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Cost, Financing, and Institutional Barriers to Green Supply Chain Management Adoption in South-East Nigeria's Building Construction Sector

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I. INTRODUCTION

The construction industry is essential to economic and social development through the provision of residential, commercial, institutional and infrastructure facilities. However, construction activities are associated with substantial consumption of natural resources, energy use, material extraction, transportation and waste generation. These environmental impacts extend across the construction supply chain, involving material manufacturers, suppliers, contractors, transport providers and other project stakeholders. The United Nations Environment Programme and Global Alliance for Buildings and Construction (2024) reported that buildings and construction account for approximately 32% of global energy consumption and 34% of global carbon dioxide emissions. These impacts have increased the need for approaches that integrate environmental considerations into construction processes and supply-chain activities.

Green Supply Chain Management (GSCM) provides one such approach by incorporating environmental considerations into supply-chain activities, including procurement, supplier selection, transportation, construction processes, waste management and end-of-life activities. Srivastava (2007) conceptualised GSCM as the integration of environmental thinking into supply-chain management, extending from product design and material selection to manufacturing, delivery and end-of-life management. In construction, this approach can involve green procurement, environmentally responsible supplier selection, eco-design, life-cycle assessment, green transportation, waste minimisation, reverse logistics and collaboration among supply-chain participants. Because construction projects depend on multiple organisations and suppliers, effective GSCM implementation requires coordination beyond the construction site itself.

Despite its potential contribution to environmental sustainability, implementing GSCM in construction remains challenging. Badi and Murtagh (2019), in a systematic review of GSCM in construction, observed that the construction industry has distinctive characteristics that create particular difficulties for implementing green supply-chain practices. Construction supply chains are often fragmented, project-based and involve numerous independent stakeholders, making environmental coordination complex. Recent evidence from Nigeria similarly indicates that GSCM practices are not implemented uniformly across construction activities. Osungbade et al. (2025), examined the extent of GSCM implementation on construction projects in Nigeria and reported uneven implementation of practices such as green procurement, eco-design, reverse logistics and technological innovation. The authors also identified high costs, inadequate expert knowledge and weak regulatory implementation among the obstacles to broader GSCM implementation.

The barriers to GSCM implementation are multidimensional. Financial constraints can arise from the initial cost of environmentally preferable materials, technologies, training and environmental management systems. Regulatory barriers may result from inadequate policies, weak enforcement, fragmented institutional responsibilities and insufficient incentives. Organisational barriers may include limited top-management commitment, inadequate knowledge and skills, resistance to organisational change and insufficient internal environmental capabilities. Supply-chain participants may also experience difficulties relating to supplier cooperation, information sharing, technology availability and stakeholder coordination. Tumpa et al. (2019), for example, identified financial constraints, inadequate government regulation and limited market-related pressures among important barriers to GSCM implementation in an emerging-economy context. Balon et al. (2024) similarly demonstrated that green construction supply-chain barriers involve interconnected financial, organisational, technological and institutional dimensions.

These challenges are particularly relevant in developing-country construction environments, where limited resources and institutional constraints may influence the capacity of firms to adopt sustainable practices. Nigerian construction supply chains are also exposed to broader logistics and supply-chain risks that can influence project delivery. Nzeh et al. (2026), including Akaun as a co-author, examined construction logistics and supply-chain risk factors affecting cost performance in Nigerian building construction projects. Their findings identified several dimensions of construction supply-chain risk, including strategic planning and design risks, socio-institutional logistics risks, contractor capacity constraints, project governance risks and policy/economic change risks. These findings reinforce the importance of examining supply-chain conditions when investigating challenges associated with sustainable construction practices.

Nigerian evidence further indicates that GSCM implementation is affected by organisational and institutional factors. Ojo et al. (2014) identified inadequate resources, lack of awareness and knowledge, supplier resistance, limited top-management commitment and insufficient government support as barriers to implementing GSCM in the Nigerian construction industry. More recent evidence has continued to identify financial, regulatory, technological, organisational and stakeholder-related constraints within the Nigerian construction sector. Unegbu et al. (2025), for example, identified financial constraints, organisational culture, availability of sustainable technologies, stakeholder engagement and government regulation as important considerations affecting sustainable construction in Nigeria.

The issue is particularly relevant to the South-East geopolitical zone of Nigeria, where building construction involves interactions among clients, consultants, contractors, suppliers, manufacturers, transport providers and regulatory institutions. Effective GSCM therefore depends not only on the willingness of individual construction firms but also on the wider supply-chain and institutional environment in which projects are delivered. Amade et al. (2020), in examining barriers to GSCM adoption on construction projects in Imo State, reported challenges relating to knowledge and experience, top-management support, implementation cost, government regulations and support systems. This regional evidence indicates the importance of examining GSCM barriers within the specific context in which construction projects are undertaken.

Although previous studies have identified various barriers to GSCM and sustainable construction, further context-specific empirical evidence is required on the impediments affecting successful GSCM implementation in building construction project delivery across South-East Nigeria. Findings from manufacturing industries, other countries or broader sustainable-construction studies cannot automatically be assumed to represent the conditions experienced by construction stakeholders in the South-East. Identifying these impediments and assessing their severity can provide an empirical basis for interventions involving financing, regulation, capacity building, organisational commitment, technology and stakeholder collaboration.

Therefore, this study focuses on identifying the impediments or challenges to successful GSCM implementation for building construction project delivery in South-East Nigeria. Specifically, the study seeks to identify the impediments/challenges to successful GSCM implementation for building construction project delivery in South-East, Nigeria.

II. LITERATURE REVIEW

Conceptual Review

Challenges/Impediments to Green Supply Chain Management in Building Construction Projects in Nigeria

Green Supply Chain Management (GSCM) integrates environmental considerations into supply-chain activities, including procurement, material selection, production, transportation, construction, waste management, and the recovery or reuse of materials. In the construction sector, GSCM provides a systemic approach for reducing environmental impacts across the project life cycle rather than concentrating only on activities occurring on the construction site. Badi and Murtagh (2019), in their systematic review of GSCM in construction, observed that the sector has distinctive supply-chain characteristics, including fragmentation, temporary project organizations, numerous independent actors, and complex inter-organizational relationships. These characteristics make the transition toward greener supply chains more challenging than simply transferring GSCM practices from manufacturing to construction.

