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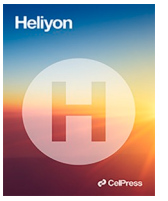

Review article

Knowledge domain and emerging trends in anxiety and depression after myocardial infarction research during 2002–2022: Bibliometric and visualized analysis

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ABSTRACT

Purpose: This study aimed to analyze developmental trends in anxiety and depression after myocardial infarction (ADMI) research in the past 20 years through bibliometrics analysis and predict future research directions.
Methods: ADMI-related publications were retrieved from the Web of Science Core Collection. Bibliometric, VOSviewer, CiteSpace, and Bibliometrix software packages were used for bibliometric analysis and visualization.
Results: Overall, 3220 ADMI-related publications were identified. The United States, China, and the Netherlands were the countries with the most publications. Carney RM, De Jonge P, and Blumenthal JA were the most influential researchers. In 2004, Van Melle JP, from the University of Groningen, published in *Psychosomatic Medicine* the most cited article. "Cardiac rehabilitation" was the primary focus area. "Cardiac rehabilitation," "management," "acute coronary syndrome," and "outcome" were the top four keywords in emerging research hotspots. Notably, the effect of traditional Chinese medicine on ADMI is an area of potential research value.
Conclusion: Numerous studies have underscored the significance of cardiac rehabilitation. Present research focuses on managing anxiety and depression post-acute coronary syndrome and enhancing clinical outcomes through cardiac rehabilitation technology. Additionally, the therapeutic potential of traditional Chinese medicine for ADMI is expected to attract increased attention from researchers in the future.

1. Introduction

Typical acute myocardial infarction (AMI) is a clinical syndrome caused by the ischemic necrosis of myocardial cells due to coronary artery occlusion or severe stenosis. It is a severe coronary heart disease and the leading cause of death and disability [1]. Anxiety

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and depression are common complications associated with AMI [2]. Numerous studies have shown that 30–50 % of patients experience varying degrees of anxiety and depression after AMI [3–5]. Previous studies have also confirmed that anxiety and depression after myocardial infarction (ADMI) negatively affect long-term prognosis and increase all-cause mortality [6]. Thus, the potential social burden and financial expenditure caused by ADMI demonstrate that it deserves more attention [7]. However, the pathogenesis and intervention measures for ADMI require further investigation. Research in this field began with its first article published in 1994, gradually increasing since 2002. Currently, over 150 research articles are published annually, indicating significant clinical and societal value for further, in-depth exploration and investigation in this field. Therefore, summarizing the development status and research hotspots, predicting the developmental trends in ADMI research, and carrying out in-depth analysis in this field are of utmost importance.

Bibliometric analysis is a tool used to comprehensively evaluate research progress in a specific scientific data field. It has been used in many research fields to measure the interrelationship and impact between publications through mathematical and statistical tools [8,9]. Bibliometric analysis provides qualitative and quantitative analysis of publications and identification of important research hotspots and trends. Additionally, it has unique advantages in identifying key researchers, central publications, core journals, and important research institutions in a field [10]. Bibliometrics have been widely used in various medical fields, including complementary and alternative medicine [11], cardiology, oncology [12], nursing [13], and epidemiology [14]. Despite the development of ADMI research with many published articles, there is a lack of summary and analysis of the characteristics of publications. Accordingly, this study aimed to use bibliometric methods to analyze publications on ADMI, systematically evaluate the research status, hotspots, and trends, highlight landmark achievements from 2002 to 2022, identify future research directions to clarify prediction ideas for future research hotspots and potential trends, and provide more reference angles for research.

2. Materials and methods

2.1. Data source and search strategy

We searched the Web of Science Core Collection (WoSCC) database on March 20, 2023, in Guangzhou University of Chinese Medicine, Guangdong Province, China, and retrieved and summarized publications on ADMI from 2002 to 2022. Publications were limited to Science Citation Index Expanded and publication types to “article” or “review.” The main search terms were as follows: “Anxiety after myocardial infarction,” “depression after myocardial infarction,” “fear after myocardial infarction,” and “anger after myocardial infarction,” among others. The detailed search strategy is included in the supplementary material. For data accuracy, we downloaded all eligible data from the WoSCC database on March 20, 2023, and bibliometric tools were used for further analysis.

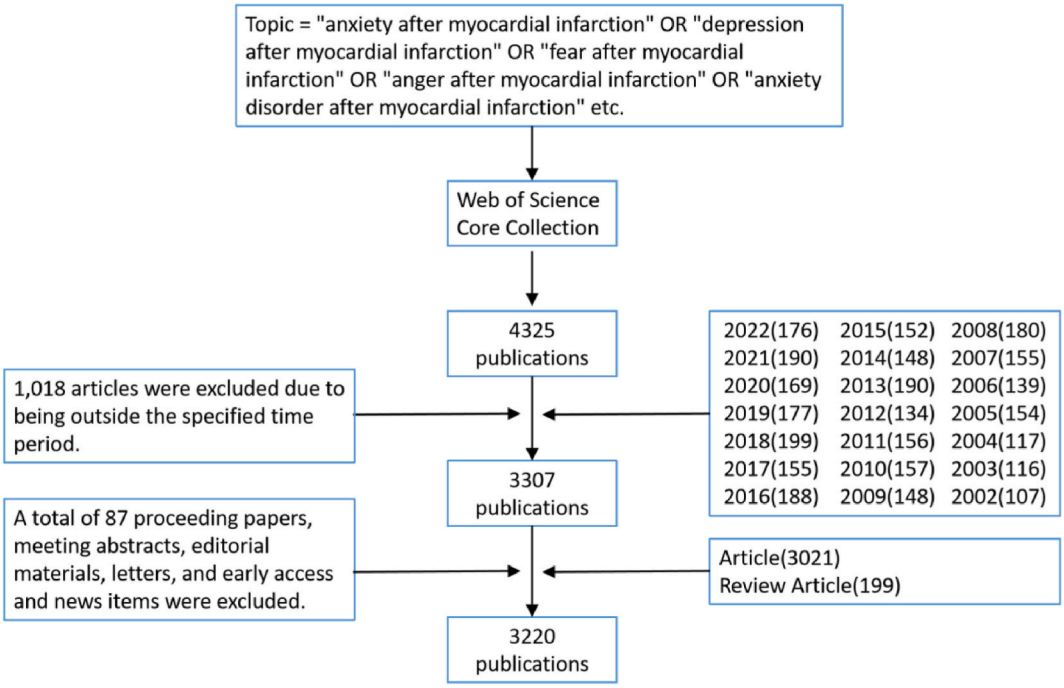

Fig. 1. Flowchart of identification and selection of the studies.

2.2. Statistical analysis

Key information was extracted from the articles that met the required criteria, including title, author, research institution, country or region, keywords, year of publication, source, number of citations, and 2020 impact factor. Bibliometric analysis (https://bibliometric.com) was conducted to track changes in publication trends over time, analyze the proportion of national publications, and assess collaboration between countries. VOSviewer (version 1.6.19) was used to analyze inter-agency collaboration and identify keywords. CiteSpace (version 6.2.R2) was used to analyze co-cited references and keywords. Additionally, Bibliometrix 4.0.0 Package (https://www.bibliometrix.org), based on R language, was used to analyze the number of publications and citations, publications and collaboration between countries, authors' production, burst references, and burst keywords.

