GLOBAL TRENDS IN CARDIAC REHABILITATION AS SECONDARY PREVENTION FOR ACUTE CORONARY SYNDROME : ANALYSES BIBLIOMETRICS 2010-2025

Subhan Ulan[1], Azizah Khoiriyati[2]
[1,2]Program Studi Magister Keperawatan, Fakultas Kedokteran dan Ilmu Kesehatan, Universitas Muhammadiyah Yogyakarta
e-mail: subhanulanners@gmail.com

ABSTRACT

Acute Coronary Syndrome (ACS) is a life-threatening cardiovascular disease which leads to high morbidity and mortality all over the world. Cardiac rehabilitation (CR) is considered a comprehensive approach that can improve functional ability and quality of life and reduce recurrent cardiovascular events in patients with ACS. However, no bibliometric approach has been published to comprehensively analyze the scientific achievements and worldwide research trends on CR as secondary prevention in ACS. This study was based on bibliometric analysis to explore the worldwide research trends, scientific progress and research hotspots of CR as a secondary prevention therapy for ACS. Methods conducted a bibliometric study of publications indexed in the Scopus database between 2010 and 2025. Appropriate articles were searched using pre-determined search strategies specific to CR and ACS. VOSviewer software was used to evaluate and visualize publication patterns, countries, journals, citations, co-authorship networks, and keyword co-occurrence. Totaly 552 publications were reviewed. The production of publications showed a steady increase, especially from 2021 onwards. The United States was also the top contributor in the number of publications and international collaborations. The most important study questions were exercise-based cardiac rehabilitation, reduction of mortality, enhancement of quality of life and secondary prevention in patients with coronary heart disease. Conclusion: Research on CR for secondary prevention of ACS has greatly expanded over the past decade, and is expected to increasingly focus on technology-based interventions, telemedicine and more accessible rehabilitation services worldwide

Keywords: Acute coronary syndrome (ACS), Bibliometric analyses, Cardiac rehabilitation, Secondary prevention

INTRODUCTION

Cardiovascular disease accounts for approximately 17.9 million deaths, or 31% of total global deaths, with 7.4 million of these caused by acute coronary syndrome. This number is expected to continue to increase to 23.3 million deaths by 2030 (WHO, 2021). In Indonesia, the 2023 Basic Health Research report indicates that the prevalence of coronary heart disease reaches approximately 1.5% of the population, equivalent to approximately 4.2 million people. ACS is the leading cause of cardiovascular disease-related deaths globally. ACS involves plaque rupture, erosion and the formation of calcified nodules, with non-atherosclerotic causes such as coronary vasospasm also contributing in some cases. (Erick Alexander Cabrera Estrada *et al.*, 2024). CR is a comprehensive multidisciplinary intervention designed to optimize recovery and improve long term outcomes for post-ACS patients. It encompasses exercise training, which is central to improving muscle strength, systemic endurance, and cardiopulmonary fitness,

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

while also addressing cognitive and psychological aspects such as depression and anxiety (Zhang *et al.*, 2025). This program has received class I recommendations (level of evidence A) from major international guidelines, including those of the American Heart Association (AHA) and the European Society of Cardiology (ESC), as an essential comprehensive post ACS management (Erick Alexander Cabrera Estrada *et al.*, 2024)

Over the past 15 years, research CR has grown significantly. This multidisciplinary intervention, which includes exercise training, nutritional guidance, and psychological support, has been shown to improve functional capacity, quality of life, and reduce mortality among post ACS patients (Zhang *et al.*, 2025). A bibliometric review covering 2001 to 2020 revealed a steady increase in CR publications, with high income countries such as the US, Canada, and the UK leading in output and collaboration (Yang *et al.*, 2024). Although growing evidence supports the effectiveness of CR in improving clinical outcomes for coronary artery disease, including increased physical activity capacity and quality of life, there is still a need for broader research encompassing diverse populations and innovative treatment methods (Myneni *et al.*, 2024).

Bibliometric analysis has proven to be an effective method for identifying the knowledge structure, thematic evolution, and scientific collaboration networks in the field of CR, offering a comprehensive understanding of the global research contribution to secondary prevention efforts. These studies collectively illustrate how bibliometric analysis can reveal the dynamic landscape of CR research, identifying productive countries, institutions, and authors, as well as research trends revealing key components such as CR in secondary prevention (Yuan et al., 2021, Manandi et al., 2025, Erdem, Bagcier and Temel, 2023)

The study of global trends in CR research, especially as a secondary prevention strategy for ACS, reveals several influential themes and areas of focus that evolved from 2010 to 2025. Bibliometric analysis of CR publications shows a significant increase in research output, with more than 85% of CR related publications appearing in the last two decades, mainly from high-income countries. Thematic clusters in CR research have evolved from traditional physical activity-based interventions to more comprehensive strategies to improve accessibility and address broader cardiovascular risk factors (Manandi *et al.*, 2025). Overall, global trends in CR research underscore the importance of expanding access, tailoring interventions to the needs of individual patients, and exploring new modalities to optimize long-term health outcomes for patients with ACS (Myneni *et al.*, 2024). Studies of CR and its role in secondary prevention, especially in the context of myocardial infarction have been extensively documented in international scientific publications indexed by Scopus from 2010 to 2025. Cardiac rehabilitation is a structured intervention that significantly improves clinical outcomes for patients with CAD by improving exercise capacity, quality of life, and reducing mortality and morbidity rates. Overall, the literature underscores the important role of CR in secondary prevention, advocating for increased access, tailored interventions, and ongoing research to optimize patient outcomes (Myneni et al., 2024, Nemani et al., 2023, Meike Sisca, 2024)

In this study, in mapping the global landscape, CR research shows significant growth, especially in the last two decades. Furthermore, the evolution of CR research has evolved from traditional exercise based interventions to include comprehensive digital health and lifestyle modification solutions, addressing psychosocial factors in addition to physical recovery. Furthermore, the focus on

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

improving accessibility and participation in CR programs, especially in low income countries, underscores the need for innovative methodologies to improve patient outcomes This comprehensive mapping and analysis provides valuable insights for future research directions and the development of more effective CR programs globally (Ullah et al., 2023, Manandi et al., 2025). Therefore, this study aims to conduct a comprehensive bibliometric analysis of research conducted worldwide on cardiac rehabilitation as a secondary prevention strategy for acute coronary syndromes. This analysis includes publication trends, identification of authors, institutions, and the most influential journals, mapping of scientific collaboration patterns, and analysis of thematic research developments from 2010 to 2025.

METHODS

Data Collection

The Scopus database provided the data used for bibliometric analysis. The Scopus database was selected because of its widespread recognition as a thorough and trustworthy source of peer-reviewed medical literature. Additionally, it contains comprehensive citation indexing and high-quality information appropriate for bibliometric analysis. Controlled vocabulary and free text terms associated with "acute coronary syndrome," "secondary prevention," and "cardiac rehabilitation" were incorporated in the search method. Based on the publication year range of 2010-2025, the research articles and systematic reviews on cardiac rehabilitation in ACS under consideration were chosen. On December 31, 2025, the chosen papers and review papers were downloaded. On the same day, 283 pertinent items were ultimately acquired (Figure 1). Proceedings papers, editorials, conference papers, letters, and articles unrelated to the subject of cardiac rehabilitation in ACS were not included. Choose the language type "English." Furthermore, nursing-related literature and publications written in languages other than English were not included.

