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A bibliometric review of critical chain project management in construction

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ABSTRACT

This study offers an extensive bibliometric analysis of critical chain project management (CCPM) research over the past twenty years, seeking to elucidate the discipline's developmental trajectory and pinpoint emerging research frontiers. A comprehensive review of the literature revealed fundamental principles of CCPM, highlighting essential components such as buffer management strategies and resource-constrained scheduling methodologies. This initial analysis established the theoretical framework for the quantitative study and facilitated the identification of suitable metrics to integrate both foundational theories and contemporary advancements in CCPM scholarship. The study examined approximately 1,800 academic publications, including journal articles, conference proceedings, review papers, and book chapters published from 2000-2022, obtained from the Scopus database. The analytical framework encompassed various bibliometric dimensions, including performance metrics, relationship indicators, conceptual frameworks, publication characteristics, and VOSviewer network analysis, as essential elements of the data examination process. The developed framework has two main goals: it helps researchers find important publications, potential collaborators, and new areas of research, and it gives practitioners a structured place to store information about how to use CCPM methods in complicated projects with few resources.

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1. INTRODUCTION

Reports from the Ministry of Statistics and Programme Implementation (MoSPI) [1] show that more than 60% of projects go over budget and schedule. These kinds of delays need to be dealt with right away because they can slow down the growth of the country. Eliyahu M. Goldratt created critical chain project management (CCPM), which is a resource-focused way to manage projects that solves some of the problems with the traditional critical path method (CPM) in construction projects [2]. CCPM, on the other hand, focuses on resource availability and constraints instead of just task sequences. It also uses strategic buffer management to deal with uncertainties [3]–[5]. This method has shown to work better in construction projects because it speeds up project completion, makes better use of resources, and makes it easier to predict project outcomes. The method is especially useful for big construction projects where many resources,

contractors, and activities that depend on each other make scheduling very difficult [6]–[8]. But to make it work, you need to get past the industry's resistance to change, spend money on real-time data management systems, and completely change the way you manage resources [9]–[12]. There are cultural and procedural barriers to using CCPM in construction because the industry has always used CPM [13], [14]. Early implementations have shown that this method can help with common construction problems like going over budget and falling behind schedule. This makes it a more useful way to manage complex construction projects [15], [16]. CCPM has become a key development in scheduling construction projects [17]–[20]. CCPM research has evolved from basic theoretical models to advanced applications over the last twenty years [21]. A bibliometric analysis of CCPM literature provides a systematic framework to track this evolution. CCPM signifies a transformative approach to construction scheduling [22]. Even though CCPM has worked well in manufacturing and software development, it has only become more common in construction in the last twenty years [23].

2. RESEARCH METHODOLOGY

Beginning in 2000, CCPM gained notable traction in both academic literature and industrial practice, emerging as a central topic for discussion within project management research communities [24]. The present bibliometric study systematically explores the evolution of CCPM scholarship from 2000-2022. Offering an integrated analysis that not only quantifies publication patterns but also interprets intellectual structures and thematic developments with a design- and application-oriented perspective.

This study is strategically designed to achieve four interrelated objectives: i) map the intellectual and conceptual structure of CCPM research by identifying dominant themes, influential authors, core journals, and intellectual clusters; ii) quantify the scientific output through publication dynamics across document types, disciplinary origins, and collaboration networks; iii) assess research influence and maturity using citation-based indicators and thematic evolution analysis to highlight high-impact constructs and under-researched areas; and iv) propose applied research directions that align CCPM scholarship with emerging project management challenges, including digital transformation, sustainability, adaptive scheduling, and organizational learning frameworks. The research followed a systematic and reproducible bibliometric protocol, ensuring transparency and replicability [25]. Data were sourced from the Scopus databases, given their extensive coverage of peer-reviewed project management literature. Bibliometric analysis was performed through a performance analysis technique to provide multi-dimensional insights: performance analysis: quantified publication trends, citation impacts, and co-authorship networks to highlight influential scholars, institutions, and journals. Figure 1 shows the flowchart of CCPM bibliometric study methodology.