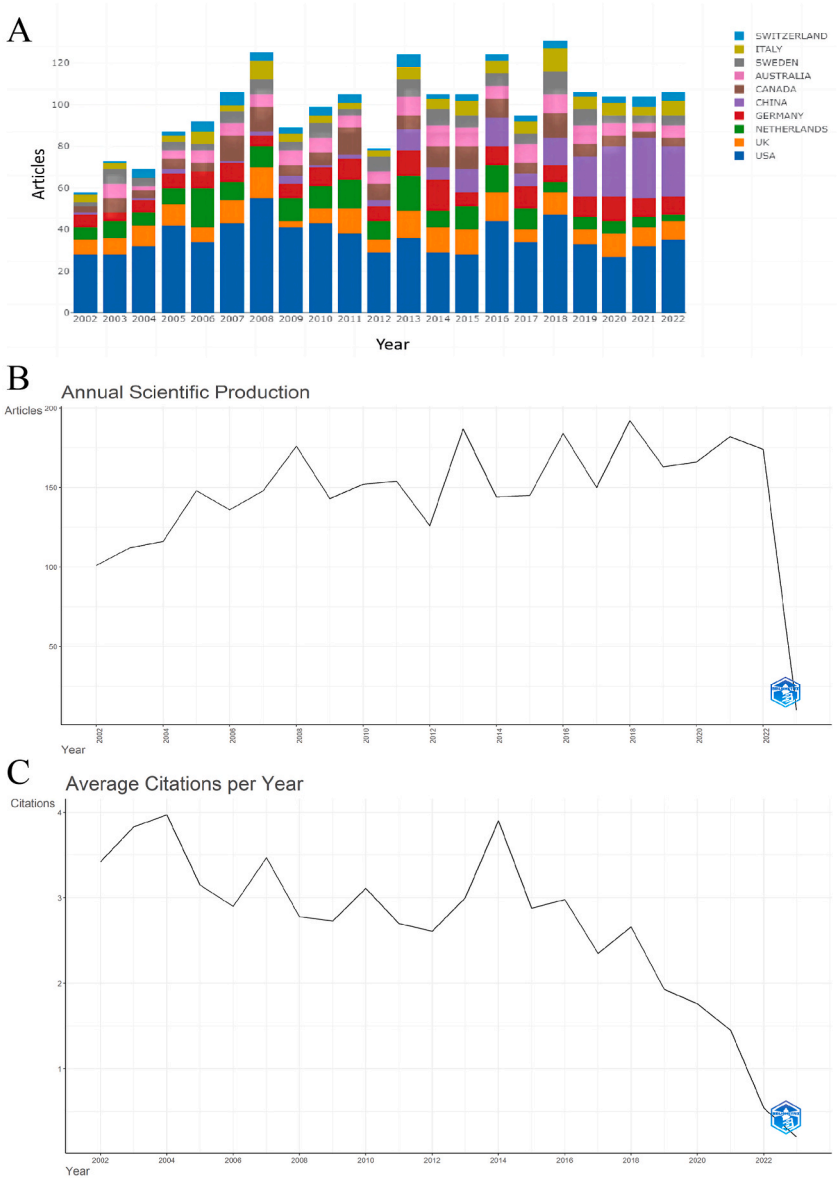

Fig. 2. Number of publications and citations on the anxiety and depression after myocardial infarction between 2002 and 2022. (A) Changes in the number of publications over the years and proportion of national publications; (B) annual scientific production; (C) average number of citations per year.

3. Results

3.1. Publication characteristics

Overall, 4325 publications were obtained from the WoSCC database. Subsequently, we obtained 3307 publications by limiting the publication time of the articles from 2002 to 2022. Furthermore, by limiting the publication types to articles and reviews, we selected 3220 publications as a data collection for bibliometric analysis (Fig. 1).

Between 2002 and 2022, a discernible upward trend was found in the number of articles on ADMI, which was subsequently stabilized at a high level. This trend indicated that ADMI has consistently been researched topics worthy of attention, with continually increasing significance (Fig. 2A and B). Furthermore, our analysis revealed a general decline in the number of citations, with the highest point observed in 2004 and a substantial increase in citations occurring in 2014 (Fig. 2C).

3.2. Distribution of publications by country

Overall, 78 countries and regions participated in the publication of 3220 articles and reviews. The United States had the highest number of articles (905), followed by China (225), the Netherlands (201), Germany (192), and Canada (156). The United States also had the highest number of citations (45,051), followed by the Netherlands (10,196), the United Kingdom (8,085), Canada (7,695), and Germany (5,791) (Table 1).

Among the top 20 countries with the most publications, 12 were in Europe, 5 in Asia, and 2 in North America; however, American countries had the highest number of publications. Intercountry exchanges were mainly centered between American-European, American-Asian, and American-Australian countries (Fig. 3A, B, and 3C).

We constructed the co-authorship network for institutions that published $\geq$10 papers (T = 10) by using VOSviewer. Duke University, University of North Carolina, and Yale Universityhad larger nodes, owing to the more significant impact of their published research (Table 2, Fig. 4A).

3.3. Author distribution

Through analyzing the authors of publications, we found that Carney RM, Freedland KE, Blumenthal JA, Vaccarino V, and Krumholz HM have been working in the field of ADMI for at least 20 years and were early investigators. Among them, Carney RM's articles from 2002 to 2006 also greatly influenced the field. De Jonge began conducting research in this field in 2004, and his articles published from 2006 to 2013 had significant influence; however, recently, they have published fewer articles than before (Fig. 4B).

Carney RM of Washington University was the most cited local author (784 citations), followed by De Jonge P of the University of Groningen (733 citations) and Blumenthal JA of Duke University (478 citations). Among them, Carney and De Jonge P had the highest number of publications and local citation frequency and are key experts worthy of attention in the field of ADMI (Table 3).

3.4. Journal distribution

Publications of ADMI research were published in 833 journals between 2002 and 2022. Table 4 shows the top 10 journals with the

Table 1
Top 20 productive and impactful countries concerning ADMI research.

Top 20	Production (articles)	Times cited
USA	905	45051
China	225	2178
Netherlands	201	10196
Germany	192	5791
Canada	156	7695
United Kingdom	152	8085
Sweden	133	3523
Italy	121	3619
Australia	107	450
Japan	84	1374
South Korea	83	814
Denmark	77	1736
Switzerland	63	1704
Poland	59	766
Spain	58	1091
Iran	56	490
France	48	2029
Turkey	46	459
Norway	44	1359
Finland	42	1020

ADMI, anxiety and depression after myocardial infarction.