Analysis method and tools

To improve the accuracy of the bibliometric analysis, we first exported the search results as plain text files and combined synonyms. We used various advanced bibliometric tools, including Microsoft Excel 2021, VOSviewer, and Scimago Graphica, to process, analyze and display the data. MapChart was used to map the distribution of publications by country, and Scimago Graphica was used to create a global map showing international collaborations. Publication trends in this field over the past 15 years are shown using Microsoft Excel 2021 to display national publications, the number of papers published each year, author citations, and publication patterns from 2010 to 2025. The bibliometric network was created and visualized using VOSviewer (Visualization of Similarities Viewer) version 1.6.20 software developed by the Center for Science and Technology Studies, Leiden University, Leiden, the Netherlands. It includes mapping of research, co-authorship, keyword co-occurrence, citations and bibliographic link networks. VOSviewer is a tool for constructing and displaying bibliometric networks. The annual publication output of countries with high publication volumes was displayed using Scimago Graphica. PRISMA retrieved the search results. To observe the mapping of countries and publication years, the findings were also analyzed in Scopus. Using a map chart program, a map of the relevant country was generated. When an article met the criteria, it was exported as a CSV file and imported into the VOS-viewer program for trend analysis and visualization as a bibliometric map.

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

Researchers modified keywords by selecting inappropriate ones. Additionally, articles were mapped and categorized based on databases using VOS-viewer. Because this study examined publicly available secondary data, ethical approval was not required.

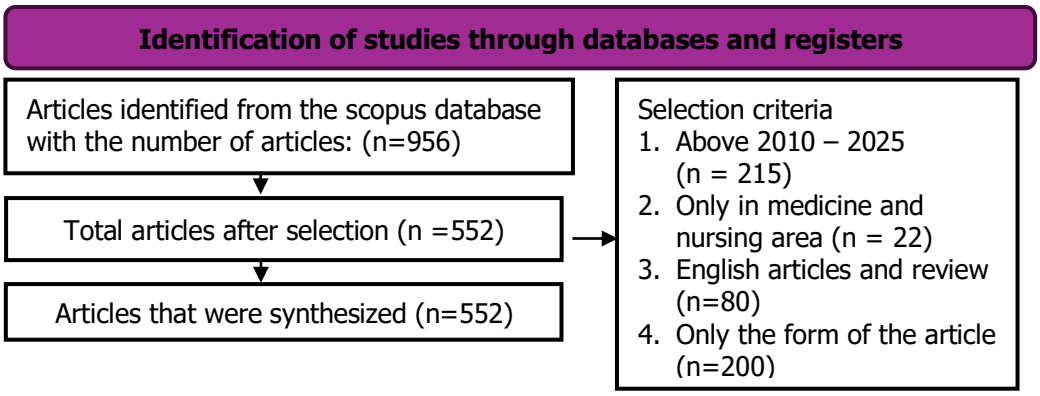


Chart 1 Article Search Flow

RESULTS

Global publication trends

Finally, 522 publications were included, of which 432 articles and 120 reviews articles. The 21 publications included in this study have a total of 39,586 citations with an average of 56.15 citations per publication. Figure 2 shows the annual distribution of publication and citation trends. An increasing trend of publications in the field of cardiac rehabilitation as secondary prevention in ACS until 2025 is observed from 2010 to 2025. The number of publications decreased in 2022 (40 documents) after the peak of annual publications in 2021 (54 documents), but there was a significant increase in 2023 to 56 documents until 2025 (49 documents), as shown in Figure 2. The graph shows that publications on cardiac rehabilitation as secondary prevention in ACS in the last decade and a half show a general trend of research to increase, to be stable and to continue to attract the interest of researchers. Research trend that grows, stable and continues to attract the interest of researchers.

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

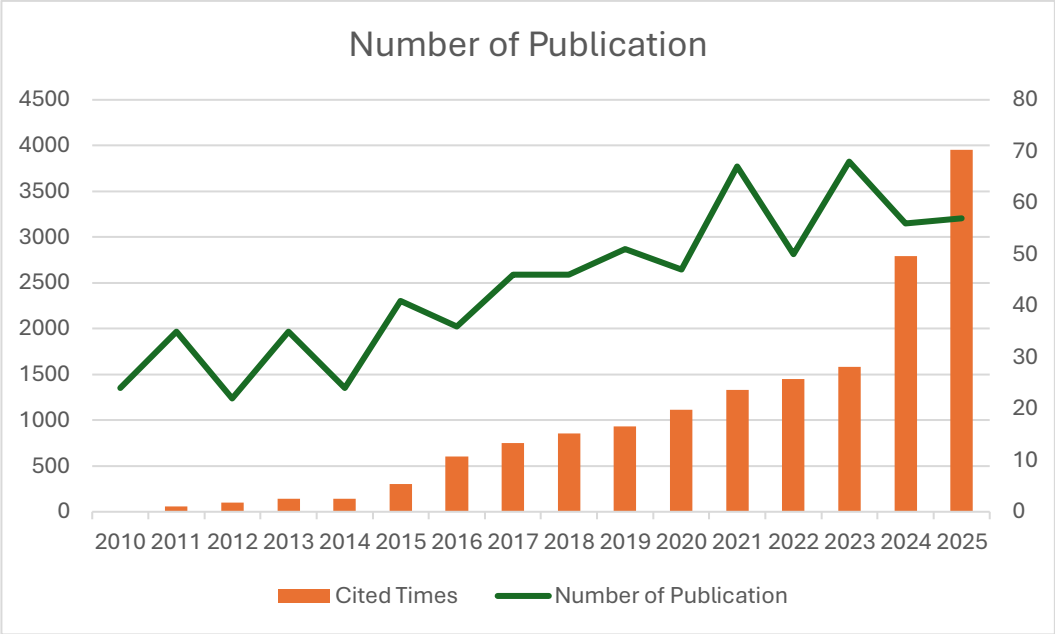


Figure 1. Annual distribution of publications and citations in CR as Secondary prevention for ACS

Analysis of countries/regions and institutions

The Scopus database showed that research on CR as a secondary prophylaxis for ACS was conducted in 93 countries or regions from 2010 to 2025. For CR as a secondary prevention for ACS, the United States had the highest number of publications (n = 113), followed by the United Kingdom (n = 86), Australia (n = 67), Spain (n = 52), Sweden (n = 51), Canada (n = 47), Italy (n = 47), the Netherlands (n = 37), Poland (n = 35), and Denmark (n = 31). The United States and United Kingdom together contributed nearly half (35%) of the total number of articles (Table 1, Figure 2). A collaboration network was also built based on the number and connection of publications in each country. 30 countries were selected and visualised based on the number of publications greater than or equal to 100 (Figure 2). It is important to have many active partnerships between different countries. For example, the experts from Spain demonstrated a high collaboration with the experts from Italy, France, the Netherlands, and Denmark, and the experts from the United States demonstrated a high collaboration with the experts from the United Kingdom and Australia. This is important to note because countries that are not on the list of the most prolific publishers still produce relevant scientific publications. In cross-border publications, the publishing countries are often indicated by the corresponding author. The top ten institutions are Australia (2 of 10), Sweden (5 of 10), the United Kingdom (1 of 10), and Canada (2 of 10). The five most productive institutions are the University of Sydney (47, 23%), Uppsala University (43, 21%), Skånes Universitetssjukhus (23, 11%), Karolinska Institutet (21, 10%) and Imperial College London (21, 101%) (Table 1). In addition, a collaborative network was created, and 51 institutions were selected for visualisation according to a minimum of 94 publications (Figure 2). The graphic depicts each country as a circle, with the size of the circle proportional to the number of publications produced by that country. The lines between the circles represents collaboration between nations. The wider the line the closer the collaboration.