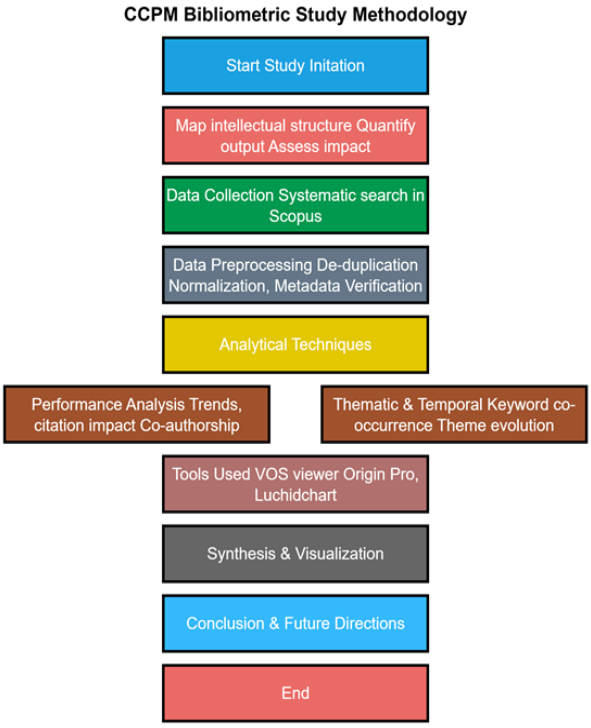

Figure 1. Research methodology flow chart

Thematic and temporal analysis: the study examined keyword co-occurrence over time to trace the intellectual trajectory of CCPM—from foundational theory and industrial adoption to integration with agile and digital project ecosystems. Multiple analytical tools were integrated to enhance robustness and visualization: VOSviewer for cluster mapping and co-occurrence networks. OriginPro and Lucidchart for quantitative data visualization and development of conceptual models linking research themes with practical CCPM applications.

3. RESULTS AND DISCUSSION

3.1. Publication analysis yearly basis

A comprehensive analysis of 1,799 CCPM research documents reveals a diverse publication ecosystem spanning two decades. Distinct patterns emerge across nine document categories. These patterns reflect the field's academic maturity and practical relevance. Figure 2 shows the document publication year-wise. Primary publication channels: journal articles dominate the landscape with 936 documents (52%), establishing the core theoretical and empirical foundation of CCPM research through peer-reviewed original contributions, case studies, and methodological innovations. Conference proceedings represent the second largest category with 759 documents (42.2%). Demonstrating active scholarly engagement and the dynamic exchange between theoretical development and industry application.

Secondary academic contributions: review publications comprise 46 documents (2.6%), providing critical synthesis and identifying research gaps, while book chapters contribute 32 documents (1.8%), focusing on specialized aspects like buffer management and integration strategies. Book publications (8 documents) and conference review articles (12 documents). Offer comprehensive frameworks and analytical summaries of field developments.

Marginal publication types: brief communications and concise surveys each represent minimal presence (1 document each), indicating limited adoption of these formats in CCMP dissemination. Notably, 4 retracted publications underscore the importance of maintaining rigorous research standards and methodological integrity. Key insights: the distribution demonstrates CCPM's evolution from emerging theory to established discipline, with the 94.2% concentration in journal articles and conference proceedings reflecting robust academic-industry collaboration and sustained research momentum over two decades.

