermore, the top 5 cited articles firstly provided the guidelines for the management and the prevention of SCD; then pointed out the enhancement of CAD as a cause of early sudden cardiac death; and finally put forward for the development of cumulative-effects models with CAD and identification of available risk markers in SCD, especially following myocardial infarction [24–29].

4.2. Research hotspots and frontiers

Keywords reflect the core contents of the literature. We can identify the research hotspots in each period and determine the evolving path of sudden coronary death using keyword co-occurrence analysis combined with co-cited references. To further clarify future research directions, timeline view from 2018 to 2023 was drawn (Supplementary Fig. 4). Based on these results, we determined research hotspots and frontiers in sudden coronary death. The main contents were as follows.

4.2.1. Research on etiology and pathology

Sudden coronary death is an unexpected sudden death on account of heart dysfunction, which is always confirmed by autopsy. At post-mortem examination, coronary heart disease and its ultimate consequence (myocardial infarction) are the most common causes of sudden coronary death, especially in over 35 years old person [28]. However, other etiologies without obvious postmortem signs can also lead to sudden coronary death.

Coronary artery anomalies (CAA) are the third etiology of sudden coronary death in our keyword occurrence, which is also the second-highest cause of sudden coronary death in young athletes from USA (30). The most lethal CAA are anomalous left coronary artery from pulmonary artery (ALCAPA) [30]. Sheppard MN et al. [30] put forward understanding the epidemiological burden of CAA and the risk of developing fatal arrhythmias that are necessary. Myocardial bridge (MB) is one of CAA into which coronary artery is embedded myocardium tissue. Sorin H et al. [31] present that autopsy studies should be the golden criterion in estimating the actual incidence of MB, which prompt us to pay more attention to autopsy results. Coronary artery spasm (CAS) with a burst strength of 6.16, resulting in total or subtotal occlusion with ST segment elevation or depression [32]. Early studies showed that CAS mostly occurs at atherosclerotic lesions, however, the latest research also found that CAS lack obstructive CAD [33, 34]. Sometimes, CAS may occur in the absence of increased oxygen demand in the central muscle of normal and diseased vessels [35]. Although CAS seems to be occurring less frequently, it is crucial for every clinician to be aware of its prevalence. Yasue H et al. [36]proposed that further studies were required to elucidate the pathogenesis and developed more effective and disease-modifying drugs.

The underlying mechanisms that predispose to sudden coronary death vary depending on the etiology and the chronic condition. So far, the precise mechanism of circulatory failure is often uncertain. Generally, CAD leads to polymorphic ventricular tachycardia (VT). Alternatively, monomorphic VT made for patients suffering from MI or persistent ischemia might degenerate into ventricular fibrillation (VF) [37]. Another mechanism is that autonomic nervous system is caused by abnormal metabolism and oxidative stress, which subsequently contributes to arrhythmia in the presence of coronary artery stenosis and myocardial ischemia [38]. Although VT and VF are the most common fatal arrhythmia, it appears that a considerable proportion of sudden coronary death is due to non-arrhythmic causes such as myocardial rupture and severe re-infarction [39].

Despite substantial progress has revealed new insights into the complex pathophysiology of sudden coronary death, the definition, classification, incidence, and clinical significance have not been elucidated. Hence, a better understanding of the epidemiological burden and risk stratification is needed. Additionally, more research into prevention addressing all etiologies, from CHD in the general population to the rarer non-atherosclerotic CAD (CAA or CAS), is needed to address many remaining uncertainties about the numerous factors underlying susceptibility to sudden coronary death.

4.2.2. Role of early risk factor in risk stratification

Important changes in the primary prevention and management of CAD have led to a significant decline in the number of deaths from CHD over the past 30 years [40]. However, the decline in sudden death has been less dramatic [39]. Hence, identifying early risk factors for prevention is an effective means to reduce the incidence of sudden coronary death. As described in the keywords co-occurrence, risk, association, and population were keywords most relevant to risk of sudden coronary death. Timeline views showed early repolarization, sports, and electrophysiology were the clusters of risk. Moreover, the recent research focused on cardiorespiratory fitness (CRF), body mass index (BMI), and left ventricular ejection fraction (LVEF).

