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MAPPING THE GLOBAL SCIENTIFIC LANDSCAPE OF COLORECTAL CANCER AND VITAMIN D3 RESEARCH: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Background: Colorectal cancer is the third leading cause of cancer-related deaths worldwide, with rising incidence in developing countries. Vitamin D3 has been implicated in colorectal cancer development, regulating cell proliferation, apoptosis, and Wnt/β-catenin signaling. Despite the growing body of literature, a comprehensive bibliometric analysis integrating colorectal cancer and vitamin D3 is still limited, highlighting a need to map research trends and collaboration patterns. **Objective:** This study aimed to evaluate global research trends, thematic structures, and collaboration networks in colorectal cancer and vitamin D3 research to identify hotspots and gaps. **Methods:** A quantitative bibliometric analysis was conducted using the Scopus database with the TITLE-ABS-KEY query: ("colorectal cancer" OR "colorectal carcinoma" OR "colorectal neoplasm" OR "colon cancer" OR "rectal cancer") AND ("vitamin D3" OR cholecalciferol OR "25-hydroxyvitamin D3" OR calcitriol). Publications from 2015–2025 in English, including articles and reviews, were included. Data were analyzed using VOSviewer and Biblioshiny to assess publication trends, country- and author-level output, co-authorship networks, keyword co-occurrence, and thematic evolution. **Results:** Publication output peaked in 2020–2021, with the United States and China leading contributions. Munoz, A., Bostick, R.M., and Zhang, Y. were the most prolific authors. Keyword analysis revealed two main clusters: molecular mechanisms (VDR, calcitriol, Wnt/β-catenin) and clinical studies (vitamin D3 supplementation, serum concentration, trials). Thematic mapping indicated mature molecular research, active clinical translation, and emerging topics. **Conclusion:** Colorectal cancer research balances well-established molecular insights with evolving clinical applications. Concentrated output in high-capacity countries and underrepresentation in high-burden regions highlight opportunities for capacity building, international collaboration, and evidence-based prevention strategies.

INTRODUCTION

Colorectal cancer is one of the most prevalent malignancies globally and represents a major public health challenge. It ranks as the third leading cause of cancer-related deaths worldwide, with a steadily increasing incidence in developing countries. In 2020, over 1.9 million new cases were reported, resulting in approximately 0.9 million deaths, making colorectal cancer the third most commonly diagnosed cancer and the second leading cause of cancer mortality globally[1–4].

Vitamin D3 has emerged as a significant factor in colorectal cancer development and progression. Its active form, calcitriol, regulates cell proliferation, apoptosis, and signaling pathways including Wnt/β-catenin, which are critical in colorectal tumorigenesis. Observational studies associate higher vitamin D3 levels with reduced colorectal cancer risk and

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improved patient outcomes, although clinical supplementation trials yield mixed results[5–7].

Bibliometric analysis is a quantitative approach to map scientific publications and examine research trends, key topics, and collaboration patterns among researchers and institutions[8]. In colorectal cancer research, bibliometric studies map publication patterns, keyword co-occurrence, and author or country collaboration, providing a holistic overview of research evolution and identifying emerging or underexplored topics[9–13].

Despite the growing body of literature, a comprehensive bibliometric analysis integrating colorectal cancer and vitamin D3 is still limited, particularly one that evaluates global trends, thematic structures, and collaboration networks. Addressing this gap can inform future research priorities, support translational applications, and guide public health strategies. Therefore, this study aims to to examine global research trends, major thematic areas, and authors collaboration networks in colorectal cancer and vitamin D3 studies using Scopus-indexed publications. The findings provide an overview of the development of this research field and highlight directions for future studies.

METHODS

Study Design

This study employed a quantitative bibliometric approach to analyse the global scientific literature on colorectal cancer and vitamin D3.