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

TABLE 1: The top ten nations and organisations studying CR as a secondary preventive measure for ACS

Rank	Countries			Institution		
	Countries	Article counts	%	Institution	Article counts	%
1	United States	113	20%	The University of Sydney, Australia	29	14%
2	United Kingdom	86	15%	Uppsala University, Swedia	25	12%
3	Australia	67	12%	Skånes Universitetssjukhus, Swedia	23	11%
4	Spain	52	9%	Karolinska Institutet, Swedia	21	10%
5	Sweden	51	9%	Imperial College London	21	10%
6	Canada	47	8%	University of Toronto, Canada	19	9%
7	Italy	47	8%	Lunds Universitet, Swedia	19	9%
8	Netherlands	37	7%	Faculty of Medicine and Healt, University of Sydney, Australia	18	9%
9	Poland	35	6%	University Health Network, University of Toronto, canada	18	9%
10	Denmark	31	5%	Uppsala Clinical Research Center, Swedia	18	9%

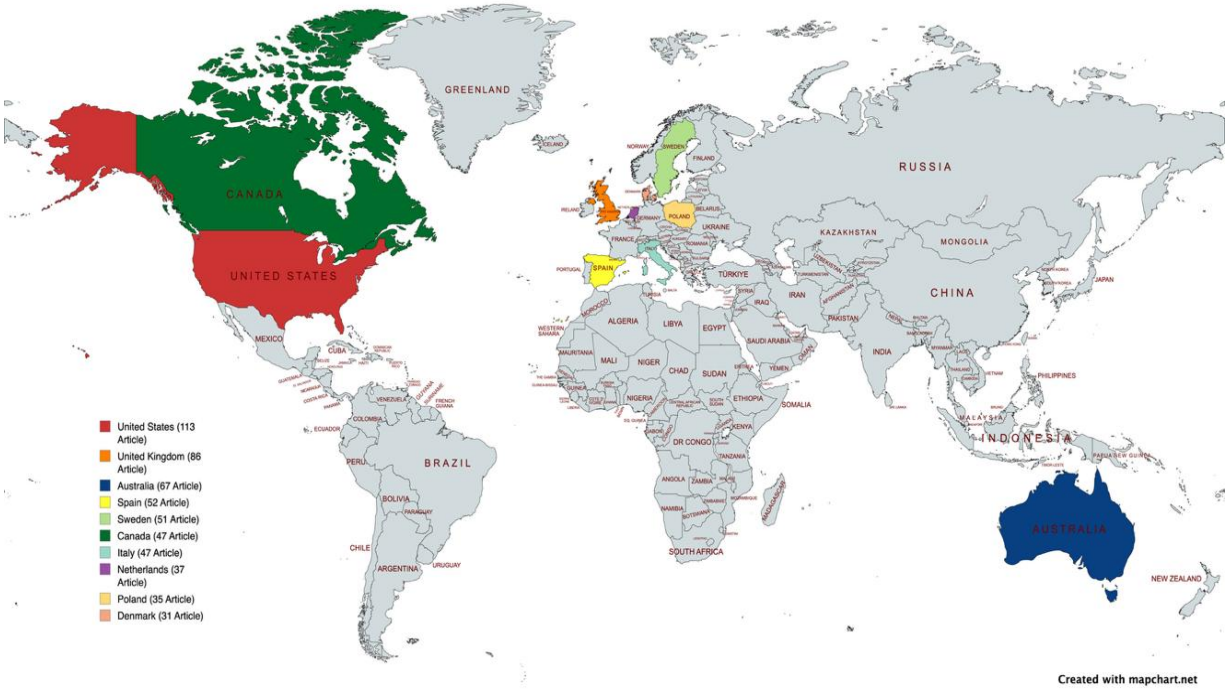
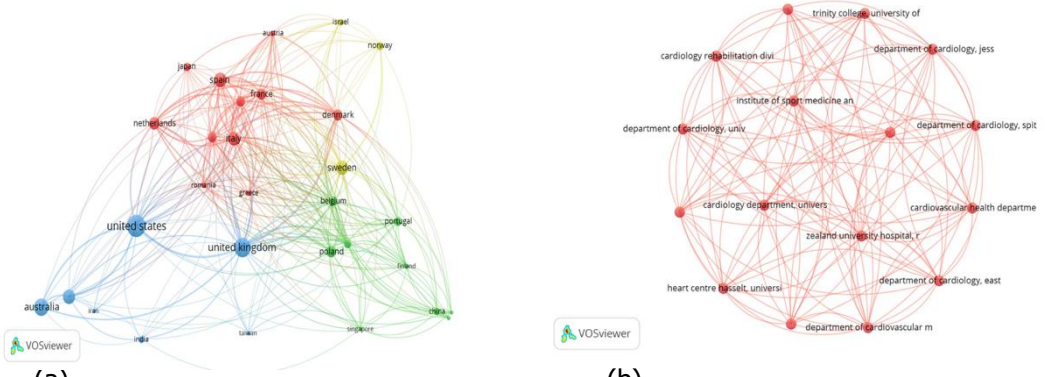


Figure 2. Distribution Map Articles related to CR as a Secondary prevention in ACS

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026



(a) (b)

Fig. 3 (a) Collaborative network map of countries/regions (b) Collaborative network map of institutions.

Authors and co-cited authors

The analysis was based on 552 papers, written by 509 authors in total (Table 2; Figure 4). The most published authors were Redfern, Julie (233), Leosdottir, Margret (256), Bäck, Maria (214) etc. There are several authors in the field of CR as secondary prevention for ACS; however, this study showed no centrality and a cohesive academic network.

The co-citation analysis showed that 33 (out of 551) writers cited from the 291 objects examined were cited more than ten times. The most frequently cited author was Grace s.l. (115), followed by Taylor Road s. (114), Ebrahim Shah (95), Ades Philip a. (89), Yusuf Salim (82) and others (Table 2). This indicates that these authors might be contributing significantly to the progress of the field and are very important to the field of CR as a secondary preventive for ACS research.

TABLE 2 : the top ten authors and co-cited authors who have studied CR as a secondary prevention for ACS.