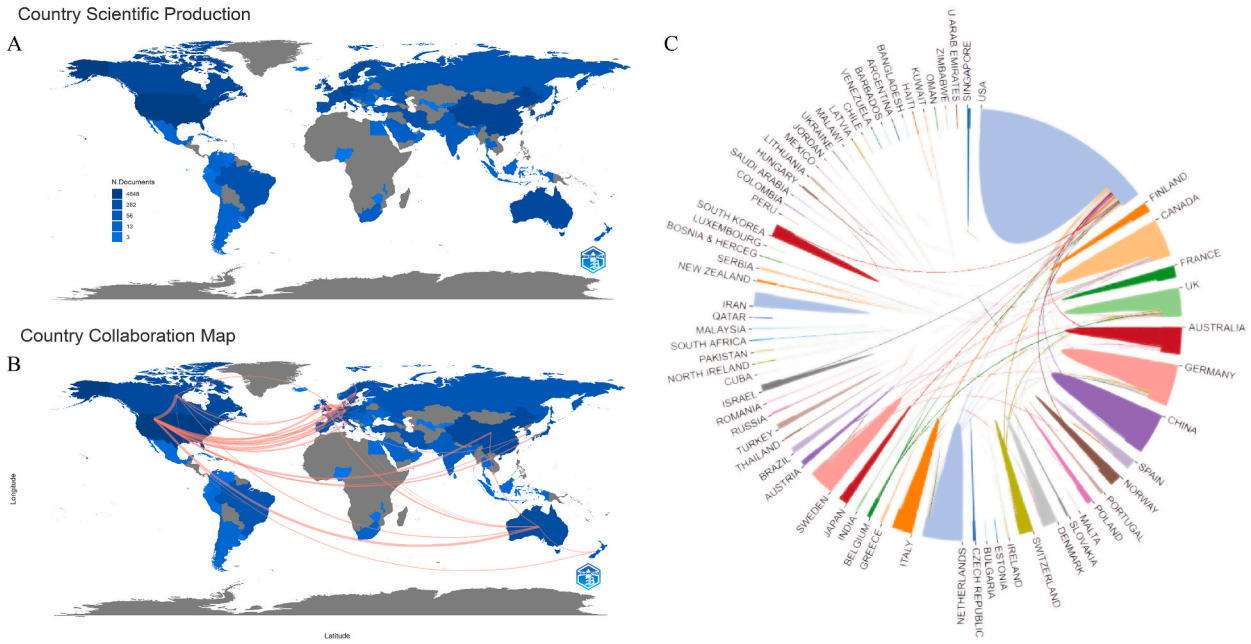

Fig. 3. Countries associated with anxiety and depression after myocardial infarction research between 2002 and 2022. (A) The number of publications arising from various countries; (B) country collaboration map; (C) international collaboration between countries.

Table 2
Top 20 productive and impactful institutions concerning ADMI research.

Top 10	Production (articles)	LCS
University of Groningen	171	4697
Columbia University	152	3726
Duke University	149	3726
Yale University	129	5409
Tilburg University	128	5282
University of San Francisco	126	3773
Washington University	118	5428
Emory University	114	3545
Harvard University	112	3545
Karolinska Institute	110	1374

ADMI, anxiety and depression after myocardial infarction; LCS, local citation score.

largest number of publications. The articles published in these journals accounted for 20.37 % of the total number of publications. Psychosomatic Medicine (145 articles with 10,163 citations) was the most prolific and the most cited journal, followed by American Journal of Cardiology (81 articles, cited 2968 times) and Journal of Psychosomatic Research (published 79 articles and cited 2597 times).

The dual-map overlay shows the five main citation paths (Fig. 5). The reference journal is placed on the left, referenced journal on the right, and the color path represents the reference relationship [15]. The publications were primarily published in journals in the fields of medicine, clinical medicine, neurology, sports, psychology, education, and health, whereas most cited publications were published in journals in the fields of molecular biology, genetics, health, nursing, medicine, psychology, education, society, economics, and politics.

3.5. Co-cited references

Based on the local citation frequency of the literature, the 10 most influential articles on ADMI were selected. Among these, Van Melle JP had the highest local citation score in the literature published in Psychosom Med in 2004, followed by Thombs BD's article in J Gen Intern Med in 2006 and Glassman AH's article in JAMA in 2002. Among the top 10 locally cited studies, two were from Psychosom Med, JAMA, and Circulation, indicating that these three journals profoundly influence the field of ADMI (Table 5).

Finally, we performed a reference burst. Cluster analysis of co-cited references showed that co-cited references could be divided into nine clusters (Fig. 6A). Physical activity, depressive symptoms, and anxiety were the top three clusters with the largest size (Fig. 6B–Table 6). Based on the Cluster analysis of co-cited references, we analyzed the top 10 references in clusters 0, 1, 2, 3, and 4

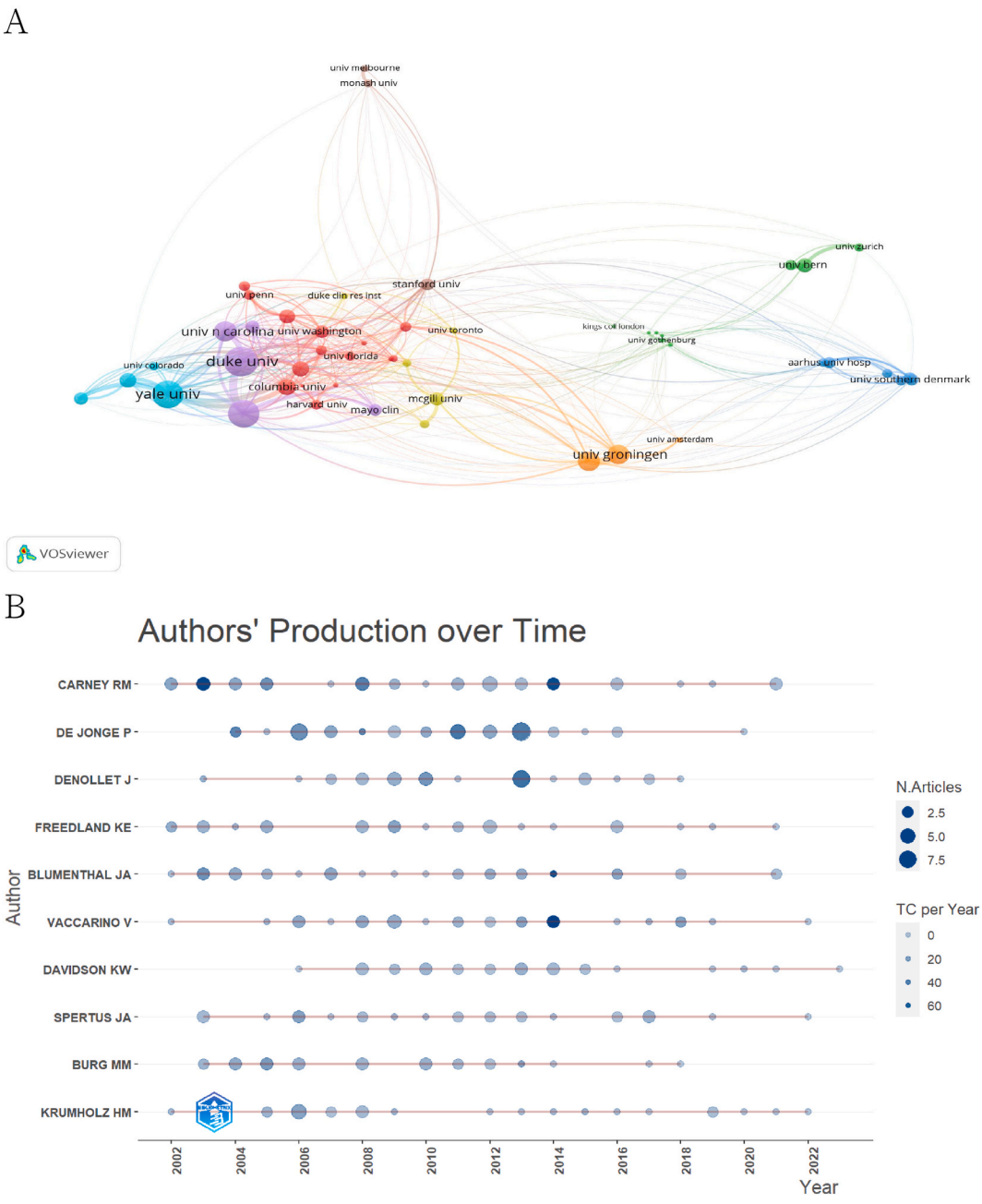

Fig. 4. Distribution of publications by institution and author. (A) Network map of institutions; (B) authors' production over time.