Data Source and Search Strategy

Data were retrieved from the Scopus database using the TITLE-ABS-KEY search query ((“colorectal cancer” OR “colorectal carcinoma” OR “colorectal neoplasm” OR “colon cancer” OR “colon carcinoma” OR “colon neoplasm” OR “rectal cancer” OR “rectal carcinoma” OR “rectal neoplasm” OR “bowel cancer” OR “large intestine cancer”) AND (“vitamin D3” OR cholecalciferol OR “25-hydroxyvitamin D3” OR “25(OH)D3” OR “1,25-dihydroxyvitamin D3” OR calcitriol)). The search was conducted on 3 February 2026 and initially yielded 1,136 records. After restricting the publication years to 2015–2025, 718 records were excluded, leaving 418 records for further screening. Subsequently, document type and language filters were applied, limiting the dataset to English-language peer-reviewed journal articles and review articles indexed in Scopus. Editorials, notes, letters, errata, conference papers, and other non-eligible document types, as well as non-English publications, were excluded (n = 35). Following the application of all inclusion and exclusion criteria, a total of 383 records were deemed eligible and included in the final analysis (Fig.1). The final dataset was exported and analyzed using VOSviewer and Biblioshiny (Bibliometrix R package) for bibliometric performance and science mapping analyses.

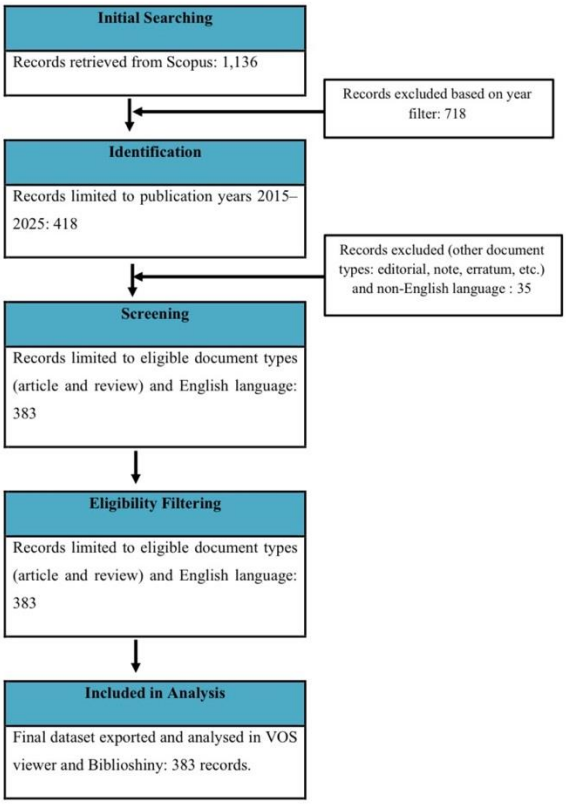

Figure 1. Prisma Flow Diagram Adapted for Bibliometric Analysis

Data Extraction and Preparation

All bibliographic information, including titles, abstracts, keywords, authors, affiliations, and references, was exported in CSV format. The records were screened to identify incomplete entries. Only documents with complete metadata were included in the final analysis.

Bibliometric Analysis

Bibliometric mapping was conducted using VOSviewer (version 1.6.20) to visualize scientific

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networks. A minimum keyword occurrence threshold of 20 and full counting were applied to improve network interpretability. Keyword co-occurrence and co-authorship analyses were performed to identify thematic relationships, temporal trends, and patterns of author collaboration. In addition, thematic mapping was conducted using Biblioshiny (Bibliometrix R package) to classify research themes based on centrality and density.

Ethical Considerations

This study analyzed secondary data retrieved from a publicly accessible bibliographic database. As no human subjects or identifiable personal data were involved, ethical approval was not required.

RESULT

Annual Publication Trends

The annual publication trends on colorectal cancer and vitamin D3 research demonstrated variable patterns from 2015 to 2025. The number of publications increased between 2015 and 2017, followed by a decrease in 2018. Publication output rose again from 2019, reaching the highest level in 2020. High publication output was maintained in 2021, after which a decline was observed during 2022 and 2023. An increase in the number of publications was recorded in 2024 and 2025 (Fig.2).