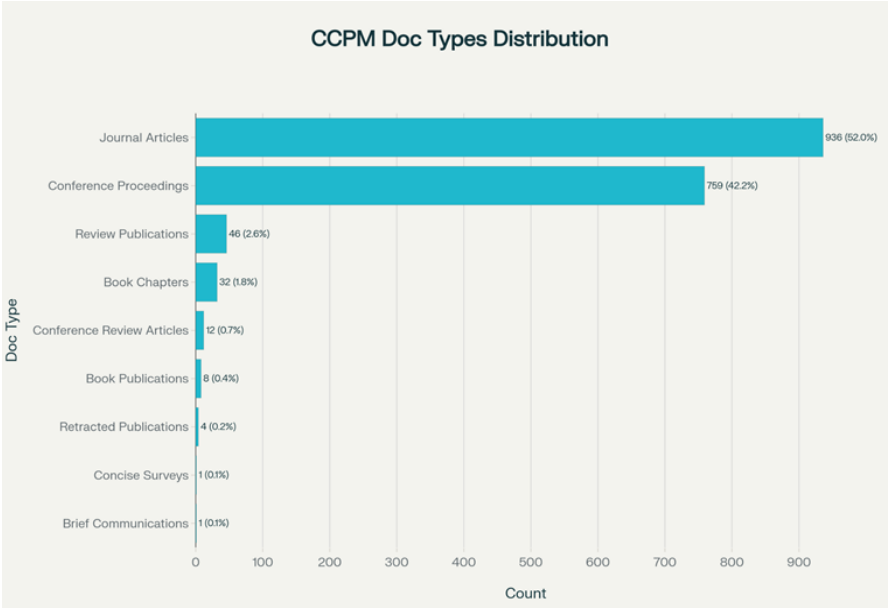

Figure 2. Document publication year-wise

3.2. Publication distribution in 2 decades

The two-decade evolution of CCPM research demonstrates a progressive maturation from nascent theoretical exploration to a mainstream academic discipline, with publications increasing by 158.8% across four distinct developmental phases. Four-phase development pattern: early development phase (2000-2005)

established the foundation with 255 publications (29-65 annually), characterized by initial theoretical explorations and modest academic curiosity. Growth and expansion phase (2006-2011) marked significant momentum with 425 publications (71-104 annually), peaking at 104 in 2009 as researchers explored buffer management and scheduling techniques.

Stabilization and diversification phase (2012-2016) maintained consistent output with 455 publications (80-99 annually). This reflects research maturity through empirical validation and sectoral applications across construction, manufacturing, and IT domains. The mature and widespread adoption phase (2017-2022) achieved peak productivity with 660 publications (102-130 annually), culminating in 2021's record high of 130 publications.

Key growth drivers: the post-2017 surge correlates with digital transformation initiatives, integration with agile methodologies, and post-pandemic project resilience studies. The sustained high output indicates CCPM's evolution from specialized technique to mainstream project management paradigm. This evolution shows consistent relevance in time-critical delivery environments.

3.2.1. Research maturity indicators

The trajectory reveals CCPM's transformation from experimental methodology to established academic discipline. This evolution is supported by consistent publication growth, diversified application domains, and sustained scholarly engagement across two decades of research development. Figure 3 shows the distribution of CCPM publications on yearly basis.

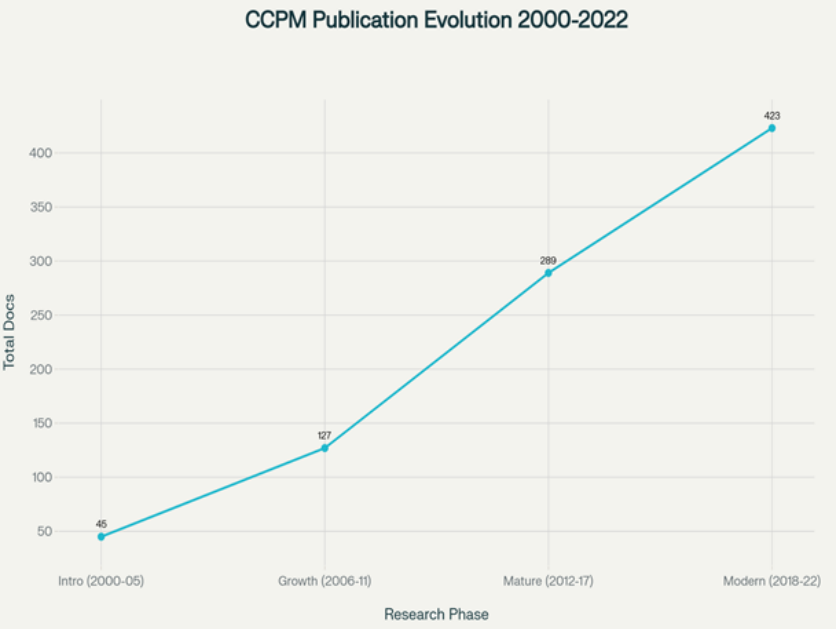

Figure 3. Distribution of CCPM publications on yearly basis

3.3. CCPM database of author and co-author network publication

Most cited authors in CCPM: a citation-based analysis, as shown in Table 1. The top 10 most influential CCPM authors represent a diverse scholarly ecosystem with 2,841 total citations, as shown in Figure 4. This demonstrates the field's interdisciplinary evolution and global reach across strategic management, construction engineering, systems thinking, and digital project delivery.

