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Designing a Cost-Efficient Inventory System Using The Economic Order Quantity Model for Construction Materials Distributors

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Abstract

Background: The construction materials distribution sector faces significant challenges in managing inventory due to fluctuating demand and the absence of systematic planning. Distributor Bintang Kerahiman, operating in Palembang and South Sumatra, currently relies on estimation-based inventory decisions, leading to frequent stockouts and overstocking. These inefficiencies lead to increased operational costs and lost sales opportunities, underscoring the need for a more structured, quantitative inventory control approach based on the Economic Order Quantity model.

Aim: This study aims to design a cost-efficient inventory system by applying the Economic Order Quantity model and to compare its performance with the company's existing inventory method.

Methods: A quantitative approach was employed using historical sales data from March to August 2025 across 30 selected products. Demand forecasting was conducted using the moving average method. Inventory parameters, including ordering cost, holding cost, safety stock, and reorder point (ROP), were calculated. The optimal order quantity was determined using the Economic Order Quantity formula, and total inventory costs were compared between the current method and the proposed model.

Results: The implementation of the Economic Order Quantity model successfully reduces total inventory costs by optimizing order quantities and balancing ordering and holding costs. Across 30 products, the model demonstrated consistent cost savings and reduced inefficiencies. Additionally, profit improvements were observed due to decreased lost sales. For instance, profit for Afur BCP PVC Basket increased from IDR 990,000 to IDR 996,000, while Mold Cleaning Liquid increased from IDR 305,000 to IDR 330,000.

Conclusions: The Economic Order Quantity model is more effective than the existing method in minimizing inventory costs, reducing stock imbalances, and improving service levels. The integration of safety stock and reorder point further enhances the system's ability to handle demand variability.

Implication. This study provides practical implications for construction material distributors by offering a data-driven inventory control framework. The findings support improved decision-making, cost efficiency, and customer satisfaction. Furthermore, the proposed system can be extended by integrating digital inventory applications and hybrid models for future research.

Keywords: Economic Order Quantity (EOQ), safety stock, reorder point, cost efficiency, construction supply chain.

INTRODUCTION

The construction and building materials industry is a key driver of economic growth, with demand influenced by infrastructure, housing, and renovation activities. This creates fluctuating and uncertain demand patterns, requiring distributors to ensure product availability while maintaining operational efficiency through effective inventory management (Chen et al., 2024, Edalatpour et al., 2025, Kedir & Hall, 2021).

Distributor Bintang Kerahiman operates in Palembang and South Sumatera as a supplier of construction tools, serving customers from individual buyers to contractors and retailers. The company manages over 100 product types; however, this study focuses on 30 items with the highest inventory risk.

In practice, the company faces significant inventory challenges, including demand uncertainty and inconsistent purchasing patterns. Preliminary observations show frequent stockouts during demand surges and overstock conditions for certain items, leading to customer dissatisfaction, lost sales, and reduced profitability (Silva et al., 2025).

These issues stem from two main factors: highly variable demand without reliable forecasting and inventory planning based on subjective estimations rather than data-driven methods. Consequently, procurement decisions often fail to align with actual demand, resulting in inefficiencies and increased operational costs.

From an industrial engineering perspective, inventory management requires a structured quantitative approach that accounts for demand, ordering costs, and holding costs. The Economic Order Quantity (EOQ) model is widely used to determine optimal order quantities by minimizing total inventory cost, while also enabling the calculation of safety stock and reorder point (ROP) to address demand variability and lead time uncertainty. Despite the emergence of advanced models, the EOQ model remains relevant for small and medium enterprises due to its simplicity and practical applicability, especially when combined with demand forecasting (Jaber & Peltokorpi, 2025, Nardo et al., 2020).

Therefore, this study aims to design a cost-efficient inventory system using the EOQ model and compare it with the company's existing method. The expected outcome is to provide data-driven recommendations to optimize order quantities, improve operational efficiency, reduce inventory costs, and enhance profitability.

Effective inventory management is crucial for minimizing costs and ensuring product availability. However, Distributor Bintang Kerahiman relies on estimation-based planning, leading to frequent stockouts, overstock, and inefficiencies. The absence of analytical methods leads to suboptimal decisions, as demand variability and lead-time uncertainty are not properly accounted for. Therefore, this study aims to develop a cost-efficient inventory system using the EOQ model to determine optimal order quantities, safety stock, and reorder points, and to evaluate its performance compared to the existing method in terms of cost efficiency and profitability.