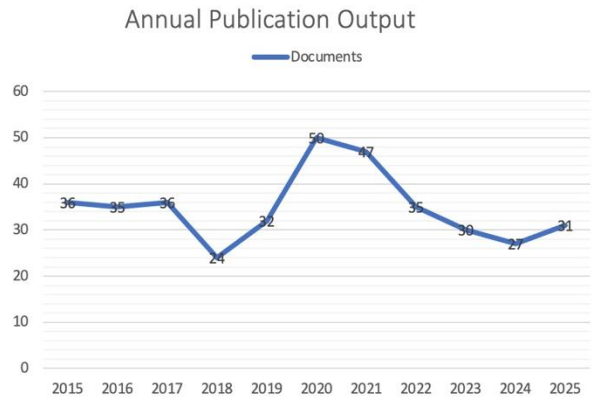

Figure 2. Trends in Annual Publication Output

Research Output by Country

The United States and China recorded the highest numbers of publications, with contributions consisting of both single-country publications (SCP) and multiple-country publications (MCP). Poland and Germany followed with moderate publication outputs. Iran, Japan, Spain, and Italy contributed similar numbers of documents, predominantly through SCP. Saudi Arabia, India, the Netherlands, and Brazil showed lower publication counts. The remaining countries, including the United Kingdom, Australia, Romania, Argentina, Denmark, Hungary, Canada, and Egypt, contributed relatively small numbers of publications with varying SCP and MCP proportions (Fig.3).

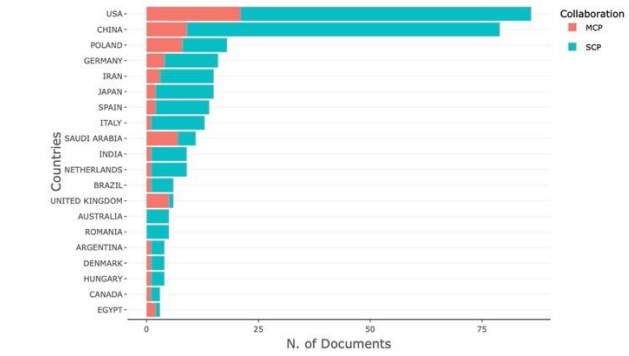

Figure 3. Research Output by Country

Country Collaboration Network

The country-level collaboration network shows the United States and China as the most prominent nodes, indicating the highest publication output and collaboration links. Germany, Japan, and the United Kingdom also appear as central contributors with multiple international connections. Additional collaborating countries include Italy, Poland, Spain, Iran, India, Saudi Arabia, France, Sweden, Denmark, Lebanon, and Puerto Rico, forming several interconnected clusters within the global research network (Fig. 4).

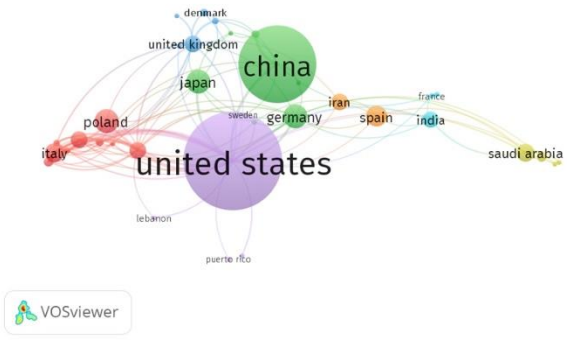

Figure 4. Country Collaboration Network

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Most Profilic Authors

The analysis of author productivity shows that Munoz, A. recorded the highest number of publications (13 documents). Bostick, R.M. and Zhang, Y. each contributed 12 documents, followed by Larriba, M.J. and Manson, J.E. with 11 publications each. Zhang, J. produced 10 documents. Barbáchano, A., Baron, J.A., Barry, E.L., and Chen, S. each contributed eight publications during the study period (Fig.5).

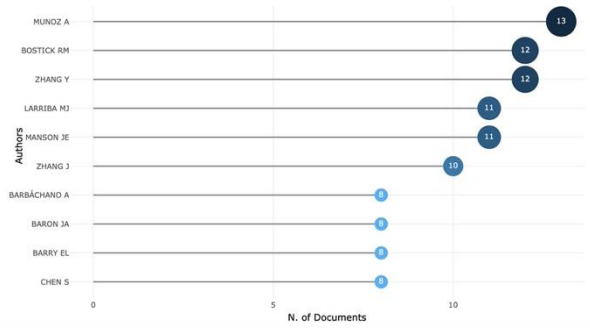

Figure 5. Most Profilic Authors

Authors Collaboration Network

The co-authorship network reveals several distinct collaboration clusters among authors. Manson, J.E. appears as a central node with extensive collaborative links across multiple clusters. Other prominent authors within the network include Brenner, H., Akutsu, T., Ohdaira, H., Ebeling, P.R., and Meyerhardt, J.A., each forming interconnected author groups. Additional authors such as Kimlin, M.G., Baxter, C., Neale, R.E., Ng, K., and Walter, J. are positioned within their respective clusters, indicating multiple collaborative relationships across the network (Fig.6).