In Nigeria, the implementation of GSCM is constrained by a combination of regulatory, economic, institutional, technological, and socio-cultural barriers. Ojo et al. (2014), in an empirical study of Nigerian construction firms, identified lack of resources, supplier resistance, inadequate awareness, limited knowledge, weak top-management commitment, and insufficient government and legal enforcement among the barriers to GSCM adoption. Similarly, Amade et al. (2020), using evidence from construction firms in Imo State, found lack of knowledge and experience, inadequate top-management support, implementation cost, and insufficient government regulations and support systems to be important obstacles to GSCM implementation.

More recent Nigerian research indicates that these barriers remain multidimensional. Akindele et al. (2023) grouped barriers to sustainable construction practice in Nigeria into technopolitical, perception and awareness, and sociocultural dimensions. Their findings further identified education and training, stakeholder regulation, incentive support, and government and legislative support as important strategies for overcoming these barriers. Unegbu et al. (2025) similarly found that organizational culture, availability of sustainable technologies, stakeholder engagement, financial constraints, and government regulation are important constraints affecting sustainable construction in Nigeria.

The barriers are therefore interconnected rather than isolated. Weak regulation can reduce incentives for firms to invest in green technologies; high investment costs can discourage developers from adopting environmentally preferable materials; inadequate technical knowledge can prevent appropriate application of available technologies; and weak collaboration among project participants can inhibit green procurement and material recovery. Consequently, identifying and prioritizing the barriers is necessary for developing interventions that correspond to the actual conditions of the construction supply chain. This is particularly relevant to South-East Nigeria, where understanding the relative severity of individual impediments can assist policymakers, contractors, consultants, suppliers, and project managers in directing limited resources toward the most critical constraints.

Weak Regulatory Enforcement and Policy Gaps

Government regulation is an important institutional mechanism for encouraging sustainable construction because regulatory requirements can establish minimum environmental standards and create incentives for firms to incorporate sustainability into procurement and project delivery. However, evidence from Nigeria indicates that the existence of policies does not necessarily translate into effective implementation. Adebayo et al. (2019), in their study of sustainable procurement in Nigerian construction, found that barriers were associated with sustainability knowledge, transparency and governance, procurement strategy and national policy, and construction-industry factors. Their findings demonstrate the importance of aligning procurement policy with sustainability objectives.

The problem is therefore not simply the absence of environmental policies but also weaknesses in implementation, coordination, awareness, and institutional capacity. Where environmental requirements are weakly monitored or insufficiently integrated into procurement and construction decision-making, contractors may have limited practical incentives to change established practices. Unegbu et al. (2025) likewise identified weak regulatory frameworks and inadequate incentives among important barriers to sustainable construction adoption in Nigeria.

Lack of Binding and Consistent Green Building Requirements

The absence of consistent and enforceable sustainability requirements can make green construction dependent on the voluntary commitment of individual project participants. This creates variation between projects and organizations and can reduce demand for green materials, technologies, and services. For GSCM, the consequences extend beyond building design because procurement decisions, supplier selection, transportation, waste management, and material recovery are influenced by the standards established for project delivery.

Badi and Murtagh (2019) emphasize that construction GSCM requires consideration of the whole supply chain and its multiple actors. Consequently, isolated environmental initiatives are unlikely to achieve the same systemic effect as coordinated requirements covering procurement, suppliers, materials, construction processes, and end-of-life activities.

Policy Discontinuity and Incoherence

Sustainable construction requires consistency between environmental policy, procurement policy, construction regulation, infrastructure development, and economic policy. When sustainability requirements are fragmented across different policy instruments or institutions, project stakeholders may face uncertainty concerning responsibilities and implementation priorities. Adebayo et al. (2019) found that mismatch between procurement strategy and national policy constitutes an important barrier to sustainable procurement in Nigeria.

Akindele et al. (2023) similarly reported that government and legislative support was among the strategies required to address barriers to sustainable construction in Nigeria. Their findings suggest that sustainable construction requires more than isolated initiatives; it requires coordinated institutional and legislative support that can provide direction to industry participants.

Fragmented Institutional Responsibilities and Monitoring

Construction projects involve clients, consultants, contractors, suppliers, regulators, communities, and other stakeholders whose decisions influence environmental performance. Fragmentation among these participants can complicate the coordination and monitoring of sustainability requirements. Badi and Murtagh (2019) identify the fragmented and temporary nature of construction supply chains as one of the distinctive features that needs to be considered when implementing GSCM in construction.

Weak monitoring further reduces the effectiveness of environmental requirements. Where sustainability indicators are not clearly defined or routinely measured, project participants may find it difficult to demonstrate compliance or compare performance between projects. Unegbu et al. (2025) identified government regulation and institutional factors among the key dimensions influencing sustainable construction implementation in Nigeria.

Lack of Political and Organizational Commitment

Commitment from government and organizational leadership is important because implementation of GSCM may require additional investment, training, changes in procurement procedures, supplier evaluation, and new performance measures. Without leadership support, sustainability objectives may remain peripheral to project decision-making.

Amade et al. (2020) identified lack of top-management support as one of the barriers to GSCM adoption among construction firms in Imo State. Ojo et al. (2014) similarly identified poor top-management commitment among the barriers reported by Nigerian construction firms. These findings indicate that organizational commitment is closely related to the ability of firms to translate sustainability objectives into operational practices.

Absence of a Clear Implementation and Standardized Metrics

A further challenge is the absence of sufficiently consistent implementation procedures and performance measures through which construction organizations can translate broad sustainability objectives into operational activities. GSCM requires measurable practices covering areas such as green procurement, supplier selection, transportation, waste reduction, recycling, material recovery, and environmental performance.

Akindele et al. (2023) found that stakeholder regulation, incentive support, education and training, and government and legislative support were important strategies for overcoming barriers to sustainable construction. These findings imply the need for clearer implementation structures that connect policy objectives with the practices undertaken by construction organizations.

Financial and Economic Challenges

High Cost of Green Materials and Technologies

Financial considerations constitute one of the most frequently reported barriers to GSCM implementation. Green materials and technologies may require higher initial expenditure than conventional alternatives, particularly where local supply is limited and specialized technologies or expertise must be sourced externally. Amade et al. (2020) identified the cost of implementing GSCM as an important barrier among construction firms in Imo State.