While EOQ has been widely studied for inventory optimization, gaps remain in its practical application for small-to-medium construction material distributors with high product variety and fluctuating demand. Few studies integrate EOQ with demand forecasting, safety stock, and reorder points as a unified framework. Moreover, comparative analyses between traditional estimation-based practices and quantitative models in real-world cases are scarce, highlighting the need for applied research bridging theory and practice in construction material distribution (Petropoulos et al., n.d,; Xie & Xie, 2025, Zabraoui, 2025).

LITERATURE REVIEW

Inventory Management in Construction Material Distribution

Effective inventory management is critical for construction material distributors to balance product availability with cost efficiency. Studies show that poor inventory control leads to stockouts, overstock, increased holding costs, and lost sales (Zabraoui, 2025). Distributors often face challenges such as fluctuating demand, high product variety, and lead time uncertainty, which complicate procurement and inventory planning (Chang & Lin, 2019).

Economic Order Quantity (EOQ) Model

The Economic Order Quantity (EOQ) model is one of the most widely applied quantitative methods for inventory control. EOQ determines the optimal order quantity that minimizes total inventory cost, considering ordering and holding costs (Alnahhal et al., 2024). Key parameters include order quantity (Q^*), safety stock, and reorder point (ROP), which help mitigate demand variability and lead time uncertainty (Jadidi et al., 2025).

Despite the emergence of advanced models, EOQ remains relevant for small and medium enterprises (SMEs) due to its simplicity, practicality, and ease of integration with demand forecasting (Wahedi et al., 2023). Applications have been reported in manufacturing, retail, and construction-related sectors, improving cost efficiency and operational performance.

The EOQ model calculates the optimal order quantity that minimizes total inventory costs, considering ordering and holding costs (Jadidi et al., 2025). The total inventory cost (TC) is the sum of ordering cost (OC) and holding cost (HC):

$$TC = OC + HC - \frac{D}{Q}S + \frac{Q}{2}H \quad (1)$$

Where:

- D= Annual demand (units/year)
- Q= Order quantity (units)
- S= Ordering cost per order
- H= Holding cost per unit per year

The EOQ formula for optimal order quantity is:

$$Q^* = \sqrt{\frac{2DS}{H}} \quad (2)$$

Safety Stock and Reorder Point

To handle demand variability and lead time uncertainty, distributors calculate Safety Stock (SS) and Reorder Point (ROP):

$$SS = Z \text{ x } \sigma L \quad (3)$$

$$ROP = d \text{ x } L + SS \quad (4)$$

Where:

- Z= Service level factor (from standard normal distribution)
- σ_L= Standard deviation of demand during lead time
- d= Average demand per period
- L= Lead time in periods

Safety stock ensures sufficient inventory during unexpected demand spikes, while ROP triggers replenishment before stockouts occur.

Integration with Demand Forecasting

Several studies highlight the importance of integrating EOQ with demand forecasting techniques to enhance inventory accuracy. Without incorporating historical demand and trend analysis, EOQ-based decisions may under- or overestimate stock levels, especially in markets with volatile demand patterns (Barros et al., 2021). Safety stock and ROP calculations are crucial to prevent stockouts during peak demand periods. EOQ becomes more effective when integrated with demand forecasting, especially for SMEs with volatile demand (Chaudhary & Mittal, 2026). Forecasting allows more accurate determination of D, σ_L, and subsequently Q^*, SS, and ROP.

Comparative Analyses and Real-World Implementation

Research comparing traditional estimation-based inventory methods with EOQ-based quantitative approaches is limited, particularly for SMEs in construction material distribution. Most studies focus on theoretical models or large-scale supply chains, leaving a gap in practical case studies that assess cost savings, order efficiency, and profitability improvements (Badakhshan et al., 2024; Setiawan, Susanto, Rinamurti, & Alfian, 2025a). Applied studies are essential to validate EOQ effectiveness in real-world operations with high product diversity and demand fluctuations. EOQ application in small-to-medium construction material distributors is limited. Few studies integrate EOQ with forecasting, SS, and ROP as a unified decision framework. Comparative studies between estimation-based inventory practices and EOQ-based models are scarce.