The risk of sudden coronary death depends on a variety of factors and changes significantly over time. Reduced LVEF is a well-known predictor of death, and it is associated with a significantly increased risk of SCD[41]. Guidelines currently suggest clinical and exercise capacity assessments in combination with invasive and non-invasive imaging for risk stratification [42–45]. Moreover, QT interval [46], T-wave morphology dispersion [47], early repolarization pattern [48], and total cosine R-to-T [49] have been found to predict sudden coronary death. However, the sensitivity and specificity for prediction are inadequate. CRF and BMI have recently come into researchers' sight. CRF is briefly defined as the human body's ability to capture and use oxygen for physical activities or exercise involving numerous organs and systems. It can represent the comprehensive functional ability of the human body in response to physiological stimulation of stress, thus regarded as a powerful prognostic indicator of health outcomes [50]. Jimenez PD et al. [51] perform a meta-analysis on the CRF in the risk of sudden cardiac death and recommend more study to bring new understanding to the specific roles of CRF in the different population. BMI is an important international standard that is commonly used to access a person's obesity and health. One study finds that being overweight or obese is associated with lower mortality [52], while another study of the Japanese population shows that having a BMI more than 27.5 kg/m^2 was associated with increased MI mortality [53]. Apart from these elements, common risk factors for developing a CAD substrate, or expression of a coronary event involve heart rate variability [54], diabetes [55], coronary situation [56], midday nap habits [57], air pollution, temperature [58], age, sex, cholesterol, blood pressure, smoking, and physical fitness [59]. Although numerous researches have attempted to identify factors associated with a higher risk of sudden coronary death, their practical value is sometimes unclear. Conclusive evidence on the larger population sizes and confounders are essential for identifying patients with sudden coronary death. Therefore, this gives us a hint that parameter combinations can provide strong risk predictors.

4.2.3. Potential predictive biomarker and novel measurement method

Exploration of predictive biomarkers based on sudden coronary death has been a momentous field of ongoing research since the application of aspartate transaminase in the diagnosis of acute MI. Biomarker and inflammation were two of cluster #1 (sudden coronary death) in an 11-year timeline viewer, and machine learning (ML) was a new cluster. Deep learning and cardiovascular magnetic resonance imaging have been active until now. Moreover, the strongest citation bursts showed that low density lipoprotein and late gadoliniumn enhancement were prevalent beginning in 2017.

Plasma biomarkers, including not only traditional biomarkers like B type natriuretic peptide (BNP) [60] or troponin [18] but also inflammatory biomarkers as *C*-reactive protein (CRP) or high-sensitive CRP (hsCRP) [61], have improved CAD risk prediction. Moreover, researchers have investigated emerging biomarkers and further categories, such as inflammation (lpoprotein-associated phospholipase A2 [62], pentraxin-3 [63]), myocardial stress (soluble form of ST2 (18)), plaque stability (matrix metalloproteinase [64], transcription factor 3 [65], complement component 7 [66], OX40L and ICAM-1 [67]), myocardial fibrosis [68,69], RNA (circRNA [70–72], miRNA [73, 74], mRNA [75]), and DNA (SNP[9, 76, 77], insertion/deletion [78]). We find that the significance of serum predictive biomarkers for sudden coronary death has been established in these studies. Interesting, some previously reported nutrients like omega-3 fatty acids [79], nonesterified fatty acids [80], free fatty acids [81], and dietary magnesium [82] are still the focus of research by scholars. In addition to investigating the relationship between biomarkers and sudden coronary death, some studies have also explored their underlying mechanisms, so that we can achieve early prevention and postmortem diagnosis of sudden coronary death. Nie YY et al. [83] demonstrate that miR-96 promotes acute MI progression by directly targeting the X-linked inhibitor of apoptosis (XIAP) and inhibits the anti-apoptotic function of XIAP, which provides early prevention for acute MI.

With the emergence of high throughput technology, omics technology develops rapidly. Wang J et al. [84] use label-free quantitative proteomics to construct the corresponding network model and suppose that the cathepsin family could be a potential biomarker of sudden coronary death. Along with the rapid development of computer technology, various artificial intelligence algorithms provide new means for massive data mining and analysis. ML may become a valuable tool for SCD risk prediction due to its capacity to find patterns that are difficult for humans to identify [85–87]. Radiological technology based on coronary artery calcification can also be a clue for the diagnosis of sudden coronary death [88,89]. Jaber WA et al. [90] encouraged positron emission tomography with computed tomography assessment in CAA to reduce the occurrence of sudden death. Although increasing evidence indicates that novel biomarkers and measurement method can be used in the sudden coronary death, further research is required to be carried out with a specific research purpose.