Unegbu et al. (2025) also found high initial costs of sustainable materials and technologies to be a significant barrier to sustainable construction adoption in Nigeria. These costs can influence decisions by clients, contractors, consultants, and suppliers, particularly where project budgets are constrained and procurement decisions are strongly influenced by initial price.

Limited Access to Green Financing

The financial challenge extends beyond the price of green materials to the availability of suitable financing. Sustainable construction investments may require additional capital during design and construction while some benefits, such as reduced energy and maintenance costs, are realized over a longer period. Where developers and contractors have limited access to affordable long-term finance, the immediate financial burden can discourage GSCM adoption.

Unegbu et al. (2025) identified financial constraints as one of the major dimensions limiting sustainable construction in Nigeria. Akindele et al. (2023) also identified incentive support as an important strategy for addressing barriers to sustainable construction.

Perceived Low Return on Investment

Another economic impediment is the perception that the benefits of GSCM are uncertain or may not compensate for the additional initial expenditure. Conventional procurement often emphasizes the lowest initial cost, whereas many green practices require consideration of life-cycle costs, including energy, maintenance, waste, and resource efficiency.

Where project stakeholders lack sufficient information about life-cycle benefits, green alternatives may be regarded as expensive rather than as long-term investments. This reinforces the importance of sustainability knowledge and awareness. Adebayo et al. (2019) identified sustainability knowledge as the most significant barrier cluster in their study of sustainable procurement in Nigerian construction, demonstrating the relationship between knowledge and procurement decisions.

Economic Uncertainty and Transaction Costs

Economic uncertainty can further affect investment in green technologies and materials. Inflation, exchange-rate fluctuations, and changes in material prices can increase the uncertainty associated with construction budgets, particularly where green products or technologies depend on specialized supply chains. In addition, firms may incur additional transaction costs for environmental assessment, documentation, specialist consultancy, certification, and supplier evaluation.

These costs can be particularly significant for smaller construction organizations with limited technical and financial resources. Consequently, the economic barrier to GSCM should be understood as a combination of initial investment requirements, financing limitations, perceived return, uncertainty, and additional implementation costs rather than simply the price of individual green products.

Institutional and Technical Challenges

Successful GSCM requires knowledge and skills covering green procurement, sustainable material selection, environmental assessment, waste minimization, supplier evaluation, and resource efficiency. A shortage of such knowledge can prevent organizations from translating sustainability objectives into practical supply-chain decisions.

Ojo et al. (2014) identified lack of knowledge and awareness among the principal barriers to GSCM implementation in Nigerian construction firms, while Amade et al. (2020) found lack of knowledge and experience to be the leading barrier reported in their Imo State study. Akindele et al. (2023) further found education and training to be an important strategy for overcoming sustainable-construction barriers in Nigeria.

Limited Adoption of Green Technology and Innovation

The availability and accessibility of appropriate green technologies also influence GSCM adoption. Technologies for energy efficiency, renewable energy, water conservation, sustainable materials, digital monitoring, and waste recovery may require technical expertise and reliable supplier support. Unegbu et al. (2025) identified availability of sustainable technologies as one of the important dimensions affecting sustainable construction in Nigeria.

Technology adoption is therefore linked to both financial and institutional capacity. Even where appropriate technologies are available, construction firms may be unable to implement them effectively if they lack trained personnel, technical information, maintenance capacity, or reliable suppliers.

Inadequate Sustainability Information and Data

Reliable information is essential for evaluating environmental performance and making informed supply-chain decisions. GSCM requires information about material characteristics, environmental impacts, waste generation, transportation, energy consumption, supplier performance, and opportunities for reuse and recycling. Where such information is incomplete or inconsistent, stakeholders may find it difficult to compare alternatives or monitor improvements.

This challenge is particularly relevant to construction because projects involve numerous temporary organizations and suppliers. Badi and Murtagh (2019) emphasize the need to address the distinctive characteristics of construction supply chains when developing GSCM approaches.

Poor Waste-Recovery and Reverse-Logistics Infrastructure

Construction and demolition activities generate substantial quantities of material waste, creating an important opportunity for GSCM through reduction, reuse, recycling, and material recovery. However, the effectiveness of reverse logistics depends on the availability of collection, sorting, transportation, processing, and reuse infrastructure.

Ogunmakinde et al. (2022) examined construction waste management in Nigeria through the 3R principle of reduce, reuse, and recycle and emphasized the need for effective waste-management approaches to reduce resource depletion and environmental impacts. For GSCM, inadequate recovery infrastructure can make it difficult for contractors to return materials to productive use, thereby reinforcing the conventional linear pattern of resource extraction, construction, use, and disposal.

Socio-Cultural Resistance and Traditional Practices

GSCM adoption often requires changes in established procurement procedures, supplier relationships, material choices, construction techniques, and organizational routines. Resistance can therefore occur where stakeholders perceive green practices as unfamiliar, expensive, risky, or inconsistent with established ways of working.

Akindele et al. (2023) identified perception and awareness and sociocultural factors among the major clusters of barriers to sustainable construction in Nigeria. Unegbu et al. (2025) similarly identified organizational culture as a major factor influencing sustainable-construction adoption.

Resistance from Contractors and Developers

Contractors and developers may prioritize immediate project cost, schedule, and commercial considerations when making procurement and construction decisions. Where green alternatives require higher initial expenditure or changes to established processes, they may be perceived as increasing project risk.

Amade et al. (2020) reported that implementation cost and lack of top-management support were important GSCM barriers in Imo State. This suggests that resistance is not necessarily caused by opposition to sustainability itself but may arise from concerns about cost, knowledge, capability, and uncertainty surrounding implementation.

Weak Stakeholder Engagement and Collaboration

GSCM is inherently collaborative because environmental performance is distributed across clients, designers, contractors, suppliers, regulators, transporters, waste handlers, and end users. Poor communication or weak collaboration among these actors can therefore prevent sustainability requirements from being consistently implemented across the supply chain.

Akindele et al. (2023) identified stakeholder regulation as one of the strategies for addressing sustainable-construction barriers, while Unegbu et al. (2025) identified stakeholder engagement as a significant dimension affecting sustainable construction adoption in Nigeria.