Research Gap

Limited application of EOQ in small-to-medium construction material distributors. Few studies integrate EOQ with demand forecasting, safety stock, and ROP as a unified framework. Scarce comparative analyses between estimation-based practices and quantitative EOQ models in real-world settings.

Implication for Current Study

These gaps justify the need for research that implements EOQ in Distributor Bintang Kerahiman, combining demand forecasting, safety stock, and reorder point calculations. The study aims to provide a cost-efficient inventory system that optimizes order quantity, reduces total inventory costs, and improves service levels in practice. Implementing EOQ with safety stock and ROP calculations in Distributor Bintang Kerahiman aims to minimize total inventory costs, optimize order quantities, and improve service levels in a practical, real-world setting.

METHOD

Research Design

This study employs a quantitative descriptive research design to analyze and improve inventory management at Distributor Bintang Kerahiman. The research compares the existing estimation-based inventory system with a data-driven Economic Order Quantity (EOQ) model, incorporating Safety Stock (SS) and Reorder Point (ROP) for 30 selected high-risk products (Gallego-garc & Gallego-garc, 2021).

Data Collection

Data are collected from the distributor's historical sales and inventory records, including: Product demand per period (d), Lead time (L), Ordering costs (S), Holding costs (H), and Current inventory and procurement policies. The study focuses on 30 representative products with the highest likelihood of stockouts and overstocking.

Economic Order Quantity (EOQ) Model

The EOQ model is applied to calculate the optimal order quantity (Q^*) that minimizes total inventory costs using formulas 1 and 2:

Safety Stock (SS) and Reorder Point (ROP)

To mitigate demand variability and lead time uncertainty, Safety Stock and Reorder Point are calculated using formulas 3 and 4:

Implementation Procedure

The methodology follows these steps: (1) Data Preparation: Collect historical demand, cost, and lead time data. (2) EOQ Calculation: Compute optimal order quantities (Q^*) for each product. (3) Safety Stock & ROP Determination: Determine SS and ROP values to handle demand uncertainty. (4) Simulation and Comparison: Compare the EOQ-based system with the current estimation-based system in terms of: Total inventory costs, Stockout frequency, and Customer service level. (5) Evaluation and Recommendation: Analyze results to propose a cost-efficient inventory strategy. (6) Data Analysis. Descriptive statistics for historical demand and inventory levels. Cost comparison between the current practice and the EOQ-based system. Sensitivity analysis to evaluate the impact of demand variability and lead time changes.

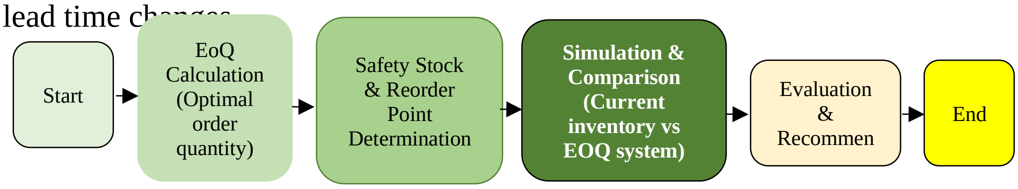


Figure 1. Flowchart methodology

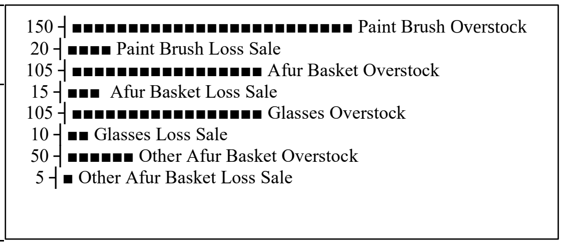
The flowchart illustrates the research methodology for designing a cost-efficient inventory system using the Economic Order Quantity (EOQ) model at Distributor Bintang Kerahiman. It highlights key steps, including data collection, EOQ calculation, safety stock and reorder point determination, and comparison with the current inventory method to improve cost efficiency and reduce stockouts.

DISCUSSION

The summary table presents a detailed comparison of key inventory metrics for selected products, including overstock, loss sale, EOQ, reorder point (ROP), and safety stock. This table provides a clear snapshot of the areas where overstock and stockouts occur, and shows the recommended EOQ-based replenishment strategy to minimize these inefficiencies, as shown in Table 1.