4.2.4. Prevention and management of sudden coronary death

Lifestyle adjustments, the use of certain drugs, and treatment of the main condition are all part of the SCD prevention strategy. As shown in the timeline viewers, implantable cardioverter device (ICD), wearable cardioverter defibrillator (WCD), and sports have been active until now. Additionally, polyunsaturated fatty acids first appeared in 2012 but lasted only 3 years. One or two intakes of seafood long-chain n-3 polyunsaturated fatty acids per week are related to a modestly lower risk of fatal CHD [91]. Moderate physical activities reduce the occurrence of adverse outcomes from CAD (44). Concerning pharmacological prevention of sudden coronary death, beta-blockers are most widely used [92]. However, beta-blockers should be used only when the patient hemodynamic condition has

stabilized [93]. Amiodarone is another medication that reduces arrhythmia recurrence to prevent sudden coronary death [94]. Nevertheless, amiodarone fails to provide strong benefits in the long-term prescription due to various adverse effects and interactions. Yet, ICD is the mainstay of sudden coronary death prevention. Guidelines suggest the application of ICD use may be considered less than 40 days after an acute MI in patients with pre-existing LVEF dysfunction or 3 months after revascularization [24,94] and early prophylactic ICD implantation alleviates total and cardiac mortality [95]. Vest Prevention of Early Sudden Death Trial (VEST) evaluates the efficacy of the WCD in preventing sudden coronary death, however, WCD doesn't significantly reduce the major outcome rate of arrhythmia death [96]. Hence, large-scale studies of ICD and the efficiency of WCD are needed to confirm.

In brief, treatment of these prominent symptoms and optimization of cardiac function are essential to prevent sudden coronary death. Comprehensive analysis of multiple indicators is a promising approach to patient screening and risk stratification whereas ICD is a dominating tool for SCD prevention. Recently, significant efforts have been made to identify risk factors and biomarkers for sudden coronary death. However, the accurate identification of sudden coronary death has always been a key scientific and technical "bottleneck" problem at home and abroad. Therefore, continuous efforts should combine the etiologies, pathologies, risk factors, biomarkers, and novel measure methods, in order to provide new strategies for the diagnosis of sudden coronary death, and then provide scientific basis for the exploration of prevention and treatment strategies for high-risk patients with sudden coronary death.

4.3. Limitations

This study has some limitations as well. Firstly, there are many databases that acquire literature (such as PubMed, Socups, and others), but all the data in our study originate from the WoSCC database. Although most literature is contained in the WoSCC database, the literature included in our study may not be exhaustive. Secondly, the jagged quality of the included literature may result in some deviation. However, the knowledge map based on the included literature can quickly and intuitively understand the global trends, research hotspots and frontiers in fields related to sudden coronary death.

5. Conclusion

In summary, our knowledge and understanding of sudden coronary death have been significantly improved through intensive studies of reviews and articles from 2012 to 2023. According to the search, our paper is the first bibliometric analysis of sudden coronary death based on the CiteSpace. We effectively integrate literature data and reproduce the research process of sudden coronary death using information visualization techniques. The USA has the highest absolute productivity, and Harvard University has the greatest influence on sudden coronary death. Huikuri HV is an outstanding contributor who works closely with Junttila MJ to explore biomarkers of sudden coronary death. Currently, the research on sudden coronary death mainly focuses on the interaction of the etiologies and pathologies. Furthermore, the rational use of multiple indicators to individualize the assessment of sudden coronary death and other risk factor, the establishment of a novel sudden coronary death risk model and large-scale population studies will be developing research trends in the future.

Ethics approval and consent to participate

As a bibliometric analysis of existing publications, this study does not require ethical approval and no human subjects were enrolled.

Author contribution statement

Li Luo: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.
Chunmei Zhao: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.
Niannian Chen: Performed the experiments; Analyzed and interpreted the data.
Yiming Dong; Zhanpeng Li; Yaqin Bai; Peng Wu: Analyzed and interpreted the data.
Cairong Gao; Xiangjie Guo: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

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Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e18586.

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