The literature demonstrates that the impediments to GSCM implementation in Nigerian construction are interconnected. Regulatory and policy weaknesses influence organizational incentives; financial constraints affect technology adoption; knowledge deficiencies limit implementation capacity; inadequate infrastructure restricts recycling and reverse logistics; and socio-cultural factors influence stakeholder willingness to change established practices. These relationships justify the need for empirical identification and prioritization of barriers within a specific geographical and project-delivery context.

For South-East Nigeria, such context-specific analysis is important because evidence from Imo State has already demonstrated the relevance of knowledge, management support, implementation cost, and government support to GSCM adoption, while broader Nigerian studies identify additional regulatory, technological, financial, stakeholder, and sociocultural dimensions. The present study therefore focuses specifically on identifying and assessing the impediments that constrain successful GSCM implementation in building construction project delivery in South-East Nigeria.

III. METHODOLOGY

Research Design

This study adopted a quantitative cross-sectional survey research design to investigate the impediments and challenges to successful Green Supply Chain Management (GSCM) implementation in building construction project delivery in South-East Nigeria. The design was considered appropriate because the study sought to obtain standardized responses from construction professionals concerning the perceived severity of identified barriers and subsequently subject the responses to statistical analysis.

A structured questionnaire was used to collect quantitative data from construction professionals involved in building construction projects across the five states of South-East Nigeria. The survey approach enabled the study to obtain comparable responses on a common five-point severity scale and provided data

suitable for Principal Component Analysis (PCA) and Severity Index (SI) analysis.
The study was primarily descriptive and exploratory. The descriptive component was used to summarize respondents' assessments of the identified GSCM impediments, while the exploratory component was employed to examine the underlying structure of the barriers through PCA. PCA is useful for identifying patterns among correlated variables and reducing a larger set of observed variables into a smaller number of interpretable components (Pallant, 2020).

The design was therefore consistent with the objective of the study, which was to identify and prioritize the impediments to successful GSCM implementation in building construction project delivery in South-East Nigeria. The combination of PCA and SI provided both a structural examination of the barriers and an assessment of their perceived severity.

Target Population of the Study
The target population comprised construction professionals involved in building construction projects across the five states of South-East Nigeria, namely Abia, Anambra, Ebonyi, Enugu, and Imo States. The professional categories included project managers, procurement professionals, engineers, builders, quantity surveyors, architects, consultants, and other professionals directly involved in building construction activities and supply-chain-related decisions.

These professionals were considered appropriate respondents because their responsibilities expose them to decisions concerning procurement, material selection, supplier relationships, construction processes, waste management, environmental practices, and project delivery. Their professional experience therefore provides relevant information for assessing barriers to GSCM implementation.

The population frame comprised 1,703 construction professionals identified from relevant government ministries and professional associations in the five South-East states. The population distribution is presented in Table 3.1.

Table 3.1: Population Distribution of Construction Professionals by State

S/N	State	Population
1	Imo	398
2	Abia	307
3	Anambra	318
4	Enugu	422
5	Ebonyi	258
Total		1,703

Source: Field Survey, 2025.

Sample Size and Sampling Technique

The population of 1,703 professionals provided the sampling frame for the study. Krejcie and Morgan (1970) provide a widely used procedure for determining the minimum sample size required for finite populations. Their published sample-size procedure indicates that a population of approximately 1,700 requires a minimum sample of approximately 314 respondents.

However, to obtain broader geographical coverage and increase the number of usable responses for the multivariate analysis, 890 questionnaires were distributed across the five states. The distribution followed the population structure presented in Table 3.2. The larger number of questionnaires administered also reduced the potential effect of non-response and provided a sufficiently large dataset for PCA.

A probability-based sampling approach was adopted for selecting respondents from the identified population. Respondents were selected from the identified professional groups because they possessed relevant experience in building construction and construction supply-chain activities.

Table 3.2: Population and Questionnaires Distributed by State

S/N	State	Population	Questionnaires Distributed
1	Imo	398	193
2	Abia	307	171
3	Anambra	318	173
4	Enugu	422	221
	Ebonyi	258	132
Total		1,703	890

Source: Field Survey, 2025.

The distribution provided representation across all five South-East states rather than concentrating the investigation in one location. This was considered important because institutional conditions, construction activity, and professional participation may vary among the states.

Data Collection Instrument

A structured questionnaire was employed as the principal instrument for primary data collection. The questionnaire was developed from the literature reviewed on GSCM, sustainable construction, and barriers to green supply-chain implementation. Particular attention was given to construction-sector evidence, including the Nigerian study by Amade et al. (2020), which directly investigated barriers to GSCM adoption in construction projects in Imo State. The study identified lack of knowledge and experience, inadequate top-management support, implementation cost, and insufficient government regulations and support systems among the reported barriers.

For the present study, the questionnaire items addressing Objective Two were presented in a structured format and measured using a five-point Likert-type severity scale:

1 = Not Severe
2 = Slightly Severe
3 = Moderately Severe
4 = Very Severe
5 = Extremely Severe

The use of a common response scale enabled the perceived severity of individual impediments to be compared systematically.

The questionnaire was organized into sections corresponding to the broader study. The section addressing Objective Two contained the identified impediments to GSCM implementation. The items were derived from the literature and adapted to the context of building construction project delivery in South-East Nigeria.

Instrument Validity

Content validity was established through a review of the questionnaire items against the study objective and relevant literature. The items were examined to ensure that they adequately represented the major dimensions of GSCM implementation barriers, including regulatory, financial, institutional, technical, operational, and socio-cultural impediments.

The instrument was also subjected to expert review by individuals with relevant knowledge of construction management, project management, supply-chain management, and sustainability. Their observations were used to improve the clarity, relevance, and comprehensiveness of the questionnaire before the main survey.

Where the Content Validity Index (CVI) was employed, items meeting the predetermined acceptance criterion of 0.80 or above were retained. This procedure helped establish that the questionnaire adequately represented the constructs being investigated.

Reliability of the Instrument

The reliability of the questionnaire was assessed to determine the internal consistency of the measurement items. A pilot test was conducted among respondents with characteristics comparable to those of the target population but who were not included in the main analysis.

Cronbach's alpha was used to assess the internal consistency of the questionnaire items. A coefficient of approximately 0.70 or higher was considered acceptable for research purposes. The reliability assessment provided evidence that the items used to measure the identified impediments demonstrated adequate internal consistency.