Table 1. Summary of overstock, loss sale, and EOQ recommendations

Product	Overstock (Units)	Loss Sale (Units)	EOQ (Units)	ROP (Units)	Safety Stock (Units)
Paint Brush	136	20	25	100	20
Afur Basket	105	15	28	113	30
Glasses	105	10	20	90	15
Other Afur Basket	50	5	18	80	10



The results of this study demonstrate that transitioning from an estimation-based inventory system to a structured Economic Order Quantity (EOQ) model significantly enhances the operational efficiency of Distributor Bintang Kerahiman. The discussion focuses on three primary areas: cost optimization, risk mitigation through safety stock, and the impact on overall profitability (Setiawan, Susanto, Rinamurti, & Alfian, 2025b).

Cost Optimization through Balanced Parameters

The fundamental weakness in the distributor's existing method was the reliance on subjective intuition, which often led to disproportionate ordering frequencies. By applying the EOQ formula, the study found a "sweet spot" where the sum of ordering costs and holding costs is minimized. As shown in the results, the EOQ model balances these two competing costs. When the company ordered too frequently in small batches, annual ordering costs spiked; conversely, over-ordering to avoid stockouts led to excessive holding costs and potential capital tied up in the warehouse. The EOQ model provided a mathematically optimal order quantity (Q*) for the 30 analyzed products, ensuring efficient resource allocation (Öztürk & Konstantaras, 2025; Puspika et al., 2025).

Mitigation of Stockouts and Overstock

One of the most critical findings is the role of Safety Stock (SS) and Reorder Point (ROP). Previously, Distributor Bintang Kerahiman suffered from "lost sales" due to stockouts during demand surges. *Safety Stock:* By incorporating a service-level factor (Z) and demand variability (σL), the proposed system provides a buffer that protects the distributor against the inherent uncertainty in the construction sector. *Reorder Point:* The ROP calculation ensures that procurement is triggered exactly when the remaining stock equals the expected demand during lead time plus the safety stock. This eliminates the "guessing game" currently practiced by management. The integration of these parameters transforms the inventory system from reactive (ordering when shelves are empty) to proactive (ordering based on calculated thresholds) (C et al., 2025).

Impact on Profitability and Service Levels

The numerical results for products like Afur BCP, PVC Basket, and Mold Cleaning Liquid provide concrete evidence of the model's financial benefits. The increase in profit (e.g., from IDR 990,000 to IDR 996,000 for Afur BCP) is not merely due to lower costs but also to captured demand. By reducing the frequency of "lost sales," the distributor can fulfill more customer orders, thereby increasing the service level. In South Sumatra's construction materials market, high product availability is a key differentiator. The EOQ model effectively turns inventory management from a cost center into a strategic advantage.

Comparison with Literature and Practical Limitations

These findings align with the theories of classic models like EOQ, which offer substantial value to SMEs (Small and Medium Enterprises) today (Alnahhal et al., 2024). While more complex models exist, the simplicity of the EOQ model allowed seamless integration with the Moving Average forecasting method used in this study. However, it is important to note that the EOQ model assumes a relatively constant demand and stable lead times. While the inclusion of Safety Stock mitigates some volatility, extreme market shifts such as sudden spikes in national infrastructure projects or drastic price changes in raw materials may require periodic adjustments to the model's input parameters.

Comparative Analysis of Cost and Profit

The effectiveness of the proposed system is most evident when comparing metrics from the existing estimation method against those of the EOQ model. The following Table 2 summarizes the performance shift for key products:

Table 2. Performance comparison: existing method vs. EOQ model

Comparison Parameter	Existing Method (Estimation)	Proposed EOQ Model	Efficiency Impact
Order Quantity	Fluctuating (Based on intuition)	Optimal (Q*)	Reduced holding costs
Order Frequency	Irregular/Reactive	Mathematically Scheduled	Optimized ordering costs
Safety Stock (SS)	None (Frequent stockouts)	Calculated via Service Level	Minimized Lost Sales
Total Inventory Cost	High/Unpredictable	Minimal (Optimized)	Operational cost savings
Profit (Afur BCP)	IDR 990,000	IDR 996,000	+0.6% Increase
Profit (Mold Liquid)	IDR 305,000	IDR 330,000	+8.2% Increase