(Table 7). As shown in Fig. 6B, physical activity received extensive attention from researchers in this field around 2015, with its popularity gradually declining in recent years. Conversely, depressive symptoms have been increasingly studied since 2010 and continue to attract sustained attention, likely becoming a future research hotspot in this field. However, research on anxiety mainly concentrated before 2015, experiencing a decline in popularity in recent years. Other clusters, such as cardiovascular prognosis, coronary artery bypass grafts, acute coronary syndromes, and type-D personality, were all studied before 2015. In recent years, interest in "Life's simple 7" has decreased, while research on coronavirus disease-19 has received more attention in recent years, expected to emerge as a future research hotspot in this field. Fig. 6C shows the most representative burst strength, duration, and time references. The article by Berkman et al. [16] had the highest burst strength. Berkman et al. [16] conducted a prospective randomized controlled trial demonstrating that psychosocial intervention could improve depression and social isolation in patients with coronary heart disease. The results showed that although the psychosocial intervention group had some improvement, it did not reach the expected level [16].

Table 3
Top 10 productive and impactful authors.

Top 10	Institution	Production (articles)	LCS
Carney RM	Washington University	43	784
De Jonge P	University of Groningen	43	784
Denollet J	Tilburg University	32	278
Freedland KE	Washington University	30	248
Blumenthal JA	Duke University	29	478
Vaccarino V	Emory University	29	343
Davidson KW	Columbia University	26	79
Spertus JA	University of Missouri	26	222
Burg MM	Yale University	25	232
Krumholz HM	Yale University	25	192

LCS, local citation score.

Table 4
Top 10 most productive and impactful journals.

Top 10	Production (articles)	Times cited	IF (2021)	H-index
Psychosomatic Medicine	145	10163	3.864	59
American Journal of Cardiology	81	2968	27.206	31
Journal of Psychosomatic Research	79	2597	4.62	32
International Journal of Cardiology	68	1365	4.036	20
American Heart Journal	66	2596	5.099	29
PLOS One	55	1448	3.752	21
Journal of Affective Disorders	47	819	6.533	17
Circulation	41	4867	39.922	34
European Heart Journal	38	2801	35.855	26
Heart	36	1283	7.369	21

H-index, Hirsch index; IF, impact factor.

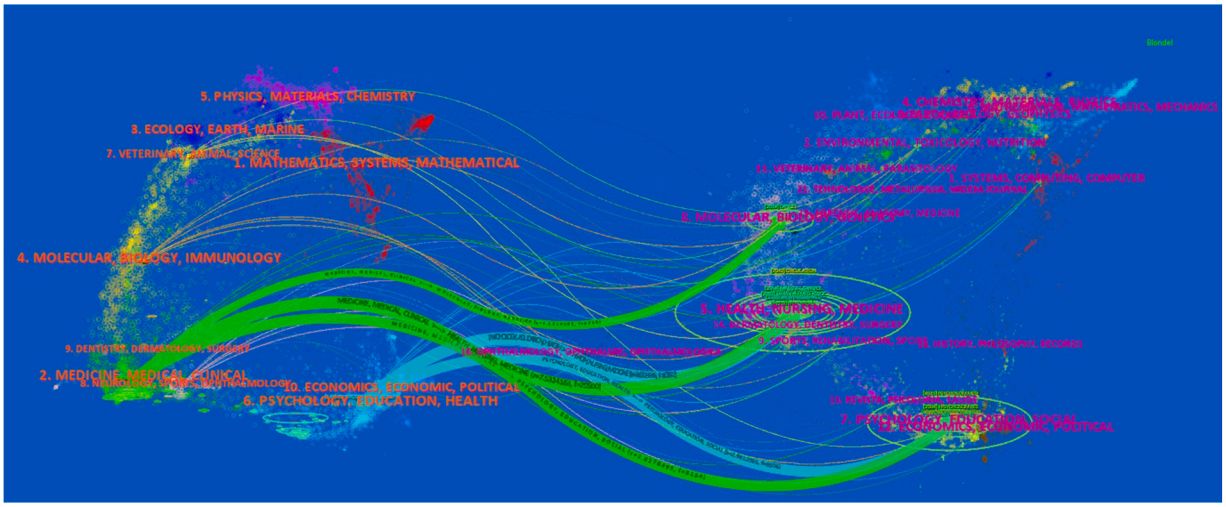

Fig. 5. Dual-map overlay of journals related to anxiety and depression after myocardial infarction research.

3.6. Analysis of keywords

Our cluster analysis of 4745 keywords in the data collection showed seven cluster results (Fig. 7A, Table 8). The modularity Q of the cluster was 0.3008, and the mean silhouette value was 0.683. The timeline of clustering showed that "cardiac rehabilitation" was the more important area of research in this field (Fig. 7B).

We analyzed the thematic evolution of the keywords and found that the initial research on "anxiety and depression after myocardial infarction" focused on the themes of "coronary heart disease," "myocardial infarction," and "inflammation," among others. As the research field has advanced, the main research hotspots have gradually shifted toward "management" and "percutaneous coronary intervention," among others. In the last 3 years, "trial," "outcomes," and "cardiomyopathy" have been gaining attention (Fig. 7C).

"Cardiac rehabilitation" and "prognosis" had the highest burst strength. "Management," "cardiac rehabilitation," "acute coronary

Table 5
Top 10 studies with the highest number of citations.

First author	Institution	Journal	IF (2021)	Year	LCS	GCS
Van Melle JP	University of Groningen	Psychosomatic Medicine	3.864	2004	251	753
Thombs BD	Johns Hopkins University	Journal of General Internal Medicine	6.473	2006	200	548
Glassman AH	New York State Psychiatric Institute	JAMA	157.375	2002	192	1000
Barth J	University of Freiburg	Psychosomatic Medicine	3.864	2004	168	918
Lespérance F	University of Montreal	Circulation	39.921	2002	145	519
Lichtman JH	Yale University	Circulation	39.921	2014	130	684
Roest AM	Tilburg University	Psychosomatic Medicine	3.864	2010	93	250
Strik JJMH	Maastricht University	American Journal of Cardiology	27.206	2003	82	265
Whooley MA	San Francisco Department of Veterans Affairs Medical Center	JAMA	157.375	2008	79	573
Blumenthal JA	Duke University	LANCET	202.731	2003	75	430

LCS, local citation score; IF, impact factor; GCS, global citation score.