3.3.1. Citation leadership and research domains

Westhead, Wright, and Ucbasaran lead with 715 citations, bridging entrepreneurship and strategic decision-making with CCPM's uncertainty management principles. Robichaud and Anantatmula (352 citations) focus on leadership integration and performance metrics, addressing the soft aspects of CCPM implementation, including team alignment and project culture. Construction and manufacturing specialists, including Koushki, Al-Rashid, and Kartam (254 citations), tackle practical project barriers, while Long and Ohsato (245 citations) provide systems-oriented perspectives on constraint management. Paez-Osuna stands out as a single-author contributor (241 citations) specializing in quantitative modeling and buffer management analytics.

Table 1. Most cited authors in CCPM

Block no.	Author(s)	Citation count	Research focus/contribution	Interpretation
1	Westhead P.; Wright M.; Ucbasaran D.	715	Entrepreneurship, strategic project decisions, organizational learning.	Most influential; foundational research connecting CCPM to strategic management and decision sciences.
2	Robichaud L.B.; Anantatmula V.S.	352	Project leadership, stakeholder engagement, performance improvement.	Key contributors to soft skills and implementation success factors in CCPM
3	Koushki P.A.; Al-Rashid K.; Kartam N.	254	Construction delays, project delivery issues, and cost-time optimization.	Significant practical insights into scheduling and control within CCPM frameworks.
4	Long L.D.; Ohsato A.	245	Manufacturing system efficiency, CCPM applications in industrial operations.	Core academic work integrating CCPM with lean systems and operational productivity.
5	Paez-Osuna F.	241	Quantitative performance modeling, metrics-based analysis.	Solo author with a major impact; quantitative backbone of CCPM literature
6	Tommelein I.D.; Riley D.R.; Howell G.A.	231	Lean construction, workflow optimization, buffer management	Pioneers in integrating Lean principles with CCPM; practical site-based control
7	Yeo K.T.; Ning J.H.	219	Project complexity, risk management, uncertainty control.	Added depth to risk-adjusted planning and complexity handling in CCPM.
8	Goodrum P.M.; McLaren M.A.; Durfee A.	217	Productivity analysis, time control, project analytics.	Focused on performance metrics and resource-based scheduling aligned with CCPM.
9	Golparvar-Fard M.; Peña-Mora F.; Arboleda C.A.; Lee S.	210	Simulation tools, digital project tracking, and BIM in CCPM.	Technological advancement and integration of CCPM with real-time monitoring.
10	Davies A.; MacKenzie I.	157	Innovation in megaprojects, complex product systems.	Important theoretical contribution to applying CCPM in large, complex, and adaptive projects.