Reliability assessment was important because the study involved multiple questionnaire items representing different dimensions of GSCM implementation barriers. Establishing internal consistency strengthened confidence that the responses could be subjected to subsequent statistical analysis.

Sources and Types of Data

The study relied primarily on primary quantitative data, supported by secondary literature used in the development of the research instrument.

Primary Data

Primary data were collected through structured questionnaires administered to construction professionals across the five South-East states. The questionnaire captured respondents' assessments of the severity of identified impediments to GSCM implementation.

Secondary Data

Secondary information was obtained from peer-reviewed journal articles, academic books, conference publications, institutional reports, and other credible scholarly sources. The secondary literature was used to establish the conceptual and empirical basis for identifying potential GSCM barriers and developing the questionnaire items.

The literature was particularly important in ensuring that the impediments assessed in the questionnaire were grounded in previous empirical and theoretical research rather than being selected arbitrarily.

Method of Data Analysis

Data collected for Objective Two were analyzed using Principal Component Analysis (PCA) and the Severity Index (SI). Descriptive statistics were also used to summarize the responses.

Principal Component Analysis

Principal Component Analysis was employed to identify the underlying structure among the identified impediments to GSCM implementation. PCA is a multivariate statistical technique that transforms a set of potentially correlated observed variables into a smaller number of components that account for substantial proportions of the variance in the original variables (Pallant, 2020).

The suitability of the data for PCA was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. A satisfactory KMO value indicates that the correlation pattern is suitable for factor analysis, while a statistically significant Bartlett's test indicates that the correlation matrix contains sufficient relationships among variables for dimensional analysis. Pallant (2020) identifies a KMO value of approximately 0.60 or above as an indication of acceptable factorability, while Bartlett's test should be statistically significant. Components were initially considered for retention using the eigenvalue-greater-than-one criterion, supported by examination of the scree plot and the interpretability of the resulting component structure. Varimax rotation was used to obtain a clearer and more interpretable distribution of the variables across components.

The rotated component matrix was examined to determine the impediments associated with each underlying component. Variables with meaningful factor loadings were grouped according to their conceptual similarity and interpreted as dimensions of GSCM implementation barriers.

The PCA therefore served two purposes: first, it reduced the complexity of the 25 identified impediments; and second, it revealed the underlying dimensions through which the impediments could be interpreted.

Severity Index

The Severity Index was used to determine the relative severity of each identified impediment based on respondents' assessments. The technique has been used in construction-management research to assess and rank the relative effects of factors influencing construction projects. For example, Aibinu and Jagboro (2002) used questionnaire-based empirical analysis to examine the effects of construction delays in Nigeria, while construction studies in other developing contexts have similarly used severity-based approaches to prioritize project factors.

For the five-point scale used in this study, the Severity Index was calculated as:

$$SI = [\Sigma(fW) / (A \times N)] \times 100$$

Where:

SI = Severity Index;

f = frequency of responses assigned to each rating;

W = weight assigned to each response category;

A = highest possible weight on the scale (5);

N = total number of valid responses.

Thus, for a five-point scale, the response weights were:

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Response	Weight
Not Severe	1
Slightly Severe	2
Moderately Severe	3
Very Severe	4
Extremely Severe	5

The resulting SI ranges from 20% to 100% when all respondents select the lowest or highest category respectively. Higher SI values indicate greater perceived severity of the impediment.

The Severity Index was used to rank the 25 impediments according to respondents' perceptions. This enabled the study to distinguish between relatively less severe and more severe constraints to GSCM implementation.

Rationale for Combining PCA and Severity Index

The combination of PCA and Severity Index was adopted because the two techniques provide complementary information.

First, PCA identifies the underlying dimensions among the 25 impediments. This enables several related barriers to be grouped into broader components rather than treating every item as an isolated problem. Second, the Severity Index provides an empirical basis for prioritizing individual impediments according to their perceived severity.

Third, comparing the PCA structure with the SI rankings provides a more comprehensive understanding of the barriers. PCA addresses the question of how the barriers are structurally related, while SI addresses how severe individual barriers are perceived to be.

The combined approach therefore supports the study objective of identifying and prioritizing impediments to successful GSCM implementation in building construction projects in South-East Nigeria.

Data Processing and Presentation

The questionnaire responses were coded and entered into statistical software for analysis. Data screening was undertaken before the main analysis to identify incomplete responses, coding errors, and other inconsistencies.

Descriptive statistics, including frequencies, percentages, means, and standard deviations where appropriate, were used to summarize the responses. PCA was subsequently performed on the 25 identified impediments to establish their underlying structure.

The KMO statistic and Bartlett's Test of Sphericity were examined before interpreting the PCA. The eigenvalues, percentage of variance explained, scree plot, component loadings, and rotated component matrix were then assessed.

The SI was calculated for each impediment using the frequency distribution of responses. The resulting values were arranged in descending order to establish the relative ranking of the barriers.

The statistical analyses were performed using IBM SPSS Statistics, while Microsoft Excel was used where necessary for data organization and calculation of the Severity Index.

Ethical Considerations

Ethical principles were observed throughout the data-collection process. Participation was voluntary, and respondents were informed of the academic purpose of the study. Respondents were not required to provide information that could unnecessarily identify them, and the information supplied was treated confidentially.

The data were analyzed in aggregate form and used solely for academic research. The identity of individual respondents and their specific responses were not disclosed in reporting the findings.

The study adopted a quantitative cross-sectional survey design to investigate impediments to GSCM implementation in building construction project delivery in South-East Nigeria. The target population consisted of 1,703 construction professionals across Abia, Anambra, Ebonyi, Enugu, and Imo States, from which 890 questionnaires were distributed. The questionnaire measured 25 identified impediments using a five-point severity scale.

PCA was employed to establish the underlying dimensions of the barriers, while the Severity Index was used to rank the individual impediments according to their perceived severity. KMO and Bartlett's Test of Sphericity were used to establish the suitability of the data for PCA, while component extraction, rotation, and loading interpretation were used to identify the underlying barrier dimensions. The combination of PCA and SI provided a structured approach for identifying, grouping, and prioritizing the challenges affecting GSCM implementation in the study area.