Figure 6

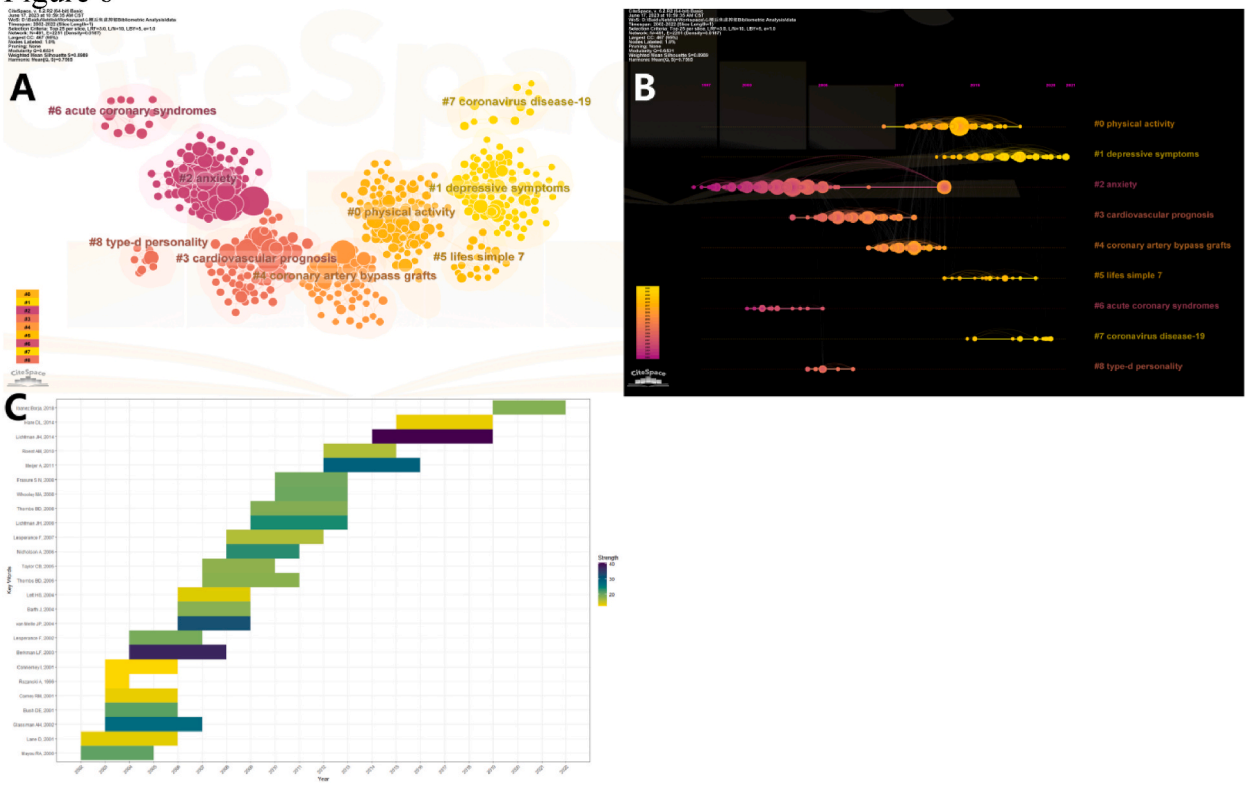

Fig. 6. Visualization of co-cited reference analysis. (A) Cluster analysis of co-cited references; (B) timeline distribution of the top nine clusters; (C) representative burst references among the top 25 references with the strongest citation bursts.

Table 6
Co-reference cluster analysis of ADMI research.

Cluster ID	Size	Silhouette	Mean year	Top terms	Log (likelihood ratio)
#0	100	0.818	2013	Physical activity	14.98
#1	91	0.895	2017	Depressive symptoms	9.65
#2	86	0.974	2001	Anxiety	11.56
#3	69	0.874	2007	Cardiovascular prognosis	7.03
#4	65	0.886	2010	Coronary artery bypass grafts	7.48
#5	22	0.969	2015	Lifes simple 7	7.43
#6	13	0.985	2002	Acute coronary syndromes	20.01
#7	13	0.978	2018	Coronavirus disease-19	7.78
#8	8	0.993	2005	Type-d personality	11.43

ADMI, anxiety and depression after myocardial infarction.

Table 7
Top 10 references in clusters 0, 1, 2, 3, and 4 based on Cluster analysis of co-cited references.

	References	Journal	GCS	Contents
#0 physical activity				
1	Ibanez Borja, 2018	Kardiol Pol.	1256	2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation
2	Smolderen KG, 2017	Circulation	69	Depression Treatment and 1-Year Mortality After Acute Myocardial Infarction: Insights From the TRIUMPH Registry
3	Kim JM, 2018	JAMA	100	Effect of Escitalopram vs Placebo Treatment for Depression on Long-term Cardiac Outcomes in Patients With Acute Coronary Syndrome: A Randomized Clinical Trial
4	Correll CU, 2017	World Psychiatry	753	Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls
5	Feng LM, 2019	Medicine (Baltimore)	250	Prevalence of depression in myocardial infarction: A PRISMA-compliant meta-analysis
6	Carney RM, 2017	Nat Rev Cardiol.	102	a review article of the relationship between Depression and coronary heart disease
7	Richards SH, 2017	Cochrane Database Syst Rev	147	Psychological interventions for coronary heart disease
8	Celano CM, 2015	Am Heart J.	117	Association between anxiety and mortality in patients with coronary artery disease: A meta-analysis
9	Collet JP, 2021	Eur Heart J.	1141	2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation
10	Ghadri JR, 2018	Eur Heart J.	684	International Expert Consensus Document on Takotsubo Syndrome (Part I): Clinical Characteristics, Diagnostic Criteria, and Pathophysiology
#1 depressive symptoms				
1	Meijer A, 2011	Gen Hosp Psychiatry	335	Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: a meta-analysis of 25 years of research
2	Lichtman JH, 2008	Circulation.	684	Depression and coronary heart disease: recommendations for screening, referral, and treatment
3	Nicholson A, 2006	Eur Heart J.	104	Depression as an aetiologic and prognostic factor in coronary heart disease: a meta-analysis of 6362 events among 146,538 participants in 54 observational studies
4	Thombs BD, 2008	JAMA.	87	Depression screening and patient outcomes in cardiovascular care: a systematic review
5	Whooley MA, 2008	JAMA.	573	Depressive symptoms, health behaviors, and risk of cardiovascular events in patients with coronary heart disease
6	Frasure-Smith N, 2008	Arch Gen Psychiatry.	395	Depression and anxiety as predictors of 2-year cardiac events in patients with stable coronary artery disease
7	Lesperance F, 2007	JAMA.	45	Effects of citalopram and interpersonal psychotherapy on depression in patients with coronary artery disease: the Canadian Cardiac Randomized Evaluation of Antidepressant and Psychotherapy Efficacy (CREATE) trial
8	Roest AM, 2010	Psychosom Med.	250	Prognostic association of anxiety post myocardial infarction with mortality and new cardiac events: a meta-analysis
9	Van Melle JP, 2007	Br J Psychiatry.	102	Effects of antidepressant treatment following myocardial infarction
10	Davidson KW, 2010	Arch Intern Med.	58	Enhanced depression care for patients with acute coronary syndrome and persistent depressive symptoms: coronary psychosocial evaluation studies randomized controlled trial
#2 anxiety				
1	van Melle JP, 2004	Psychosom Med.	753	Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: a meta-analysis
2	Glassman AH, 2002	JAMA.	1000	Sertraline treatment of major depression in patients with acute MI or unstable angina
3	American Psychiatric Association [APA], 2013	–	22	Diagnostic and statistical manual of mental disorders
4	Thombs BD, 2006	J Gen Intern Med.	548	Prevalence of depression in survivors of acute myocardial infarction
5	Bush DE, 2001	Am J Cardiol.	32	Even minimal symptoms of depression increase mortality risk after acute myocardial infarction
6	Lesperance F, 2002	Circulation.	66	Five-year risk of cardiac mortality in relation to initial severity and one-year changes in depression symptoms after myocardial infarction
7	Barth J, 2004	Psychosom Med.	519	Depression as a risk factor for mortality in patients with coronary heart disease: a meta-analysis
8	Taylor CB, 2005	Arch Gen Psychiatry.	918	Effects of antidepressant medication on morbidity and mortality in depressed patients after myocardial infarction
9	Mayou RA, 2000	Psychosom Med.	393	Depression and anxiety as predictors of outcome after myocardial infarction
10	Lett HS, 2004	Psychosom Med.	11	Depression as a risk factor for coronary artery disease: evidence, mechanisms, and treatment
#3 cardiovascular prognosis				
1	van Melle JP, 2004	Psychosom Med.	753	association of depression following myocardial infarction with mortality and cardiovascular events: a meta-analysis
2	Lichtman JH, 2008	Circulation.	30	Depression and coronary heart disease: recommendations for screening, referral, and treatment
3	Frasure-Smith N, 2008	Arch Gen Psychiatry.	395	Depression and anxiety as predictors of 2-year cardiac events in patients with stable coronary artery disease