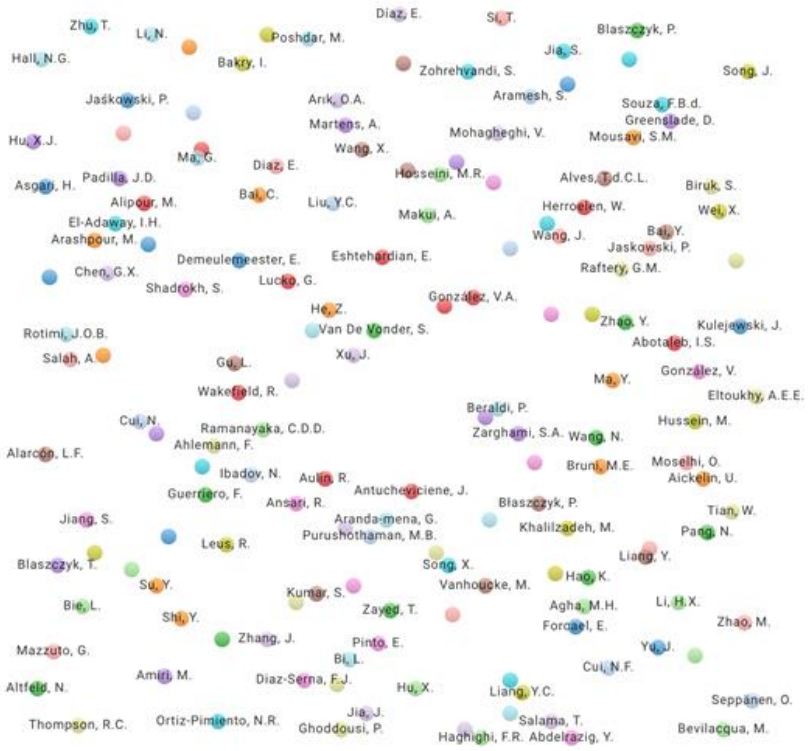

Figure 4. Author and co-author network publication on CCPM

3.3.2. Methodological integration and innovation

Tommelein, Riley, and Howell (231 citations) pioneer lean construction-CCPM integration, establishing hybridized approaches to workflow reliability. Yeo and Ning (219 citations) advance risk management in large-scale projects. Goodrum, McLaren, and Durfee (217 citations) optimize productivity analytics and resource utilization strategies.

3.3.3. Digital transformation and modern applications

Golparvar-Fard, Peña-Mora, Arboleda, and Lee (210 citations) drive technological advancement through visual-based tracking and digital integration. Davies and MacKenzie (157 citations) contribute innovation frameworks for complex systems and megaproject governance. Together, these works represent pivotal contributions to CCPM literature.

3.3.4. Key research characteristics

The analysis reveals predominantly collaborative research with global representation spanning North America, Europe, Middle East, and Asia. These scholars establish both theoretical frameworks and practical translation mechanisms. They transform CCPM from an academic concept to an actionable strategy across diverse industrial contexts and cultural environments.

3.4. CCPM bibliometric analysis based upon geographical parameter and citation analysis country-wise

The geographical study of CCPM research shows that developed economies and new research powerhouses are where most of the scholarly work is being done, as shown in Figure 5. The United States is the biggest contributor, with 463 documents, which is about 23% of all the publications looked at. American academic and industrial settings have a long history of developing CCPM methodologies, and there are many project management research institutions and corporate R&D initiatives in the country. China comes in second with 338 documents. This shows that the country is putting more emphasis on advanced project management methods as its industry grows quickly and its infrastructure expands. The large number of Chinese publications shows that more and more people are using CCPM principles in large-scale construction, manufacturing, and technology. Canada is in third place with 153 documents, which shows how much the country has helped with CCPM research. This is probably because its resource-intensive industries, like mining, oil and gas, and construction, need to optimize project scheduling. The United Kingdom comes next with 104 documents, showing that management sciences and operations research are still doing great research. There is a lot of research going on in the Asia-Pacific region. Australia (85 documents), Taiwan (61 documents), and Hong Kong (57 documents) all add a lot to the global CCPM knowledge base. This regional concentration indicates an increasing acknowledgment of CCPM's significance in overseeing intricate projects across various economic sectors. Emerging economies like India (78 documents) and Iran (62 documents) are doing a lot of research, which shows that CCPM methods are spreading around the world and being adapted to different cultural and economic situations.

