VALIDATION AND PRELIMINARY EVALUATION OF QOSTMED: A QUALITY AND COST EFFICIENCY BASED ELECTRONIC MEDICAL RECORD MODEL

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ABSTRACT

Background: *Electronic medical record (EMR) implementation requires attention to information quality, system performance, efficiency, and cost. QOSTMED (Quality and Cost Efficiency Medical Record) was designed to support quality-oriented and efficient medical record management and claims processes. This study aimed to validate and preliminarily evaluate QOSTMED using qualitative and quantitative approaches.*

Methods: *Qualitative validation was conducted through a focus group discussion (FGD) involving experts in EMR, INA-CBGs coding, and BPJS policy using the PIECES framework: Performance, Information, Economy, Control, Efficiency, and Service. A limited-scale trial involved 30 healthcare professionals from two purposively selected hospitals. A one-group pretest-posttest design compared user experience between standard EMR and QOSTMED. Paired-samples t-tests assessed differences across PIECES dimensions.*

Results: *Expert validation indicated improvements across all PIECES dimensions. The overall PIECES score increased from 63.5±7.2 with standard EMR to 74.2±6.5 with QOSMED. Significant differences were observed in Performance (mean difference=-11.7; p<0.001), Information (-11.1; p<0.001), Economy (-10.8; p<0.001), Control (-10.4; p<0.001), Efficiency (-10.1; p<0.001), and Service (-10.9; p<0.001).*

Conclusion: *QOSTMED demonstrated significantly better user-rated performance across all PIECES dimensions than standard EMR. Further studies with larger samples, comparison groups, and longer follow-up are warranted.*

KEYWORDS electronic medical records; PIECES framework; quality; cost efficiency

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INTRODUCTION

In modern health information systems, the electronic medical record (EMR) represents an important element. It can improve access to clinical information, facilitate collaboration, support treatment processes and promote operational efficiency. But simply implementing an electronic medical record (EMR) does not, by itself, improve quality or efficiency. Benefits depend on multiple aspects such as usability of the system, fit within the workflow, interoperability, user training, organizational support, and availability of appropriate technological resources. However, these benefits may not materialize due to barriers such as technical challenges, increased workload, lack of resources, poor fit with workflow and resistance from health care professionals (Kavandi, Al Awar and Jaana, 2024). A recent scoping review found that implementation of EMR can improve communication, work efficiency, processes of care, patient safety and access to data. So, the question to ask while analyzing EMR should be whether information is digitized and whether the system improves the quality and efficiency in healthcare related procedures.

The quality and completeness of clinical information captured in an EMR are especially important since clinical documentation serves as the foundation for coding diagnosis and treatment, payment, quality measurement, and health information management. Inaccurate or inconsistent documentation may affect coding and payment accuracy. Clinical documentation integrity for health data integrity and clinical coding have been acknowledged to Similarly, a systematic analysis of outpatient billing procedures identified inadequate clinical recording, low levels of formal education, and lack of feedback as the top variables associated with inaccurate or inappropriate billing (Burks *et al.*, 2022). The results indicate that the development of the quality of electronic documentation should be considered as an important element of any project aiming at improving coding and reimbursement processes.

There is also empirical evidence of the linkage between clinical documentation and payment . Seligson et al. demonstrated that standardized documentation templates and training inside an electronic medical record system greatly enhanced the capture of evaluation and management charges and reimbursement as well as quality indicators related to case-mix. Such findings imply that structured electronic recording may give benefits beyond the conservation of clinical information by facilitating a more precise representation of patient complexity and boosting the cost implications of health care services (Seligson *et al.*, 2021). Therefore, the architecture of Electronic Medical Record (EMR) system should have elements that help in complete and systematic clinical documentation and helps in downstream coding and reimbursement processes.

This issue is quite critical in Indonesia as the National Health Insurance (NHI) program adopted the Indonesian Case Base Groups (INA-CBGs) system for hospital reimbursement. Reimbursement is determined by the quality and accuracy of the clinical, administrative and coding information that accompanies the claim. Within the present investigation, 239 pending claims were uncovered in the course of the circumstance analysis. Administrative problems accounted for 111 cases (46 %), medical problems accounted for 88 cases (37 %), and coding problems accounted for 40 cases (17 %). Pending claims were therefore not merely a function of coding issues, but one coupled with interrelated administrative, clinical, documentation and coding processes. This study emphasizes the importance of a unified approach to information quality throughout the clinical and claims management workflow.

Numerous characteristics of healthcare reimbursement and claims administration have been examined including completeness of the medical record, accuracy of diagnostic and treatment coding, hospital attributes, case grouping and claims management. The

research underpinning the current study also identified these elements as the primary drivers of INA-CBGs claims findings. However, the survey did find a gap in the availability of an EMR model that expressly includes clinical documentation quality, coding accuracy, claims processing and cost effectiveness in one system. This gap is important because clinical documentation, coding and reimbursement are all interrelated processes; issues earlier in documentation can cascade into coding and impact claims outcomes.

In an effort to fill this gap, Quality and Cost Efficiency Medical Record (QOSTMED) was developed as an electronic medical record model that connects clinical documentation and administrative operations with claims-related capabilities. The model is segmented into modules for patient registration, clinical examination, medicine and prescriptions, procedures, supporting examinations, administration and cashier, and connection with the INA-CBGs e-claim system. It also features notification procedures that are intended to identify potentially problematic diagnoses and supporting documentation. The model was therefore not built as a digital alternative to paper records but as a seamless system to improve information quality, workflow efficiency and claims administration.