IV. RESULTS AND DISCUSSION

To identify the impediments and challenges to successful Green Supply Chain Management (GSCM) implementation for building construction project delivery in South-East Nigeria. The analysis covers the professional distribution of respondents, assessment of the suitability of the dataset for Principal Component Analysis (PCA), extraction and interpretation of the underlying components, and ranking of the identified impediments using the Severity Index (SI).

Demographic Characteristics of Respondents

Table 4.1: Distribution of Respondents by Profession and State

S/N	Profession	Imo	Abia	Anambra	Enugu	Ebonyi	Total	Frequency (%)
1	Project Managers	15	11	14	14	7	61	7.23
2	Architects	31	20	22	28	17	118	13.98
3	Quantity Surveyors	34	28	27	35	28	152	18.01
4	Engineers	32	33	32	40	31	168	19.91
5	Estate Valuers	28	30	31	26	26	141	16.71
6	Builders	30	31	28	35	24	148	17.54
7	Others	9	8	11	18	10	56	6.64
Total							844	100.00

Source: Author's field survey, 2025.

Table 4.1 presents the professional distribution of the 844 respondents across the five states of South-East Nigeria. Engineers constituted the largest professional group, accounting for 19.91% of the respondents, followed by Quantity Surveyors (18.01%), Builders (17.54%), and Estate Valuers (16.71%). Architects accounted for 13.98%, while Project Managers represented 7.23%. Other construction-related professionals constituted 6.64%.

The distribution demonstrates that the study obtained responses from a range of professionals involved in building construction activities. This broad professional representation is useful for examining GSCM implementation challenges because the adoption of green practices involves multiple actors across project planning, design, costing, construction, procurement and property-related activities.

Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Principal Component Analysis (PCA) was conducted on 25 identified impediments to GSCM implementation using IBM SPSS Statistics version 26.0. Prior to extraction, the suitability of the dataset for component analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity.

The KMO value obtained was 0.627. This exceeds the commonly accepted minimum threshold of 0.60 and indicates that the correlation pattern among the variables was adequate for component extraction. Kaiser (1974) developed the KMO-related measure as an indicator of the degree to which observed correlations are appropriate for factor-analytic procedures.

Bartlett's Test of Sphericity produced a chi-square value of 5088.449 with 300 degrees of freedom, significant at $p < 0.001$. The significant result indicates that the correlation matrix differs significantly from an identity matrix. Therefore, sufficient relationships existed among the 25 impediment variables to justify the application of PCA.

Communalities
Communalities indicate the proportion of variance in each observed variable accounted for by the extracted components. The extraction communalities for the 25 impediment variables ranged from 0.531 to 0.826. The lowest value was obtained for CH19, *Limited Adoption of Green Technology and Innovation* (0.531), while the highest was obtained for CH8, *Cultural Resistance to Change* (0.826).

Variables with relatively high extraction communalities included CH8, *Cultural Resistance to Change* (0.826); CH13, *Transaction Costs* (0.815); and CH10, *Lack of Standardization/Metrics* (0.801). These values indicate that substantial proportions of their respective variances were represented by the extracted components. Other variables, including CH4, *Inadequate Monitoring* (0.560), and CH22, *Poor Recycling Infrastructure* (0.557), had moderate communalities but remained sufficiently represented in the component solution.

The results therefore indicate that the extracted component structure captured meaningful portions of the variance associated with the identified GSCM impediments.

Total Variance Explained
The PCA initially examined the 25 impediment variables. Based on the Kaiser criterion, components with eigenvalues greater than 1.00 were retained. Eight components satisfied the retention criterion and were subsequently subjected to Varimax rotation to facilitate interpretation.

The eight retained components jointly explained 60.102% of the total variance in the 25 observed impediments. The first component accounted for 16.185% of the variance, with subsequent components contributing progressively smaller proportions.

The cumulative variance explained indicates that the eight-component solution provides a substantial reduction of the original 25 variables while retaining a considerable proportion of the information contained in the original dataset. The use of PCA to reduce numerous sustainability-related barriers into interpretable clusters is consistent with previous Nigerian construction research in which factor analysis was used to group barriers to sustainable procurement into underlying dimensions (Ogunsanya et al., 2019/2022).

Rotated Component Interpretation
Following Varimax rotation, the 25 impediments were grouped into eight interpretable components.
Component 1: Regulatory and Governance Weaknesses.
The first component represents regulatory and institutional weaknesses, including weak regulatory enforcement, overlapping or conflicting regulatory frameworks, corruption and rent-seeking behaviour, policy discontinuity, absence of a clear national GSCM roadmap, lack of political will, and lack of binding green building codes. The component suggests that institutional and governance conditions constitute an important structural dimension of the barriers to GSCM implementation.

Component 2: Financial and Economic Constraints.
The second component comprises high costs of green materials and technologies, limited access to green financing, high transaction costs associated with certification, unstable macroeconomic conditions, and perceived low returns on investment. These factors collectively represent the financial and economic conditions that can discourage construction organisations from investing in green practices.

Component 3: Technical and Institutional Capacity Gaps.
The third component comprises technical and institutional capacity gaps, weak stakeholder engagement and collaboration, and limited adoption of green technology and innovation. These factors indicate that the availability of appropriate knowledge, skills, organisational capacity, collaboration and technological capability can influence the practical implementation of GSCM.

Component 4: Cultural and Behavioural Resistance.
The fourth component reflects cultural resistance to change and resistance among contractors and developers arising from short-term cost considerations. These variables indicate that established construction practices, perceptions and

behavioural responses to the immediate cost of green practices may constrain GSCM adoption.

Component 5: Operational and Information Deficits.
The fifth component comprises lack of standardisation and metrics, fragmentation of construction supply chains, and lack of reliable data and information systems. These factors can constrain consistent measurement, information sharing, benchmarking and coordination across construction supply-chain participants.

Component 6: Weak Incentive Structures.
The sixth component represents deficiencies in incentive mechanisms and policy instruments designed to encourage organisations to invest in GSCM practices. The absence or weakness of financial and institutional incentives can reduce the motivation for firms to undertake green investments where the initial costs are perceived as high.

Component 7: Inadequate Monitoring Capacity.
The seventh component represents deficiencies in monitoring and enforcement capacity. Effective monitoring requires adequate institutional structures, competent personnel, information systems and mechanisms for assessing compliance with sustainability requirements.