(*continued on next page*)

Table 7 (*continued*)

	References	Journal	GCS	Contents
4	Nicholson A, 2006	Eur Heart J.	26	Depression as an aetiologic and prognostic factor in coronary heart disease: a meta-analysis of 6362 events among 146,538 participants in 54 observational studies
5	Thombs BD, 2008	JAMA.	23	Depression screening and patient outcomes in cardiovascular care: a systematic review
6	Whooley MA, 2008	JAMA.	573	Depressive symptoms, health behaviors, and risk of cardiovascular events in patients with coronary heart disease
7	Thombs BD, 2006	J Gen Intern Med.	548	Prevalence of depression in survivors of acute myocardial infarction
8	Lett HS, 2004	Psychosom Med.	58	Depression as a risk factor for coronary artery disease: evidence, mechanisms, and treatment
9	Lesperance F, 2007	JAMA.	66	Effects of citalopram and interpersonal psychotherapy on depression in patients with coronary artery disease: the Canadian Cardiac Randomized Evaluation of Antidepressant and Psychotherapy Efficacy (CREATE) trial
10	Strik JJMH, 2003	J Am Coll Cardiol.	265	Comparing symptoms of depression and anxiety as predictors of cardiac events and increased health care consumption after myocardial infarction
#4 coronary artery bypass grafts				
1	Glassman AH, 2002	JAMA.	1000	Sertraline treatment of major depression in patients with acute MI or unstable angina
2	Bush DE, 2001	Am J Cardiol.	47	Even minimal symptoms of depression increase mortality risk after acute myocardial infarction
3	Lesperance F, 2002	Circulation.	519	Five-year risk of cardiac mortality in relation to initial severity and one-year changes in depression symptoms after myocardial infarction
4	Mayou RA, 2000	Psychosom Med.	35	Depression and anxiety as predictors of outcome after myocardial infarction
5	Rozanski A, 1999	Circulation.	24	Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy
6	Musselman DL, 1998	Arch Gen Psychiatry.	90	The relationship of depression to cardiovascular disease: epidemiology, biology, and treatment
7	Ziegelstein RC, 2000	Arch Intern Med.	40	Patients with depression are less likely to follow recommendations to reduce cardiac risk during recovery from a myocardial infarction
8	Penninx BWJH, 2001	Arch Gen Psychiatry.	220	Depression and cardiac mortality: results from a community-based longitudinal study
9	Lane D, 2001	Psychosom Med.	116	Mortality and quality of life 12 months after myocardial infarction: effects of depression and anxiety
10	Lesperance F, 2000	Arch Intern Med.	86	Depression and 1-year prognosis in unstable angina

syndrome," and "outcome" were the most recent keywords to emerge from 2015 (Fig. 7D).

After excluding descriptive keywords, such as "myocardial-infarction," "acute myocardial-infarction," "depression," "anxiety," and other descriptive keywords, this analysis identified the 100 most relevant keywords. These keywords were grouped into the following five main categories: mortality, cardiac rehabilitation, prevalence, symptoms, and prognosis. It is worth noting that the therapeutic effect of Chinese medicine, such as Shuangxinfang (occurrences: two), Chai hu jia long gu mu li granule (occurrences: two), Puerarin (occurrences: two), and Tongxinluo Capsule (occurrences: one), among others, on ADMI was a potential hotspot with research value (Fig. 7E).

During the analysis, we also identified seven articles that were representative and significant for the development of the field (Fig. 8). The results showed that annual publications related to ADMI have generally been on a steady upward trend since 2002, with a brief surge in annual publications in 2004, 2008, 2013, 2016, and 2018. In 2002, the field was still in its early stages of development, and Lespérance et al. confirmed the correlation between anxiety and depression and the long-term prognosis of patients with AMI [17]. Many large prospective and retrospective clinical studies and multiple meta-analyses have been conducted in various countries in this field. Through years of research, sufficient evidence-based medical findings regarding ADMI have accumulated. In 2014, Lichtman et al. recommended to the American Heart Association that depression should be elevated as a risk factor for poor medical outcomes in patients with acute coronary syndromes [6].

4. Discussion

In this study, we used the bibliometric research method to analyze the main developmental context, research hotspots, and future research trends in the field of ADMI. We found that the United States was the most productive country; 7 of the top 10 most productive institutions were from the United States for ADMI research. Columbia University (published 152 articles) was the main representative, and the most frequently cited institution was Washington University (cited 5428 times). The research results of Carney RM's team from this institution have been influential in the field. They focused on the correlation between coronary heart disease and anxiety, depression, and the treatment of ADMI [18,19]. Their recent study found that antidepressants had the most robust evidence base and should be the first-line treatment for post-coronary artery disease-related depression. Moreover, combinations of antidepressants, psychotherapy, and exercise could be more effective than antidepressants alone [20]. The United States published 5 of the top 10 most cited articles. Johns Hopkins University's Thombs et al. is currently the most cited article in the United States (local citations, 251 times) [2]. This study found that depression was common and persistent in AMI survivors. The prevalence varies according to the assessment method. Van Melle et al. [21] of the University of Groningen had the highest number of local citations (local citations, 200 times); he conducted a meta-analysis demonstrating that depression after myocardial infarction was associated with a 2-to 2.5-fold increased risk of impaired cardiovascular outcomes.