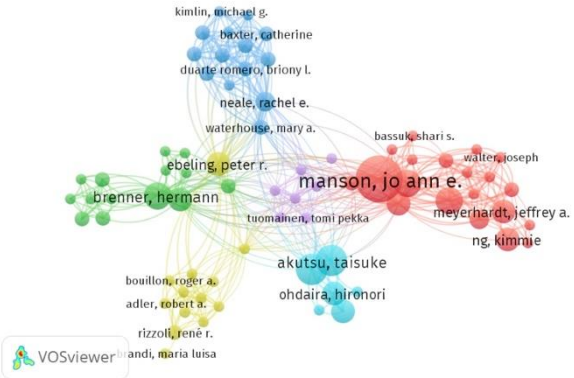

Figure 6. Authors Collaboration Network

Thematic Cluster Analysis

The keyword co-occurrence network revealed two main clusters (Fig.7). The first cluster included molecular-related terms such as VDR, VDR expression, CYP24A1, calcitriol, Wnt, β-catenin, apoptosis, cancer cell, tumor, and colon. The second cluster consisted of clinical-related terms, including vitamin D, serum, concentration, supplementation, trial, placebo, diagnosis, age, polymorphism, association, and CRC patient.

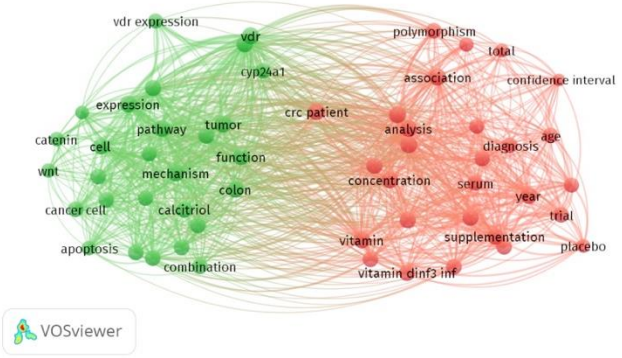

Figure 7. Thematic Cluster on Colorectal Cancer and Vitamin D3

Thematic Map

The thematic map shows keyword clusters positioned based on centrality and density (Fig. 8). The cluster including calcitriol, metabolism, and genetics is located near the boundary between the niche theme and motor theme quadrants. The cluster consisting of humans, article, and controlled study is positioned close to the boundary between the motor theme and basic theme quadrants. The cluster comprising human, colorectal cancer, and vitamin D appears in the emerging or declining theme quadrant. No clusters are located entirely within the niche theme quadrant.

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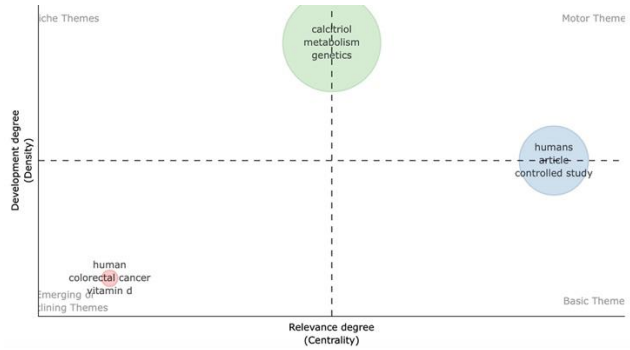

Figure 8. Thematic Map on Dengue and Climate Change Research

Overlay Visualization of Keyword Co-occurrence

The overlay visualization shows the average publication year of keywords (2019–2020). Purple–blue nodes, indicating earlier publications, include *vitamin D inf3, apoptosis, calcitriol, colon*, and *catenin*. Blue nodes include *vitamin D, VDR, cell, mechanism, pathway,* and *β-catenin.* Green nodes include *expression, tumor, cancer cell, concentration, analysis,* and *serum.* Light green nodes include *supplementation, diagnosis, age,* and *CRC patient*. Yellow nodes, indicating later publications, include *VDR expression, polymorphism, association, confidence interval, trial, placebo, total,* and *year* (Fig. 9).