Rank	Authors	Average Year	Count	TL	Co-citasi author	Average Year	Count	TL
1	Redfern, julie	2018.56	233	24	Grace s.l.	2019.64	115	302
2	Leosdottir, margret	2022.47	256	26	Taylor road s.	2021.00	114	303
3	Bäck, maria	2023.13	214	20	Ebrahim shah	2019.00	95	223
4	Grace, sherry l.	2019.64	522	5	Ades philip a.	2018.25	89	235
5	Gallagher, robyn	2020.64	257	13	Yusuf salim	2019.00	82	190
6	Hagström, emil	2023.10	141	17	De bacquer d.	2019.50	68	165
7	Hambraeus, kristina	2020.00	361	13	Eur heart j	2023.00	64	128
8	Briffa, tom	2016.20	171	18	Thompson d.r.	2023.00	63	180
9	Neubeck, lis	2017.00	231	12	Oldridge n.	2019.64	59	168
10	Brieger, david	2021.14	181	13	Agewall s.	2020.00	59	126

**TL: Total link strength*

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

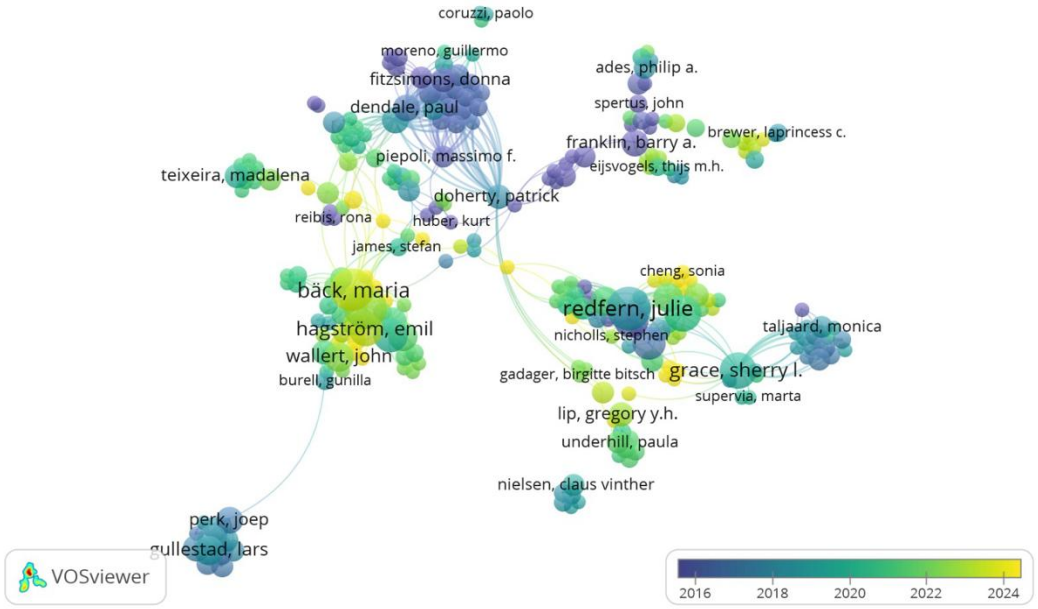


Fig 4. Top 10 authors and co-cited authors on the research of CR as Secondary prevention for ACS

Journals and co-cited journals

A detailed examination of published and co-cited journals was carried out using VOSviewer software (version 1.6.20) . The 552 publications analyzed in this study are published in more than 110 different journals, which illustrates the diversity of the sources studied. The European Journal of Preventive Cardiology has the highest number of publications (42) (Table 3). Also, equal numbers of publications were published in Journal of Cardiopulmonary Rehabilitation and Prevention (19) and BMJ Open (19). More than 10 publications were published in European Journal of Cardiovascular Nursing, Journal of Clinical Medicine, Heart Lung and Circulation, European Heart Journal, International Journal of Cardiology, BMC Cardiovascular Disorders, and Journal of the American Heart Association. The impact factor and quartile distribution rankings of these journals were retrieved from the 2021 Journal Citation Reports (JCR). The data showed that half of the top ten journals were in Q1 (90%), and Q2 (10%). Interestingly, the highest impact factor (IF) among all these Journals was found in the European Heart Journal with 40.3. Co-citation frequency was also analyzed to estimate the impact of these journals on the wider academic community. Among 552 journals 6 journals are mentioned in Table 3 with citation count more than 1000 . The most referenced journal was Circulation (2093), followed by Journal of the American College of Cardiology (1612), New England Journal of Medicine (1418), European Heart Journal (1322), etc. Interestingly, the greatest impact factor (IF) among these publications was New England Journal of Medicine (IF 96.4). The top ten most co-cited journals were distributed in Q1 (100%)

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

TABLE 3 : top ten journals and co-cited journals of research on CR as secondary prevention for ACS

Rank	Journal	Everage Year	Count	IF (2021)	JCR (2021)	Co-cited journals	Everage Year	Citation	IF	JCR
1	European Journal of Preventive Cardiology	2018.29	42	13,9	Q1	Circulation	2016.78	2093	45,1	Q1
2	Journal of Cardiopulmonary Rehabilitation and Prevention	2018.42	19	5	Q1	Journal of The American Collage of Cardiology	2016.33	1612	35,1	Q1
3	BMJ Open	2021.12	19	4,5	Q1	New England Journal of Medicine	2022.00	1418	96,4	Q1
4	European Journal of Cardiovascular Nursing	2020.19	16	5,9	Q1	European Heart Journal	2020.54	1322	40,3	Q1
5	Journal of Clinical Medicine	2022.43	14	5,2	Q1	European Journal of Preventive Cardiology	2018.29	879	13,9	Q1
6	Heart Lung and Circulation	2017.00	13	4,1	Q1	Jama	2011.00	801	30,8	Q1
7	European Heart Journal	2020.54	13	40,3	Q1	The Lancet Global Health	2023.00	782	5,1	Q1
8	International Journal of Cardiology	2016.33	12	6,4	Q1	Heart	2016.50	699	10	Q1
9	BMC Cardiovascular Disorders	2017.83	12	3,7	Q2	American Journal of Cardiology	2022.00	577	3,9	Q1
10	Journal of the American Heart Association	2016.33	10	8,5	Q1	American Heart Journal	2013.75	481	7,1	Q2

TABLE 4 : top ten co-cited references for research of CR as Secondary prevention for ACS

Rank	Title	Citation	Year
1	Exercise-based cardiac rehabilitation for coronary heart disease: cochrane systematic review and meta-analysis	18	2016
2	Exercise-based cardiac rehabilitation for coronary heart disease, cochrane database syst rev, 7	17	2011
3	Secondary prevention through cardiac rehabilitation: from knowledge to implementation. a position paper from the cardiac rehabilitation section of the european association of cardiovascular prevention and rehabilitation	14	2010
4	Initial invasive or conservative strategy for stable coronary disease	13	2020
5	cardiac rehabilitation in europe: results from the european cardiac rehabilitation inventory survey	13	2010
6	Euroaspire iv : a european society of cardiology survey on the lifestyle, risk factor and therapeutic management of coronary patients from 24 european countries	13	2016