Component 8: Green Technology and Innovation Constraints.
The eighth component reflects constraints associated with technological uptake and innovation, including limited diffusion of environmentally preferable technologies, inadequate application of digital tools and limited availability of context-appropriate green solutions.

The PCA demonstrates that GSCM implementation barriers are not confined to a single dimension. Rather, they encompass regulatory, economic, technical, behavioural, operational, institutional and technological conditions.

Severity Index Rankings

Table 4.16: Severity Index of Impediments/Challenges to Successful GSCM Implementation

S/N	Impediment/Challenge	SA (5)	A (4)	N (3)	D (2)	SD (1)	Weighted Sum	SI (%)	Rank
1	CH2. High Cost of Green Materials/Technology	346	150	104	197	47	3,083	73.06	1st
2	CH11. Absence of Clear National Roadmap for GSCM	364	145	125	92	118	3,077	72.91	2nd
3	CH8. Cultural Resistance to Change	381	129	119	80	135	3,073	72.82	3rd
4	CH19. Limited Adoption of Green Technology & Innovation	292	131	143	224	54	2,915	69.08	4th
5	CH21. Lack of Reliable Data/Information Systems	347	96	91	189	121	2,891	68.51	5th
6	CH7. Limited Access to Green Financing	321	109	119	167	128	2,860	67.77	6th
7	CH10. Lack of Standardization/Metrics	386	85	31	129	213	2,834	67.16	7th
8	CH20. Fragmentation of Construction Supply Chains	81	243	77	82	361	2,133	50.55	8th

Note: SI = [Σ(fW)/(A × N)] × 100, where f = frequency, W = response weight, A = highest response weight (5), and N = number of valid responses (844). SA = Strongly Agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly Disagree.

Table 4.16 presents the eight highest-ranked individual impediments according to their Severity Index scores. The results show that High Cost of Green Materials and Technology recorded the highest severity score (SI = 73.06%), ranking first among the assessed impediments. This result indicates that the financial burden associated with green materials and technologies represents a prominent constraint on GSCM implementation among the respondents.

The Absence of a Clear National Roadmap for GSCM ranked second with an SI of 72.91%, while Cultural Resistance to Change ranked third with 72.82%. These results indicate that, in addition to financial constraints, respondents identified policy direction and behavioural factors as important impediments to the implementation of GSCM.

Limited Adoption of Green Technology and Innovation ranked fourth (69.08%), followed by Lack of Reliable Data/Information Systems (68.51%). These findings point to technological and information-related constraints that may affect the ability of construction organisations to identify, implement and monitor green supply-chain practices.

Limited Access to Green Financing ranked sixth with an SI of 67.77%, while Lack of Standardization/Metrics ranked seventh with 67.16%. Fragmentation of Construction Supply Chains recorded the lowest SI among the eight reported impediments (50.55%). Although it ranked eighth, the result still indicates that the issue was relevant to respondents and should not be interpreted as an absence of supply-chain fragmentation.

V. DISCUSSION OF FINDINGS

The findings demonstrate that the challenges associated with GSCM implementation in South-East Nigeria are multidimensional. PCA reduced the 25 identified impediments into eight broad components covering regulatory and governance weaknesses, financial and economic constraints, technical and institutional capacity, cultural and behavioural resistance, operational and information deficits, incentive structures, monitoring capacity, and technological constraints.

The emergence of regulatory and governance-related issues as a major component is consistent with evidence from Nigerian construction research. Amade et al. (2020), in their study of barriers to GSCM adoption on construction projects in Nigeria, identified barriers associated with policy, regulatory support, knowledge and stakeholder-related issues. Their study provides a directly relevant Nigerian construction-industry basis for interpreting the present findings.

The PCA result also corresponds with the findings of Ogunsanya et al. (2019/2022), who used factor analysis to examine barriers to sustainable procurement in the Nigerian construction industry. Their study grouped 19 observed barriers into four underlying clusters, including sustainability knowledge, transparency and governance, national policy challenges, and construction-industry-related factors. The present study extends this line of evidence by examining a broader set of 25 GSCM impediments within building construction project delivery across the five states of South-East Nigeria.

The Severity Index further shows that high cost of green materials and technology was the most severe individual impediment. This finding is consistent with the broader Nigerian construction literature, where the financial implications of sustainability adoption have been identified as an important constraint. The result is also compatible with the GSCM barrier evidence reported by Amade et al. (2020), which identified cost-related and organisational barriers to GSCM adoption in Nigerian construction projects.

The absence of a clear national GSCM roadmap ranked second. This finding highlights the importance of coherent policy direction for translating sustainability objectives into construction-sector practices. Without clear implementation requirements, responsibilities, monitoring mechanisms and long-term policy continuity, organisations may face uncertainty regarding the expectations associated with GSCM adoption.

Cultural resistance to change ranked third, indicating that technical and financial interventions alone may not be sufficient to achieve widespread GSCM implementation. Construction organisations operate within established professional and organisational routines, and resistance to changing familiar practices can affect the adoption of new sustainability requirements. The result therefore supports the inclusion of behavioural and organisational dimensions in strategies for improving GSCM implementation.

The relatively high rankings of limited adoption of green technology and innovation and lack of reliable data/information systems further indicate that GSCM implementation requires more than environmental awareness. Construction organisations require appropriate technologies, information systems, skills and measurement mechanisms to translate sustainability objectives into operational practices.

The result for limited access to green financing reinforces the financial dimension of GSCM barriers. Although high cost of green materials and technology ranked first, restricted access to financing also ranked among the leading challenges. This suggests that both the direct cost of green solutions and the availability of financial mechanisms for supporting their adoption are relevant to the implementation environment.

Finally, fragmentation of construction supply chains recorded the lowest SI among the eight highest-ranked impediments. This should not be interpreted as meaning that fragmentation is unimportant. Rather, compared with the other assessed challenges, respondents assigned it a lower severity level. Nevertheless, supply-chain coordination remains relevant to GSCM because effective green practices require cooperation among clients, consultants, contractors, suppliers and other project participants.

The findings indicate that successful GSCM implementation in building construction projects in South-East Nigeria is influenced by interconnected financial, regulatory, institutional, behavioural, technological and information-related barriers. The combination of PCA and Severity Index provides both a structural classification of the impediments and an indication of their relative severity. This provides an empirical basis for focusing subsequent GSCM interventions on the most prominent barriers identified by construction professionals in the region.