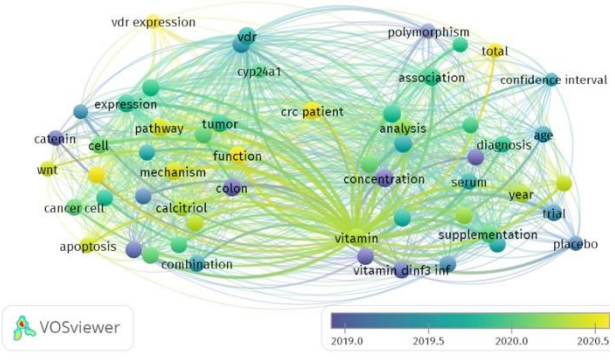

Figure 9. Overlay Visualization of Keyword Co-occurrence

DISCUSSION

Publication Trends and Research Growth

The annual publication output on colorectal cancer and vitamin D3 research exhibited fluctuating growth between 2015 and 2025. Publication numbers increased from 2015 to 2017, declined in 2018, and subsequently rose to reach a peak around 2020, followed by variations in later years and a renewed increase toward the end of the study period (Fig. 2). This pattern is consistent with broader bibliometric trends reported in colorectal cancer research. A global scientometric analysis of colorectal cancer publications from 2014 to 2023 demonstrated a sustained increase in annual research output, reflecting continuous scientific interest in this field[10].

In addition, bibliometric studies focusing on specific colorectal cancer subfields, including circulating tumor DNA, reported a marked escalation in publication output from 2015 onward, with high research activity observed through 2024[14]. Similarly, a bibliometric analysis of targeted therapies in colorectal cancer identified a strong and statistically significant upward trend in publications between 2015 and 2024 ($P < 0.001$), with high output observed during the late 2010s and early 2020s[15]. The publication peak observed around 2020 may reflect the cumulative maturation of colorectal cancer research, particularly the increasing integration of molecular biology, epidemiology, and nutritional science, including growing interest in vitamin D3 as a potential modulatory factor in carcinogenesis and disease progression. This period also coincided with wider availability of large-scale epidemiological datasets, expanded application of systematic reviews and meta-analyses, and increasing emphasis on adjunctive and preventive approaches in oncology. Collectively, these developments likely contributed to the concentration of research output around this period, resulting in a temporary peak before subsequent fluctuations.

Temporal Evolution of Research Focus

The evolution of research focus in colorectal cancer and vitamin D3 studies reflects broader shifts within the oncology research landscape. Early work in colorectal cancer research was dominated by foundational studies on biological mechanisms, including molecular pathways and cellular processes, which provided the basis for subsequent investigations into disease etiology and potential modulatory factors[10]. As research matured, there was increasing incorporation of biomarker and translational approaches, evidenced in bibliometric analyses that documented marked growth in publications addressing

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molecular diagnostics and signaling pathways in colorectal cancer, such as circulating tumor DNA research[14]. In addition, focused bibliometric evaluation of targeted therapies in colorectal cancer identified significant increases in publications over recent years, illustrating the field's progression toward clinical relevance[15]. These documented trends are consistent with the temporal evolution seen in many biomedical research domains, where initial mechanistic exploration gradually gives way to studies with greater clinical and translational emphasis. The observed shift toward integration of clinical, genetic, and intervention-oriented topics suggests that the research community has moved beyond early-stage mechanistic questions to address research themes with direct implications for patient outcomes and healthcare strategies.

Key Contributors and Collaboration Networks

The co-authorship network in colorectal cancer research reveals structured patterns of collaboration marked by distinct clusters of authors and varying degrees of connectivity. In bibliometric studies of colorectal cancer, visualization of author networks has been widely used to map research collaboration, where nodes represent authors and connecting lines indicate co-authorship relationships[11] . These patterns reflect how collaborative efforts are organized into clusters, with some authors serving as central connectors between groups, enhancing interdisciplinary engagement and information exchange. Research on colorectal cancer shows that large co-authorship networks often consist of multiple clusters, with some authors highly interconnected while others remain in smaller or more specialized groups. For example, in global colorectal cancer bibliometric analyses, author networks formed several collaborative clusters with varying link strengths, indicating distinct collaborative ties among researchers in different subfields of colorectal cancer investigation[13]. Such structural diversity suggests that influence and leadership in colorectal cancer research are not solely dependent on high publication counts but also on network centrality and the ability to bridge clusters, fostering broader scientific exchange and the spread of methodologies. These insights align with findings from bibliometric visualizations in colorectal cancer studies where author collaboration networks illustrate both productive hubs and interconnected groups of researchers[4]. Together, this evidence underscores that authors who occupy central positions within co-authorship networks may drive research trends and promote innovation, while peripheral authors contribute by maintaining the diversity of collaborative ties and facilitating the integration of emerging ideas into the research landscape.