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

7	Lessons from contemporary trials of cardiovascular prevention and rehabilitation: a systematic review and meta-analysis	13	2017
8	Health-status outcomes with invasive or conservative care in coronary disease	12	2020
9	Cardiac rehabilitation	12	2015
10	Association of diet, exercise, and smoking modification with risk of early cardiovascular events after acute coronary syndromes, circulation	11	2010

TABLE 5 : Top 20 keywords regarding research of CR as Secondary prevention for ACS

Rank	Keywords	Count	Rank	Keywords	Count
1	Secondary Prevention	460	11	ST Segment Elevation Myocardial Infarction	129
2	Heart Rehabilitation	456	12	Cardiovascular Risk	123
3	Cardiac Rehabilitation	273	13	Quality Of Life	114
4	Adult	257	14	Treatment Outcome	112
5	Acute Coronary Syndrome	246	15	Acute Heart Infarction	105
6	Heart Infarction	236	16	Non ST Segment Elevation Myocardial Infarction	89
7	Myocardial Infarction	205	17	Lifestyle Modification	80
8	Coronary Artery Disease	164	18	Ischemic Heart Disease	78
9	Cardiovascular Disease	161	19	Cardiovascular Mortality	65
10	Physical Activity	140	20	Unstable Angina Pectoris	51

3 clusters that appear on top keywords :

Clauster 1 (11 Items) : Acute Coronary Syndrome, Cardiovascular Disease, Cardiovascular Mortality, Cardiovascular Risk, Coronary Artery Disease, Heart Rehabilitation, Ischemic Heart Disease, Lifestyle Modification, Physical Activity, Quality Of Life, Secondary Prevention

Clauster 2 (6 Items) : Acute Heart Infarction, Adult, Cardiac Rehabilitation, Heart Infarction, Myocardial Infarction, Treatment Outcome

Clauster 3 (3 Items) : Non ST Segment Elevation Myocardial Infarction, ST Segment Elevation Myocardial Infarction, Unstable Angina Pectoris

Article History:
Received: April 14, 2026; Revised: May 6, 2026; Accepted: May 7, 2026

Co-cited references and references burst

The co-cited references in the field of CR as secondary prevention for ACS were analyzed exhaustively using VOSviewer. Each node size is proportional to the frequency or popularity of that topic in the literature. The bigger the node, the more often the issue is occurring in publications. Table 4 displays the results of the reference analysis. The article with the highest number of citations among the 10 most cited publications was the one titled "Exercise-based cardiac rehabilitation for coronary heart disease: a Cochrane systematic review and meta-analysis" (18). A reference burst is defined as a quick, dramatic jump in the number of citations coming from a given reference. Figure 4 displays the visualization map of references with citation bursts generated by VOSviewer. Yellow indicates the latest active or trending themes (around 2022-2025). The majority of the most powerful reference bursts among the 10 references started in 2026. Of these references, the reference with the largest burst strength was authored by Grace, Sherry L., in 2019 with an average year of 2019.64 with 522 references, in addition to Gallagher, Robyn, in 2020 with an average year of 2020.64 with 257 references. The results indicate that CR has become a more prominent sustainable secondary preventive for ACS and has promise for further growth. It will be fast in the future.

Keywords co-occurrence and hotspots analysis

The co-occurrence of related keywords can be used to identify research focus points and potential directions in a given topic. The 522 articles gave a diversity of keywords. Table 5 presents the twenty most prevalent keywords. For CR as secondary prevention for ACS, the most frequent keywords were secondary prevention (460), cardiac recovery (456), cardiac recovery (273), cardiac recovery (273), adults (257), acute coronary syndrome (246), stroke (236), and others. VOSviewer developed a term density map for visualising research hotspots on CR as secondary preventive for ACS. This map gives a clearer picture of the study focal points for CR as a secondary prophylaxis for ACS (Figure 5). The colour of each point on the map is determined by the density of the elements in the neighbourhood of that point: the greater the density the redder the point; the less the density the bluer the point. The size of the element density relies on the number of elements in the vicinity and the relevance of those elements. Keywords can be clustered into a node graph by VOSviewer to visualise the underlying relationships. This requires a minimum of 5 instances of a keyword. The visualisation of this study is shown in Figure 5, where the nodes are a keyword and the colours are the different clusters. Keywords are classified into one of the six clusters for more precise objectives. Each cluster is a different and consistent perspective or area of concentration in the research. The first cluster is coloured red, the second cluster green and the third cluster blue. The red cluster includes acute heart disease, heart disease mortality, heart disease risk, coronary artery disease, heart care, ischaemic heart disease, lifestyle changes, exercise, quality of life, secondary prevention and the green cluster includes acute heart disease, adults, heart care, heart disease, myocardial infarction and heart disease. The results of this study can be used to understand the links between different research topics. This will essentially help the design of future studies in providing a broader overview of different facets of the subject area. A timeline viewer that blends keywords with time enables you to observe the evolution of keywords and the development trajectory of significant research subjects across the area. Figure 5 shows the timeline viewer for these keywords created by VOSviewer. The average

year these keywords occurred is shown as a timeline in Figure 6. The line connecting two dots shows that the two keywords featured in the same article, and the colour of the line shows the year of the article's publication. This bibliometric map demonstrates a major shift in the focus of the scientific publications over the last 15 years. Most of the keywords emerged clearly in the period 2010–2015, after an average attention to traditional clinical care in hospitals and the physical stability of patients after an acute event. The literature on patient behaviour (patient-centeredness) was published from 2010 to 2015, whereas the phrases digital health and telerehabilitation arose in 2020–2025. It highlights the efforts of researchers to more precisely anticipate long-term therapeutic results and the transition from facility-based rehabilitation to more accessible remote rehabilitation for patients at home. This study demonstrates that cardiac nursing has transitioned from clinical treatment in hospitals to technology based continuing interventions. Therefore, digital health and telerehabilitation are new phenomena and there is a great potential for future scholars to examine them. This is vital for the sustainability of secondary prevention and for nurses to extend their involvement in improving patients' quality of life through digital innovation

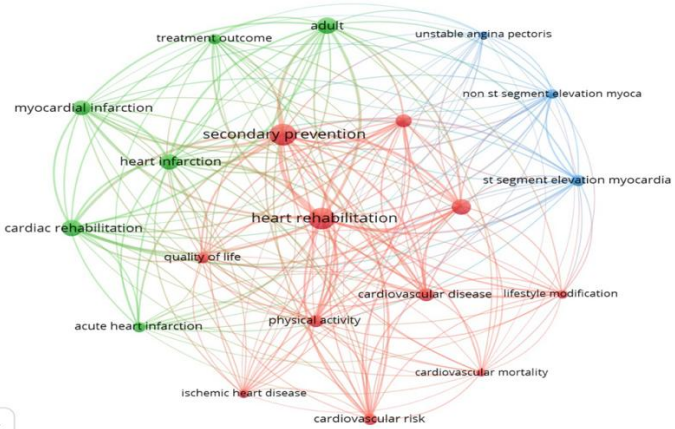


Fig 5.