The data in Table 2 suggest that while the profit increase for some items, such as Afur BCP, appears modest (0.6%), the cumulative effect across 30 products represents a substantial boost to the distributor's annual bottom line. Furthermore, the transition from a reactive state (ordering only when shelves are empty) to a predictive state (ordering when the ROP is triggered) reduces the mental workload on management and allows for better negotiation with suppliers due to more predictable ordering cycles (Setiawan et al., 2024, Setiawan, Susanto, Rinamurti, Chen, et al., 2025).

CONCLUSION

Based on historical sales (March-August 2025) at Distributor Bintang Kerahiman, EOQ implementation improved cost efficiency across 30 products by optimizing order quantities and balancing ordering and holding costs. Safety Stock and Reorder Point reduced stockouts and overstock, stabilizing inventory and service levels in South Sumatra. Quantitative control increased profits: Afur BCP PVC Basket (IDR 990,000 to 996,000) and Mold Cleaning Liquid (IDR 305,000 to 330,000, +8.2%). Overall, a structured, data-driven system shifted inventory management from reactive to proactive, enhancing operational maturity, scalability, and customer satisfaction.

Future studies can enhance EOQ by integrating digital or real-time ERP systems for automated ROP, exploring hybrid models that consider bulk discounts and seasonal price changes, and expanding the analysis to the full product catalog beyond the 30 high-risk items.

IMPLICATION

This study provides actionable insights for Distributor Bintang Kerahiman: Management can replace estimations with EOQ and ROP based on Moving Average forecasts, reducing human error. Optimal order quantity (Q*) improves working capital and cash flow. Safety Stock enhances service reliability, preventing lost sales in South Sumatra's construction sector. Calculated SS and ROP also lay the foundation for future digital integration via ERP or inventory applications, supporting data-driven procurement and operational efficiency.

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BIBLIOGRAPHY

Alnahhal, M., Aylak, B. L., Hazza, M. Al, & Sakhrieh, A. (2024). *Economic Order Quantity : A State-of-the-Art in the Era of Uncertain Supply Chains*. 1–19.

Badakhshan, E., Mustafee, N., & Bahadori, R. (2024). Computers & Industrial Engineering Application of simulation and machine learning in supply chain management : A synthesis of the literature using the Sim-ML literature classification framework. *Computers & Industrial Engineering*, *198*(October), 110649. https://doi.org/10.1016/j.cie.2024.110649

Barros, J., Cortez, P., & Carvalho, M. S. (2021). A systematic literature review about dimensioning safety stock under uncertainties and risks in the procurement process. *Operations Research Perspectives*, *8*(January), 100192. https://doi.org/10.1016/j.orp.2021.100192

C, L. E., Vicencio-ortiz, J. C., Smith, N. R., Bourguet-díaz, R. E., Armando, C., & Peimbert-garcía, R. E. (2025). *Supply Chain Analytics An integrated analytical framework for inventory and pricing of perishable products in multi-echelon supply chains*. *12*(June). https://doi.org/10.1016/j.sca.2025.100157

Chang, W., & Lin, Y. (2019). Asia Paci fi c Management Review The effect of lead-time on supply chain resilience performance. *Asia Pacific Management Review*, *24*(4), 298–309. https://doi.org/10.1016/j.apmrv.2018.10.004

Chaudhary, R., & Mittal, M. (2026). AI-driven demand forecasting for sustainable inventory model in fuzzy environment. *Sustainable Futures*, *11*(December 2024), 101752. https://doi.org/10.1016/j.sftr.2026.101752

Chen, Y., Qiu, D., & Chen, X. (2024). *Integrating Lean Construction with Sustainable Construction : Drivers , Dilemmas and Countermeasures*.

Edalatpour, M. A., Mohammad, S., & Mirzapour, J. (2025). Harmonizing project management and supply chain for sustainable construction : A comprehensive mathematical model and case study. *Sustainable Futures*, *10*(December 2024), 100805. https://doi.org/10.1016/j.sftr.2025.100805

Gallego-garc, D., & Gallego-garc, S. (2021). *applied sciences An Optimized System to*

Reduce Procurement Risks and Stock-Outs : A Simulation Case Study for a Component Manufacturer.