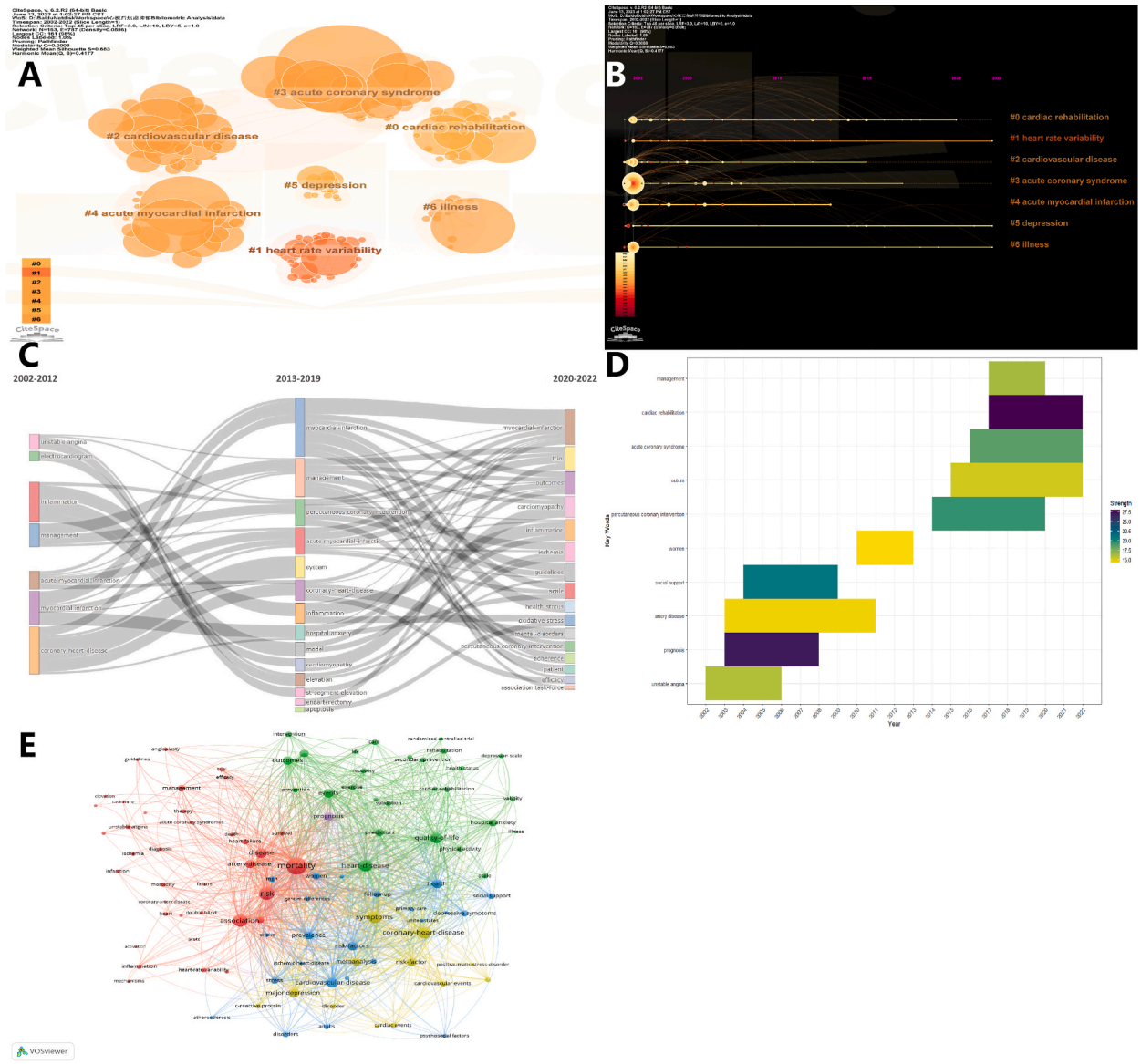

Fig. 7. Visualization of keyword analysis. (A) Cluster analysis of keyword; (B) timeline distribution of cluster analysis of keyword; (C) Sankey diagram of the keyword evolution of anxiety and depression after myocardial infarction research; (D) representative burst keywords among top 25 references with the strongest citation bursts; (E) the network map of keywords.

Table 8
Keyword cluster analysis of ADMI research.

Cluster ID	Size	Silhouette	Mean year	Top terms	Log (likelihood ratio)
#0	29	0.68	2008	Cardiac rehabilitation	104.46
#1	27	0.513	2005	Heart rate variability	55.63
#2	27	0.723	2004	Cardiovascular disease	92.43
#3	26	0.763	2005	Acute coronary syndrome	45.74
#4	21	0.695	2004	Acute myocardial infarction	64.39
#5	16	0.737	2008	Depression	51.23
#6	15	0.711	2008	Illness	19.29

ADMI, anxiety and depression after myocardial infarction.

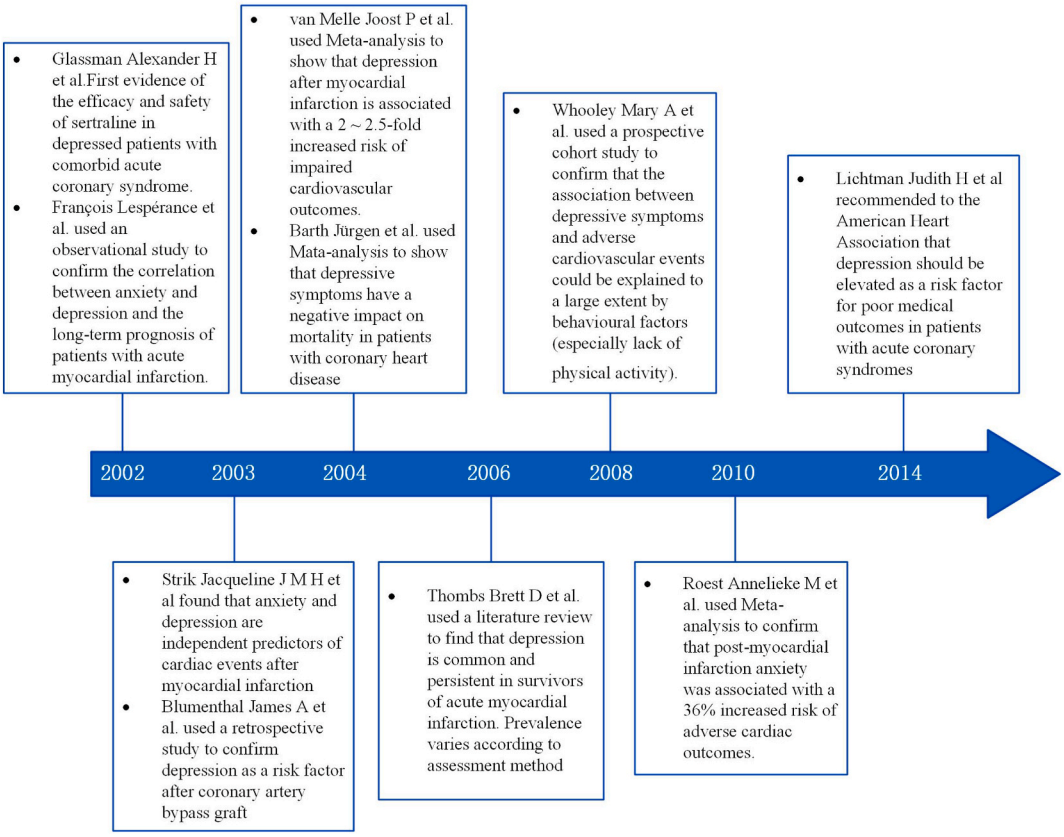

Fig. 8. Timeline of part of landmark achievements in anxiety and depression after myocardial infarction research.