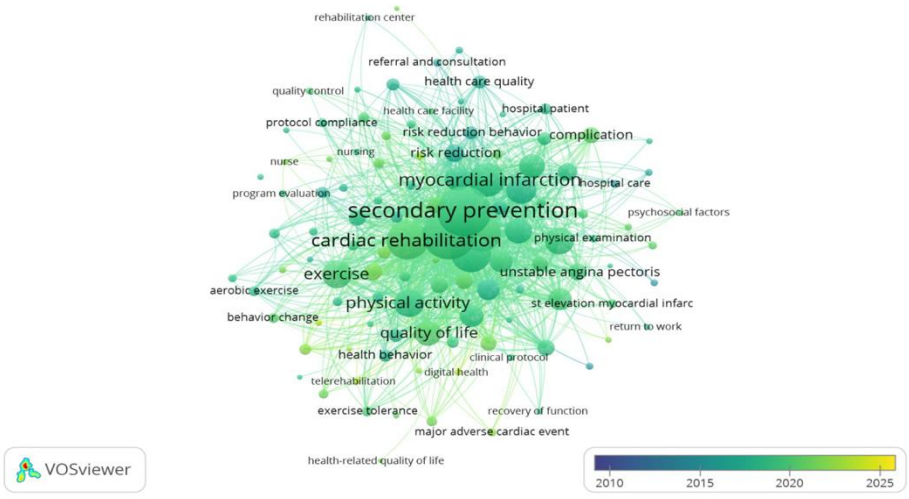


Fig 6. Overlay Visualization

DISCUSSION

Regional disparity and development trend

By using bibliometric study approach we explored the background of major developments, interesting research subjects and future research trends in the field of CR research with regard to secondary prevention for ACS. The annual distribution of papers is a good indicator of the pattern of CR research development and clearly shows the shift of scientific efforts. Figure 1 . In Western countries, the CR output for secondary prevention of ACS has increased considerably. The most articles were in the United States (113), followed by the United Kingdom (87 articles) and Australia (67 articles). The large number of papers in the United States and the United Kingdom further validates the researchers' view that industrialised countries have a more mature healthcare system than emerging countries. This phenomenon is not only quantitative but also a consequence of the high incidence of cardiovascular disease in these areas, which requires the constant creation of protocols for secondary prevention.

The rising prevalence of cardiovascular disease (CVD) worldwide is associated with factors such as urbanisation, sedentary lifestyles, and an ageing population. This trend underscores the urgent need for comprehensive preventative strategies that combine lifestyle modifications with public health measures (Shohjahon Muzaffarovich, 2026). However, the preponderance of research from these affluent countries can foster a "Western bias" in global clinical guidelines, which could make interventions more palatable for developing countries with limited resources (Okhovati, Zare and Bazrafshan, 2015, Geneva, 2018). Since research contributions from low-income countries represent a smaller proportion of global CR research (Alzate Mejía et al., 2025, Huffman et al., 2013), a bibliometric analysis of CR research highlights the importance of increasing inclusive global research to address the specific needs and contexts of low-income countries. These activities may help to reduce health disparities in secondary prevention of coronary heart disease. CR participation is much lower in middle income countries compared to high income countries. Five of the top 10 institutions in Australia show large increases in the number of cardiac rehabilitation publications. They also strategically address improving access and effectiveness of CR in Australia, reflecting the country's proactive approach to heart disease through innovative rehabilitation measures. CR has benefits in reducing mortality and morbidity, however participation rates in CR are still low (only 10% to 30% of the Australian population with heart disease are still living). This data says something about Sweden. Sweden is seventh in the world and five of the country's institutions are in the top ten, including Uppsala University, Skånes Universitetssjukhus, Karolinska Institutet, Lunds Universitet and Uppsala Clinical Research Center. Researchers say Sweden's centralised approach to research collaboration works quite well. An integrated national health registry system such as SWEDEHEART makes it possible to generate high-quality research output because it enables the collection and analysis of a large amount of data between institutions (Witt *et al.*, 2017). Additionally, Sweden stands out as a prominent nation in the fields of life sciences and medicine, characterised by its highly productive researchers and substantial output. A noteworthy proportion of its research papers are published in top quartile journals (Narayan *et al.*, 2024). This broad and cooperative approach not only improves the quality of research, but also gives Swedish institutions a good position in the world of research. For example, even though Sweden is ranked fifth, it features prominently in the top

10 universities. Hence it is critical to develop and deploy initiatives to aggressively tackle the large geographic divide with CR research still being based in the Northern Hemisphere and Australia. The changing global epidemiology of ACS suggests that research from Asia and Africa should be encouraged to confirm the effectiveness of CR programs in more heterogeneous populations. Also large and focused research is required to improve the quality of life of individuals with ACS. Secondary prevention of ACS: Investigators should prioritise the development of specialised approaches to involve developing countries in developing a comprehensive, inclusive global framework initiative for CR research and clinical practice. This would greatly improve understanding and management outcomes in this important area of health care.

Dissemination and knowledge base

Finally, the literature regarding CR for secondary prophylaxis in patients with ACS has a developed research ecosystem with a high academic authority, as confirmed by the full bibliometric study. Table 2 shows that Grace, S.L., is the most productive author (522 documents) and the most frequently cooperating author in the co-citation network (TL: 302). This means that her study output is not just quantitative but also serves as a benchmark for other researchers. This is part of a wider trend in CR studies, which has seen a steady increase in publications over the last two decades, particularly in developed countries such as the United States, Canada and the United Kingdom, where regional academic communities have formed around prominent figures like Grace (Yuan et al., 2021). The European Journal of Preventive Cardiology was found to be the most dominant journal with the maximum number of articles (Count: 42) and Impact Factor (IF) of 13.9 (Table 3). This data demonstrates that this journal is an important outlet for investigators to publish findings on CR as secondary prevention in ACS patients. However, the fascinating thing was that the analysis of co-cited journals was dominated by popular magazines such as Circulation (Citations: 2093, IF: 45.1) and Journal of the American College of Cardiology (Citations: 1612, IF: 35.1).

The researchers assume that although the European Journal of Preventive Cardiology is the top journal in terms of number of publications and impact factor for CR research, the superiority of journals such as Circulation and Journal of the American College of Cardiology in the co-citation analysis reflects the greater influence and recognition of these journals in the field of cardiovascular research. This difference may be due to the wide breadth and high influence of the research published in these journals, which usually have a number of cardiovascular issues beyond CR, thus higher citations (Rao *et al.*, 2025). The European Journal of Preventive Cardiology is more focused on preventive and rehabilitation cardiology and has a broader scope and a higher impact factor than Circulation and the Journal of the American College of Cardiology, which makes them more dominant in the co-citation network, reflecting their central role in the cardiovascular research community (Yuan *et al.*, 2021). Thus, while the European journal Preventive Cardiology is the most contributing journal in terms of quantity, the theoretical framework and the core clinical evidence in CR research still refer to highly known journals with a wider reach. So CR research is not a specialised speciality but a vital aspect of the basic subject of cardiology.