Jaber, M. Y., & Peltokorpi, J. (2025). Economic order / production quantity (EOQ / EPQ) models with product recovery : A review of mathematical. *Applied Mathematical Modelling*, *129*(January 2024), 655–672. https://doi.org/10.1016/j.apm.2024.02.022

Jadidi, O., Firouzi, F., & Sorooshian, S. (2025). A closed-form solution approach for optimal reorder point in economic order quantity models with uncertain demands. *Decision Analytics Journal*, *16*(January), 100622. https://doi.org/10.1016/j.dajour.2025.100622

Kedir, F., & Hall, D. M. (2021). Resource ef fi ciency in industrialized housing construction e A systematic review of current performance and future opportunities. *Journal of Cleaner Production*, *286*, 125443. https://doi.org/10.1016/j.jclepro.2020.125443

Nardo, M. Di, Clericuzio, M., Murino, T., & Sepe, C. (2020). *An Economic Order Quantity Stochastic Dynamic Optimization Model in a Logistic 4 . 0 Environment*.

Öztürk, H., & Konstantaras, I. (2025). *EOQ model with defective products , batch shipment and partial backorders*. 1941–1988.

Petropoulos, F., Akkermans, H., Aksin, O. Z., Ali, I., Babai, Z., Barbosa-povoa, A., Battaïa, O., Besiou, M., Boysen, N., Brammer, S., Brandon-jones, A., Briskorn, D., Browning, T. R., Buijs, P., Centobelli, P., Chiarini, A., Cousins, P., Elizabeth, A., Davies, A., … Wilhelm, M. (n.d.). *Operations & supply chain management : principles and practice*. *7543*. https://doi.org/10.1080/00207543.2025.2555531

Puspika, W., Masudin, I., Eko, T., Alfarisi, S., Palupi, D., & Radiah, S. S. (2025). Sustainable economic production quantity optimization (SEPQ) considering food waste emission and water waste emission using genetic algorithm. *Sustainable Operations and Computers*, *6*(May), 140–152. https://doi.org/10.1016/j.susoc.2025.05.003

Setiawan, H., Oktavianus, J., Abel, C., Hutajulu, C., Anggara, W. T., Ghibrandhi, A., Mobry, S., Ridwan, T., & Sidauruk, P. (2024). *No Title*. *8*(1), 7–15.

Setiawan, H., Susanto, S., Rinamurti, M., & Alfian, A. (2025a). *Integration of Ergo-Manufacturing and Simulation to Minimise Waiting Time for Cracker and Kemplang Production Process Flow (Case Study of PT . Belimo Food Industry)*. *2*(5), 293–301. https://doi.org/10.62885/jurnalimprosci.v2i5.660

Setiawan, H., Susanto, S., Rinamurti, M., & Alfian, A. (2025b). *Work System Improvement in the Production Process Station Area PT SMS Using Macro Ergonomics and Design (MEAD) to Increase Productivity*. *3*(2). https://doi.org/10.62885/improsci.v3i2.939

Setiawan, H., Susanto, S., Rinamurti, M., Chen, M., & Alfian, A. (2025). *Just In Time (JIT) Based Manufacturing Innovation for Production Cost Efficiency : Empirical Analysis at CV . Natural*. *3*(2), 118–130. https://doi.org/10.62885/ekuisci.v3i2.945

Silva, Â., Silva, M., & Ferreira, A. C. (2025). *Inventory Management and Its Influence on the Supply of High-Value Products : Case Study Evidence*. 1–19.

Wahedi, H. J., Heltoft, M., Christophersen, G. J., Severinsen, T., & Saha, S. (2023). *applied sciences Forecasting and Inventory Planning : An Empirical Investigation of Classical and Machine Learning Approaches for Svanehøj ' s Future Software Consolidation*. 1–21.

Xie, C., & Xie, C. (2025). *Inventory control strategy based on neural network and fuzzy algorithm in intelligent warehousing system*.

Zabraoui, O. (2025). Supply Chain Analytics A comparative study of multi-algorithm optimization for inventory analytics in supply chains. *Supply Chain Analytics*, *12*(June), 100154. https://doi.org/10.1016/j.sca.2025.100154