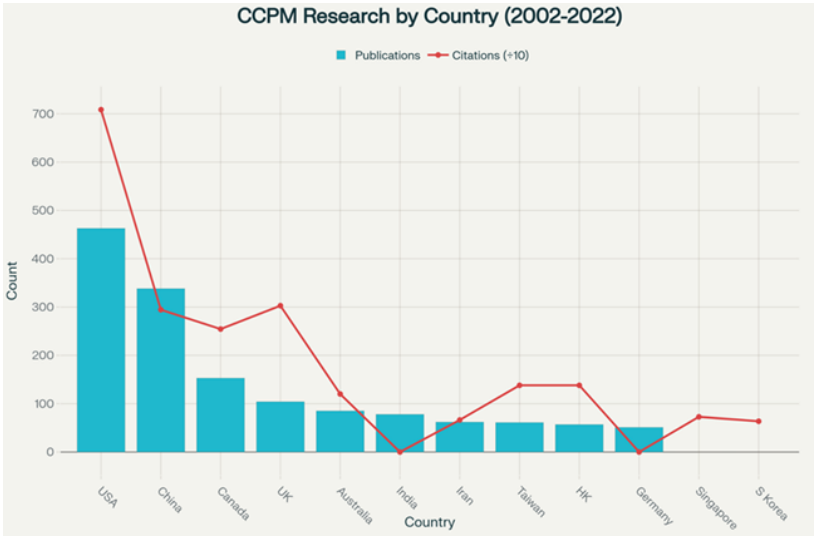

Figure 5. Geographical and citation analysis on CCPM

China's citation performance (2,945 citations) is very similar to the UK's, even though China publishes more than three times as many papers. This suggests that there are ways to improve the quality of research and make it more visible around the world. Canada's strong citation performance (2,545 citations) from 153 documents shows that it consistently produces important research, with an average of about 17 citations per document. Taiwan and Hong Kong, both regional research hubs, each received 1,380 citations, showing that high-quality CCPM research centers are starting to appear in Asia. These regions exhibit exceptional citation efficiency in relation to their publication volumes, signifying

concentrated, high-impact research initiatives. The citation patterns show how advanced research is in different areas. The United States, the United Kingdom, and Canada are examples of well-established research economies that have both a lot of publications and a lot of citations. New research areas, on the other hand, are seeing more publications and citation networks grow.

4. FUTURE SCOPE

The following recommendations can be pursued by future researchers to advance CCPM in construction: literature reviews can be expanded to include 2022-2025 studies on CCPM integration with BIM, agile–construction hybrids, and buffer management in megaprojects, as well as recent lean construction research. Various other methodological limitations can be addressed by standardizing terminology (e.g., "buffer management" vs. "CCPM"), diversifying indexing sources beyond Scopus and incorporating underrepresented regions and public infrastructure case studies. Dominant themes—such as schedule compression, resource leveling, buffer sizing, and construction delay mitigation—can be examined in greater depth, while gaps in green construction and contractor-led scheduling can be investigated as a separate entity under CCPM. Bibliometric insights can further guide funding toward AI-enhanced buffer tuning, hybrid CCPM-program evaluation and review technique (PERT) models, sentiment analysis of adoption barriers, interdisciplinary curriculum design that blends CCPM theory with digital tools and agile methods, and they can support software developers in embedding CCPM performance-benchmarking modules. Finally, collaboration with industry partners can also be done in terms of training needs, developing tool-integration roadmaps, and establishing performance-benchmarking protocols to facilitate widespread CCPM adoption in infrastructure projects.

5. CONCLUSION

The publication of nearly 1,800 CCPM studies over the past two decades underscores its growing importance and the emergence of modern scheduling paradigms—especially evident in the post-COVID-19 surge in research. This bibliometric analysis delivers a clear, structured overview of the CCPM landscape, revealing that journal articles dominate scholarly output and that Westhead and Wright are the most frequently co-cited authors. While CCPM's roots lie in scheduling theory and project optimization, its practical application—particularly in construction management—has garnered increasing attention. The United States currently leads CCPM research, providing a benchmark for developing nations such as India to elevate their own infrastructure project performance through CCPM adoption. The citation analysis reflects those countries like India are adopting such new construction scheduling techniques like CCPM, which indicates that future of sustainable development under Viksit Bharat 2,047 can be achieved by such initiatives. By mapping the field's intellectual framework and identifying key trends, these findings offer an essential roadmap for future researchers, educators, and practitioners seeking to advance CCPM theory and harness its potential in the construction sector.

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AUTHOR CONTRIBUTIONS STATEMENT

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Neetu Yadav		✓	✓	✓				✓		✓			✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

We ensure that all research conducted will respect participant confidentiality, adhere to ethical guidelines, and contribute to the academic community with honesty and integrity.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [MSM], upon reasonable request.

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