Notably, among the top 10 core journals, Psychosomatic Medicine (published 145 articles, cited 10,163 times) and Circulation (published 41 articles, cited 4867 times) had the highest number of citations, indicating that these two journals are the most valued journals in the field of ADMI. Globally, scholars aspire to publish landmark articles in these two journals. Recently, both journals have focused mainly on exploring the effects of anxiety and depression on the prognosis of myocardial infarction. For example, Iozzia et al. [22] showed that recognition of myocardial infarction plays a major role in anxiety rather than depressive disorders. During the same period, Smolderen et al. [23] suggested that only untreated depression may be associated with increased long-term mortality from AMI. Research on Circulation has gradually become more focused on mechanistic studies while Psychosomatic Medicine still focuses on clinical research. For example, an article by Vaccarino et al. [24] published in Circulation in 2018 showed that microvascular dysfunction and peripheral vasoconstriction with mental stress were implicated in mental stress-induced myocardial ischemia among women rather than men.

The timeline view of references and keywords demonstrated that ADMI research was mostly clinical studies, such as mortality, outcome, quality of life, risk factors, and management. Watkins et al. [25] showed that anxiety was associated with an increased mortality risk in patients with coronary heart disease, particularly when comorbid with depression. Similarly, Parashar et al. [26] found that depressive symptoms after myocardial infarction, irrespective of whether they persisted, subsided, or were newly developed in the first month after hospitalization, were associated with worse outcomes after myocardial infarction. De Jonge et al. [27] showed that depression was a risk factor for decreased quality of life and increased adverse cardiovascular events within 12 months after myocardial infarction. In the core article in this field, Lichtman et al. [6] advocated for depression as an independent risk factor for cardiovascular disease. Additionally, an important article (cited 135 times] found that enhancing cardiac rehabilitation with stress management training produced significant reductions in stress and greater improvements in medical outcomes than standard cardiac rehabilitation [28].

Among the top 10 most cited articles, studies on the prognostic value of anxiety and depression in coronary heart disease accounted for 80.0 % (8/10), indicating that this is a hot topic in this field. Lespérance et al. [17] found a correlation between anxiety, depression, and long-term prognosis in patients with AMI. Furthermore, Strik et al. [7] found that anxiety and depression after myocardial infarction were independent predictors of cardiac events. van Melle et al. [1] performed a meta-analysis to show that depression after myocardial infarction was associated with a 2-to 2.5-fold increased risk of impaired cardiovascular outcomes. However, Roest et al. [3] s conducted a meta-analysis to confirm that post-myocardial infarction anxiety was associated with a 36 % increased risk of adverse cardiac outcomes. Moreover, Whooley et al. [29] used a prospective cohort study to show that the association between depressive symptoms and adverse cardiovascular events could be largely explained using behavioral factors and proposed a preliminary

management model to reduce the degree of depression in patients with cardiovascular disease.

With the development of ADMI research, some new research fields have attracted researchers' attention. References and key bursts have shown that some items had the highest burst strength in the past 5 years, one of which was cardiac rehabilitation. Sun et al. [30] showed that age, gender, smoking, anxiety, and depression were significant predictors of return to work in patients with myocardial infarction and advocated for healthcare providers to collaborate with patients' family members, friends, and employers to develop and implement interventions to address these modifiable factors and facilitate return to work. Many researchers have provided practical cardiac rehabilitation strategies to improve anxiety and depression after myocardial infarction. A 2-week intensive rehabilitation program in the outpatient department positively improved anxiety and depression in patients with myocardial infarction after discharge [31]. An 8-week training program comprising 24 interval training sessions on a cycloergometer, three times a week, also had positive effects, particularly in female patients [32]. Moreover, Wallert et al. [33] conducted internet-delivered cognitive behavior therapy for patients with ADMI and used machine learning methods to predict patient compliance. In patients aged >75 years with acute coronary syndrome, Deng et al. [34] showed that aerobic exercise positively affected exercise capacity and psychological state. Overall, exercise-based cardiac rehabilitation has been demonstrated to alleviate anxiety and depressive symptoms in patients with myocardial infarction. These findings highlight that cardiac rehabilitation is essential and beneficial for minimizing anxiety and depression during recovery [35]. Research on cardiac rehabilitation for ADMI has gradually increased; however, the mode and methods need further exploration.

Another keyword with a significant citation burst was "outcome." Anxiety and depression are significantly and independently associated with an increased risk of all-cause mortality and major adverse cardiovascular events in patients with a first diagnosis of acute coronary syndrome [36,37]. Simultaneously, subclinical emotional distress has predictive value for combined clinical endpoints within 6 months in patients with AMI [38]. However, while mood disorders impair quality of life in patients with stable coronary heart disease, they do not affect mortality or morbidity [39]. Although anxiety and depression are considered independent risk factors for cardiovascular events, some studies have found that anxious patients have fewer prehospital delays before AMI [40,41].

Some researchers have explored the mechanisms by which Chinese medicine improves the clinical outcomes of ADMI. For example, Chai hu jia long gu mu li granules may reduce inflammation and treat coexisting anxiety after myocardial infarction by inhibiting *CXCR4/NF-κB/GSDMD* signaling [42]. Shuangxinfang may also improve ADMI by regulating macrophage/microglia inflammation mediated by S100A9 [43]. Chinese medicine's efficacy and mechanism of action in treating ADMI need further investigation, which may be a potential hotspot for future research.

Our study had some limitations. First, although we have improved the search strategy for research on ADMI as much as possible, we cannot ignore that some articles may have been missed. Second, most results are based on computer algorithms, and manual induction and sorting work are lacking; therefore, avoiding the omission and exclusion of some articles is difficult. Finally, although this study examined developments in the field of ADMI research in the past 20 years, due to the large number of articles, our study could determine the overall time context since the emergence of this field.

Overall, the bibliometric analysis found that ADMI research has good prospects and publications are increasing. Cardiac rehabilitation is the primary research hotspot and focus in this field, and cardiac rehabilitation, outcome, management, and acute coronary syndrome are emerging hotspots. Notably, Chinese medicine has a potential therapeutic effect on ADMI, but has not received sufficient attention. Therefore, many researchers are still needed to study this potential hotspot.

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5. Data availability statement

The data used in this paper were not deposited into a publicly available repository. The data presented in this study are available in supplementary material.

CRediT authorship contribution statement

Liang Kang: Writing – original draft, Visualization, Investigation. **Shaoyu Wang:** Writing – original draft, Visualization, Investigation. **Yihua Li:** Visualization. **Xinjun Zhao:** Validation, Methodology. **Qingmin Chu:** Validation, Investigation. **Rong Li:** Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interestsRong Li reports financial support was provided by the Natural Science Foundation of Guangdong Province. Qingmin Chu reports financial support was provided by the Natural Science Foundation of Guangdong Province.

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Appendix A. Supplementary data

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