The KMO value was 0.627, indicating an acceptable level of sampling adequacy for exploratory component analysis. Bartlett's Test of Sphericity was statistically significant, $\chi^2(300) = 5088.449$, $p < 0.001$, indicating that the correlation matrix differed significantly from an identity matrix. The significant Bartlett's test therefore confirms the presence of sufficient correlations among the observed variables to justify the application of PCA.

Table 4.2. KMO and Bartlett's Test of Sphericity

Measure	Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.627
Bartlett's Test of Sphericity: Approx. χ^2	5088.449
Degrees of freedom	300
Significance	< 0.001

Source: Author's field survey, 2025.

The results indicate that the dataset was suitable for identifying the underlying dimensions of the impediments to GSCM implementation. The KMO statistic indicates acceptable sampling adequacy, while the significant Bartlett's test confirms that the inter-variable correlations were sufficient for component extraction.

VI. CONTRIBUTION

The paper contributes to Green Supply Chain Management (GSCM) and sustainable construction literature by empirically establishing the critical dimensions of impediments affecting GSCM implementation in building construction projects in South-East Nigeria. It identifies 25 impediments and establishes an eight-component structure using Principal Component Analysis (PCA), complemented by Severity Index (SI) analysis for prioritisation. The findings demonstrate that GSCM barriers extend across governance, economic, technical, cultural, operational, financial, monitoring, and technological dimensions. The study extends GSCM and institutional perspectives by demonstrating that implementation constraints are interconnected rather than attributable to a single factor. It also provides empirical evidence from a developing-country construction context and offers practical guidance for strengthening regulatory systems, financing mechanisms, technical capacity, stakeholder collaboration, standardisation, and technology adoption to support sustainable construction practices.

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VII. PRACTICAL IMPLICATIONS

The findings indicate that addressing the cost, regulatory, cultural, and technological barriers to GSCM is important for improving sustainable construction practices in South-East Nigeria. The high cost of green materials and technologies may discourage contractors and developers from adopting sustainable alternatives, while limited green financing further constrains investment. A clear national GSCM roadmap, effective regulatory enforcement, and standardised sustainability metrics can provide greater certainty for construction stakeholders. In addition, professional training, awareness programmes, and demonstration projects can help reduce resistance to change and improve technical capacity. The findings also emphasise the importance of reliable data systems and stronger stakeholder coordination for monitoring sustainability performance. These measures can support more systematic and coordinated implementation of GSCM throughout the construction supply chain.

VIII. CONCLUSION

This study investigated the impediments and challenges to successful Green Supply Chain Management (GSCM) implementation for building construction project delivery in South-East Nigeria using data obtained from 844 construction professionals across Anambra, Enugu, Imo, Abia, and Ebonyi States. Principal Component Analysis (PCA) and Severity Index (SI) were employed to identify the underlying dimensions and relative severity of the identified impediments.

The PCA results established the suitability of the dataset for factor analysis, with a KMO value of 0.627 and a statistically significant Bartlett's Test of Sphericity ($p < 0.001$). The 25 identified impediments were reduced into eight underlying components, collectively explaining 60.102% of the total variance. The components reflected governance and regulatory weaknesses, economic and financial constraints, technical and institutional capacity limitations, cultural resistance, operational and data deficiencies, inadequate incentives, monitoring limitations, and technological constraints.
The first component accounted for the largest proportion of explained variance (16.185%) and was predominantly associated with governance and regulatory challenges, including weak regulatory enforcement, policy discontinuity, corruption, overlapping regulatory frameworks, absence of a clear GSCM roadmap, and inadequate green building codes. This finding indicates that institutional and governance conditions constitute an important structural dimension of the barriers to GSCM implementation in the study area.

The Severity Index results further identified the most prominent impediments.High cost of green materials and technology ranked first (SI = 73.06%), followed by absence of a clear national GSCM roadmap (SI = 72.91%), cultural resistance to change (SI = 72.82%), limited adoption of green technology and innovation (SI = 69.08%), lack of reliable data systems (SI = 68.51%), limited access to green financing (SI = 67.77%), lack of standardisation and metrics (SI = 67.16%), and fragmentation of construction supply chains (SI = 50.55%)

The findings demonstrate that GSCM implementation in South-East Nigeria is constrained by interconnected financial, institutional, technological, cultural, and operational challenges. The prominence of cost-related and policy-related barriers suggests that improving access to finance, establishing clearer policy direction, strengthening regulatory implementation, and developing technical capacity are important conditions for wider adoption. Similarly, addressing cultural resistance, data limitations, and inadequate standardisation would improve the ability of construction organisations to implement and monitor sustainable practices.

The study concludes that successful GSCM implementation requires an integrated approach rather than isolated interventions. Coordinated regulatory reform, financial support, capacity development, stakeholder collaboration, standardisation, and technological support are required to address the multidimensional barriers identified in the study. The empirical evidence generated provides a basis for policymakers, construction organisations, professional bodies, and other stakeholders to prioritise interventions aimed at improving GSCM implementation and sustainable building construction project delivery in South-East Nigeria.

IX. RECOMMENDATIONS

The study recommends that relevant government agencies should strengthen regulatory enforcement and develop a clear national GSCM roadmap with defined responsibilities and implementation targets. Government and financial institutions should improve access to green financing through appropriate loans, grants, incentives, and other mechanisms that can reduce the initial cost of green materials and technologies. Construction organisations should strengthen professional training in green procurement, sustainable materials, life-cycle assessment, waste management, and environmental performance measurement. Standardised sustainability metrics and reliable data systems should also be developed to improve monitoring and reporting. Furthermore, awareness programmes and demonstration projects should be promoted to reduce cultural resistance, while stronger collaboration among clients, contractors, consultants, suppliers, regulators, and professional bodies should be encouraged to support coordinated GSCM implementation.

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AUTHORS CONTRIBUTIONS

A. G.J. conceived the idea, organized,and wrote the bulk of the manuscript. Supervised by B.A, while C.C.N., U.M.C., O.C.O., I.O.A., F.U.U., and I.R.E. contributed to investigation, data analysis, and writing. All authors read and approved the final version of the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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