The distribution of the top ten journals in the JCR Journal Citation quartiles shows that 90% of the journals are in Q1 and 10% in Q2 which highlights the major influence of CR as a secondary preventive therapy in patients with ACS . This distribution could reflect the great effect and research quality of the topic that is critical for creating secondary preventive approaches. CR is a well-established paradigm that includes exercise, risk factor treatment and education to minimise mortality and recurrent ischaemia episodes, therefore enhancing the quality of life of ACS patients (Manandi *et al.*, 2025). However, the underuse of CR, especially among women, elderly people and minority and socioeconomically disadvantaged groups, highlights the importance of specific initiatives to promote equitable access (Bola *et al.*, 2025). Scientists discovered a huge gap between the quality of the scientific data and what really happens in clinics. The existence of impediments to access for minorities, women and the elderly indicates that the current literature might be too narrow in its focus on generic clinical efficacy and has yet to produce inclusive implementation strategies. The future task for CR research is not to offer physical proof but to recreate inclusive solutions and integrate them into concrete policies capable of guaranteeing fair access for all strata of the socio-economic spectrum.

The ten co-cited references in the knowledge base (Table 4) were published prior to 2020. Many of such allusions were generated from 2010 to 2017. We performed a systematic search of the Medline database for the most cited references to cardiac rehabilitation programs in secondary prevention of ACS patients. Exercise-based cardiac rehabilitation has showed significant clinical advantages such as decreased cardiovascular mortality and increased quality of life in patients with coronary heart disease (Anderson *et al.*, 2016). A second reference revealed that exercise-based cardiac rehabilitation considerably lowered the risk of cardiovascular death but did not produce a meaningful decrease in total mortality. The study also indicated an improvement in health-related quality of life (HRQL) and the necessity of reporting clinical outcomes such as mortality, hospitalisations and cost-effectiveness (Dibben *et al.*, 2021). A third reference is the initial invasive versus conservative method for stable coronary heart disease. Results demonstrated that patients with stable coronary heart disease and moderate or severe ischaemia had an unaltered risk for ischaemic cardiovascular events or death from any cause at a mean of 3.2 years with an early invasive approach (Ambrosetti *et al.*, 2021). There is a large body of evidence showing that exercise-based cardiac rehabilitation is a critical component in secondary prevention of coronary heart disease. Cochrane's meta-analysis has shown this intervention to improve the quality of life of patients and to considerably reduce cardiovascular mortality. While these benefits exist, CR programme implementation worldwide is poor, with substantial discrepancies in access and utilisation, particularly in low and middle income countries (LMICs) and among women under-represented in CR trials (Madrini et al., 2025, (Dibben *et al.*, 2021). More recent data updates also indicate that cardiac rehabilitation still has therapeutic benefits, including fewer hospitalisations and better health-related quality of life (HRQL) (Dibben *et al.*, 2021)The study also sheds light on the importance of therapy outcomes and cost-effectiveness. On the other hand, big trials such as the ISCHAEMIA trial showed no additional benefit of early invasive treatments over conservative measures in lowering cardiovascular events and death in patients with stable coronary heart disease (Davos & Rauch, 2020). The results show that cardiac rehabilitation is a prominent non-invasive technique for

long-term treatment of patients especially in secondary prevention following acute cardiac events.

Overall, the data imply that cardiac rehabilitation courses are crucial in the management of cardiovascular health and should be employed more to enhance outcomes for patients in a variety of groups. Future study should strive to refine CR methods, assure inclusion and representativeness of various groups and overcome implementation challenges to maximise the potential of CR to improve cardiovascular outcomes globally. However, there are challenges to standardising cardiac rehabilitation methods and integrating them into everyday practice. These challenges encompass inconsistencies in how programs are delivered, disparities in the training of healthcare providers, and the necessity for customised strategies to address the unique requirements of varied patient groups.

The analysis of hotspots and frontiers

In bibliometrics, keywords are crucial because they provide information about the focus and trends of a research field through techniques such as keyword co-occurrence analysis, keyword cluster analysis, and timeline view. In Table 5, the twenty most important keywords indicate the focus of research in the field of CR as secondary prevention for ACS patients. Secondary Prevention (460) is the most representative, followed by Cardiac Rehabilitation (456), Cardiac Rehabilitation (273), and so on. Keywords play a crucial role in bibliometrics by indicating the focus and trends in a research field, particularly through techniques such as keyword co-occurrence analysis, keyword cluster analysis, and keyword analysis. Top keyword analysis indicates the priorities and progress of research on CR as secondary prevention for ACS patients. According to a bibliometric observation conducted by Manandi et al (Manandi et al., 2025), the shift towards digital interventions to improve accessibility is demonstrated by the increasing focus of CR research on exercise. This trend is reinforced by Lou et al., who suggest that wearable technology and the rapid expansion of telemedicine in CR may replace the conventional CR model. Digital health technologies, such as mobile apps and internet-based platforms, are considered promising solutions to overcome the limitations of conventional facility based CR programs. This will promote health equity and improve care delivery (S. Miraclin Sharon, 2023). This aligns with the findings of research by Wang et al., which emphasized the importance of understanding residual cardiovascular risk and addressing it as part of secondary prevention strategies (Wang *et al.*, 2023).

Despite progress, challenges remain in ensuring equitable access to CR, especially for underserved populations. Furthermore, tailoring interventions to meet the needs of diverse patients, such as women, older adults, and those with comorbidities (Rawat and Sharma, 2023). Addressing these challenges and optimizing long-term health outcomes for ACS patients through the development of personalized, technology assisted CR programs is crucial(Wang et al., 2023, Rawat and Sharma, 2023). Collectively, these studies demonstrate that key terms not only reflect the current state of research but also provide a foundation for future research, emphasizing the need for a comprehensive approach to CR as secondary prevention for ACS.

Strengths and Weaknesses

In this study, the Scopus database was used to obtain data on CR as secondary prophylaxis in ACS patients, and a full bibliometric analysis was performed using VOSviewer. Bibliometrics, as opposed to standard meta-analysis, is very good at visualising the structure of scientific knowledge, influences and trends. This technique investigates the distribution of emergent research, collaborations and thematic clusters, providing insights into the global landscape, collaborations and research focus. Emerging topics, vulnerabilities, and gaps are identified to guide strategic research paths. However, bibliometrics may be blind to qualitative details and may be skewed towards popular research, leaving out unpublished or unindexed material.

CONCLUSION

This study summarizes the key characteristics of CR research as secondary prophylaxis for ACS patients in general, including contributions by country, institution, author, publication, citation, and research approach. According to the visual analysis of VOSviewer, the number of publications showed a gradual increase from 2010 to 2025, with the United States and the United Kingdom as the leading countries and the University of Sydney, Australia, as the main source of papers in this research trend. However, progress in developing countries is minimal, revealing severe gaps in research capacity and focus. It is necessary to establish efficient CR approaches for secondary prevention of ACS patients that actively involve low-income countries to help decrease health disparities in secondary prevention of coronary heart disease. An important increase of digital integration, such as telemedicine and wearable technologies in CR cardiac rehabilitation, should be the focus of future studies to make sure of access to all socioeconomic strata. Standardization of CR procedures and their inclusion into normal treatment emphasize the importance of CR in the management of ACS patients. These results underscore the need for further research and international collaboration to address the difficulties and improve the outcomes of patients in this area.