Global Distribution of Research Output

The global distribution of research output in colorectal cancer clearly shows that a few countries dominate scholarly activity, reflecting their research capacity and strategic integration in international scientific networks. The United States consistently ranks as the most productive nation in CRC research, contributing the largest share of publications and frequently appearing as a central collaborator in bibliometric analyses (e.g., immunotherapy in CRC)[12]. China follows closely and, in some subfields, has shown rapid growth in publication volume, at times surpassing other nations in annual output while also maintaining strong collaborative links with multiple partners[16].

Beyond these leading contributors, several other countries such as Germany, Italy, Japan, and the United Kingdom also make significant contributions and participate in international research networks, forming interconnected clusters that strengthen global knowledge exchange and interdisciplinary work[10]. Mid-tier nations play an important role in regional research ecosystems, while smaller or peripheral contributors, though producing fewer publications, still enhance the diversity of perspectives and support the globalization of research efforts. Overall, both the concentration of research activity in high-output countries and the extent of international collaboration are key factors shaping global scientific progress in colorectal cancer research.

In addition to the dominant contributions from traditional research hubs, it is also important to note that some countries with a high burden of colorectal cancer such as India and Russia appear to be underrepresented in scientific outputs relative to their disease incidence. Global burden data show that these countries rank among those with substantial numbers of colorectal cancer cases worldwide, yet they have fewer indexed publications or collaborative links in bibliometric analyses compared to leading producers

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such as the United States and China. Furthermore, several regions including parts of North Africa and the Middle East (e.g., Algeria, Libya, and low-income contexts such as Somalia and Sudan) exhibit elevated colorectal cancer incidence or mortality but remain minimally represented in the international research landscape, highlighting a gap between disease burden and research activity. This discrepancy suggests opportunities for expanded research capacity and international partnerships to better align scientific responses with global health needs[17].

Thematic Structure and Research Maturity

Thematic mapping of colorectal cancer and vitamin D research reveals two main domains: molecular mechanisms and clinical applications. Molecular-related themes, including vitamin D receptor expression, CYP24A1, Wnt signaling, and β-catenin, reflect well-established, mature research streams forming the foundation of the field. In contrast, clinical themes such as vitamin D supplementation, serum concentration, trials, and patient-focused studies occupy motor and emerging quadrants, indicating active development and ongoing translation from molecular insights to clinical interventions[9,18].

Clusters in the emerging quadrant, including terms like humans, controlled study, and article, suggest nascent or transitioning topics with lower centrality and density. The absence of purely niche clusters indicates that research themes are interconnected and progressing toward broader integration. Overall, the field demonstrates a balance between mature mechanistic understanding and evolving clinical research, highlighting ongoing opportunities for interdisciplinary and translational studies[11].

Implications for Future Research and Public Health

Bibliometric trends in colorectal cancer research indicate that scientific output is concentrated in a few countries, highlighting the need to expand research capacity in high-burden but underrepresented regions such as India, Russia, and parts of North Africa and the Middle East. Strengthening international collaborations could enhance knowledge transfer and promote context-specific studies. Molecular mechanisms, including vitamin D receptor signaling and Wnt/β-catenin pathways, are well-established, while clinical and translational research, such as supplementation trials and patient-focused outcomes, remains emergent. Future studies should bridge mechanistic and clinical domains, explore genetic and lifestyle factors, and prioritize interventions applicable to diverse populations. From a public health perspective, these insights support strategic resource allocation, targeted screening, preventive interventions, and evidence-based policies in high-incidence regions. Despite limitations of bibliometric analysis, including database and language biases, the findings provide guidance for coordinated research and public health efforts to reduce colorectal cancer burden globally.

CONCLUSION

Colorectal cancer research demonstrates a dynamic interplay between mature molecular investigations and emerging clinical studies. Bibliometric and thematic analyses reveal concentrated scientific output in a few high-capacity countries, while high-burden regions remain underrepresented, highlighting opportunities for capacity building and international collaboration. Molecular pathways such as vitamin D receptor signaling form a well-established foundation, supporting the translation of insights into patient-centered interventions. Strategic research efforts that integrate mechanistic, clinical, and public health perspectives are essential to address knowledge gaps, promote global equity in research, and guide effective prevention strategies.

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