REFERENCES

Alzate Mejía, O.A. *et al.* (2025) "Mapping Six Decades of Research and Innovation in Cardiac Electrophysiology: A Historical Scientometrics Analysis," *Journal of Multidisciplinary Healthcare*, 18, pp. 6103–6114. Available at: https://doi.org/10.2147/JMDH.S538851.

Ambrosetti, M. *et al.* (2021) "Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology," *European Journal of Preventive Cardiology*, 28(5), pp. 460–495. Available at: https://doi.org/10.1177/2047487320913379.

Anderson, L. *et al.* (2016) "Exercise-based cardiac rehabilitation for coronary heart disease," *Cochrane Database of Systematic Reviews*. John Wiley and Sons Ltd. Available at: https://doi.org/10.1002/14651858.CD001800.pub3.

Bola, H. *et al.* (2025) "Cardiac Rehabilitation for Coronary Artery Disease: Gaps, Digital Models, and the Future of Personalized Prevention," *The American Journal of Cardiology* [Preprint]. Available at: https://doi.org/10.1016/j.amjcard.2025.12.013.

Davos & Rauch (2020) *ESC Handbook of Cardiovascular Rehabilitation*, *ESC Handbook of Cardiovascular Rehabilitation*. Oxford University Press. Available at: https://doi.org/10.1093/med/9780198849308.001.0001.

Dibben, G. *et al.* (2021) "Exercise-based cardiac rehabilitation for coronary heart disease," *Cochrane Database of Systematic Reviews*. John Wiley and Sons Ltd. Available at: https://doi.org/10.1002/14651858.CD001800.pub4.

Erdem, İ.H., Bagcier, F. and Temel, M.H. (2023) "Top 50 cited articles on cardiac rehabilitation: A bibliometric and altmetric analysis study," *Journal of Surgery and Medicine*, 7(1), pp. 63–68. Available at: https://doi.org/10.28982/josam.7642.

Erick Alexander Cabrera Estrada *et al.* (2024) "Acute coronary syndrome: Definition, pathophysiology, diagnosis, and management," *World Journal of Advanced Research and Reviews*, 21(1), pp. 2537–2548. Available at: https://doi.org/10.30574/wjarr.2024.21.1.0352.

Geneva (2018) *Clinical research in resource-limited settings A consensus by a CIOMS Working Group Council for International Organizations of Medical Sciences (CIOMS)*.

Huffman, M.D. *et al.* (2013) "Global cardiovascular research output, citations, and collaborations: A time-trend, bibliometric analysis (1999-2008)," *PLoS ONE*, 8(12). Available at: https://doi.org/10.1371/journal.pone.0083440.

Madrini, V. *et al.* (2025) "Cardiac Rehabilitation in Patients with Coronary Heart Disease—Challenges, Inequalities, and Opportunities for Global Health," *Global Heart*. Ubiquity Press. Available at: https://doi.org/10.5334/gh.1480.

Manandi, D. *et al.* (2025) "A century of cardiac rehabilitation research: Bibliometric review of publication history, keyword trends, and citations," *npj Cardiovascular Health*, 2(1). Available at: https://doi.org/10.1038/s44325-025-00062-w.

Meike Sisca (2024) "THE EFFECTIVENESS OF COMMUNITY-BASED CARDIAC REHABILITATION PROGRAMS IN REDUCING THE RELAPSE RATE OF POST-MYOCARDIAL INFARCTION PATIENTS," *Action Research Literate* [Preprint].

Myneni, P. *et al.* (2024) "Effectiveness of Cardiac Rehabilitation in Enhancing Clinical Outcomes for Coronary Artery Disease: A Systematic Analysis," *Cureus* [Preprint]. Available at: https://doi.org/10.7759/cureus.69224.

Nemani, R.R.S. *et al.* (2023) "Role of Cardiac Rehabilitation in Improving Outcomes after Myocardial Infarction." Available at: https://doi.org/10.1101/2023.10.20.23297313.

Okhovati, M., Zare, M. and Bazrafshan, A. (2015) "Variations in Ischemic Heart Disease Research by Country, Income, Development and Burden of Disease: A Scientometric Approach," *Journal of Cardiovascular and Thoracic Research*, 7(4), pp. 164–167. Available at: https://doi.org/10.15171/jcvtr.2015.35.

Rao, S. V. *et al.* (2025) "2025 ACC/AHA/ACEP/NAEMSP/SCAI Guideline for the Management of Patients With Acute Coronary Syndromes: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines," *Circulation*. Lippincott Williams and Wilkins, pp. e771–e862. Available at: https://doi.org/10.1161/CIR.0000000000001309.

Rawat, A. and Sharma, A. (2023) "Advancements and Considerations in Cardiac Rehabilitation: A Comprehensive Review," *Acta Pharma Reports*, 2(2), pp. 10–14. Available at: https://doi.org/10.51470/APR.2023.2.2.10.

S. Miraclin Sharon (2023) "CARDIAC REHABILITATION," *Futuristic Trends in Medical Sciences* [Preprint].

Shohjahon Muzaffarovich, K. (2026) "CARDIOVASCULAR DISEASES: THE SILENT KILLERS OF THE MODERN WORLD." Available at: https://doi.org/10.5281/zenodo.18372743.

Ullah, A. *et al.* (2023) "Revolutionizing Cardiac Care: A Comprehensive Narrative Review of Cardiac Rehabilitation and the Evolution of Cardiovascular Medicine," *Cureus* [Preprint]. Available at: https://doi.org/10.7759/cureus.46469.

Wang, L. *et al.* (2023) "Bibliometric analysis of residual cardiovascular risk: trends and frontiers," *Journal of Health, Population and Nutrition*, 42(1). Available at: https://doi.org/10.1186/s41043-023-00478-z.

Witt, N. *et al.* (2017) "Sweden: Coronary and structural heart interventions from 2010 to 2015," *EuroIntervention*. EuroPCR, pp. Z70–Z74. Available at: https://doi.org/10.4244/EIJ-D-16-00830.

Yang, M. *et al.* (2024) "Effect of cardiac rehabilitation care after coronary intervention on cardiac function recovery and negative mood in patients with myocardial infarction," *World Journal of Clinical Cases*, 12(1), pp. 59–67. Available at: https://doi.org/10.12998/wjcc.v12.i1.59.

Yuan, G. *et al.* (2021) "Cardiac Rehabilitation: A Bibliometric Review From 2001 to 2020," *Frontiers in Cardiovascular Medicine*. Frontiers Media SA. Available at: https://doi.org/10.3389/fcvm.2021.672913.

Zhang, Y. *et al.* (2025) "Seize the advantages of cardiac rehabilitation," *Annals of Medicine*. Taylor and Francis Ltd. Available at: https://doi.org/10.1080/07853890.2025.2519680.