The evaluation of QOSTMED was structured using the PIECES framework, which encompasses Performance, Information, Economy, Control, Efficiency, and Service. This multidimensional approach allows the system to be evaluated not only in terms of technical performance but also in relation to information quality, economic implications, control mechanisms, operational efficiency, and service delivery. In the present study, qualitative validation was conducted through a focus group discussion involving experts in electronic medical records, INA-CBGs coding, and BPJS policy. The experts assessed the developed model across the six PIECES dimensions. A subsequent limited quantitative evaluation used a one-group pretest-posttest design involving 30 healthcare professionals from two purposively selected hospitals, with user experience assessed across the same six PIECES dimensions.

Therefore, this study aimed to validate and preliminarily evaluate QOSTMED as a quality- and cost-efficiency-oriented electronic medical record model using qualitative expert assessment and quantitative user evaluation based on the PIECES framework.

RESEARCH METHOD

2.1 Study design

This study employed a mixed-method validation design consisting of qualitative expert validation followed by a quantitative preliminary evaluation of the QOSTMED electronic medical record model. The validation stage was conducted after the QOSTMED model had been developed based on the identified needs related to clinical documentation, medical record management, and INA-CBGs claims processes. The purpose of this study was to assess the developed model from both expert and end-user perspectives. The qualitative component assessed the model using the PIECES framework, comprising Performance, Information, Economy, Control, Efficiency, and Service. The quantitative component used a one-group pretest-posttest design to compare healthcare professionals' experiences when using the standard electronic medical record and QOSTMED.

2.2 Qualitative expert validation

Qualitative validation was conducted through a focus group discussion (FGD) involving experts with relevant expertise in electronic medical records, INA-CBGs coding, and BPJS Health policy. The object of the expert assessment was to explore the applicability and prospective operability of QOSTMED from the standpoint of technical,

information, economic, control, efficiency and service. The FGD assessment was organized around the six dimensions of the PIECES framework:

2.2.1. Performance: the capability of the system to enable speedier documentation, coding and validation processes;
2.2.2. Information: the completeness, timeliness and standardization of information in medical records;
2.2.3. Economy: potential contribution of the system to the economy of administrative costs and optimization of claims;
2.2.4. Control: authorization of users, audit trails and mechanisms to control access and system use;
2.2.5. Efficiency: ability to reduce redundant activities, facilitate data entry and improve workflow; and
2.2.6. Service: accessibility of patient information and system contribution to healthcare service delivery.

The experts made judgments and recommendations for each dimension. Qualitative data were used to identify strengths of the developed model and areas that need further development. The advice offered are to enhance data security by encryption, backup and firewall measures and to include a user module. Importantly, the qualitative assessment was considered expert validation of the model rather than an objective measurement of the size of gains in cost, productivity or claim outcomes.

2.3 Quantitative preliminary evaluation

QOSTMED was tested in a small-scale experiment with 30 healthcare workers from two hospitals selected by purposive sampling after expert validation. A one-group pretest-posttest approach was employed to compare participants' experiences with the standard electronic medical record versus QOSTMED. Participants evaluated the two systems with a questionnaire based on the six PIECES dimensions: Performance, Information, Economy, Control, Efficiency, and Service. The questionnaire gave scores of perceived experience of users and evaluation of system performance. Both standard EMR and QOSTMED were evaluated by the same individuals, allowing within-participant comparisons of perceived system performance across the six dimensions.

2.4 Statistical analysis

Descriptive statistics for each PIECES dimension were calculated as mean ± standard deviation (SD) for standard EMR and QOSTMED. The same individuals evaluated the two systems and hence a paired-samples t-test was used to analyze differences between the two systems. The analysis yielded the mean difference, t statistic, degrees of freedom, and two-tailed p value. Statistical significance was evaluated at the level of $p < 0.05$. Mean difference was determined as standard EMR minus QOSTMED; Thus, a negative mean difference shows that the score for QOSTMED was higher than the conventional EMR. The results were interpreted with this direction of calculation in mind.

2.5 Ethical considerations

The study was approved by the institutional ethics committee of the relevant institution on 21 July 2025 (Approval No. 115/UN27.06.11/KEP/EC/2025). All participants were briefed about the purpose and procedures of the study and signed informed permission before to participation. Participation was voluntary and the anonymity of the participants' information and responses was preserved throughout the study.

RESULT AND DISCUSSION

3.1 Result

3.1.1 Qualitative Expert Validation

A focus group discussion (FGD) with specialists in electronic medical records, INA-CBGs coding, and BPJS Health policy was conducted for qualitative validation of the QOSTMED model. The study focuses on six characteristics of PIECES: Performance, Information, Economy, Control, Efficiency and Service.

The expert evaluation showed that the QOSTMED improved in all six dimensions of PIECES. In terms of Performance, experts believed that the system may accelerate documentation, coding and validation. The Information dimension was provided by the real-time, full and standardized medical record information and interaction with the e-claim process. For Economy, analysts saw the possibility for reduced administrative expenses and the rejection of claims through increased efficiency and optimization of INA-CBGs claims.

QOSTMED was useful for Control, including user-level authorization and audit-trail functions that might enhance accountability and minimize the possibility of incorrect claims. But experts said data security might be boosted by using encryption, backup systems and firewall protection. In the Dimension of Efficiency, the system was judged to remove redundant data entry, facilitate collaboration across units, and decrease workload. Experts said on the service side that more complete and more readily available patient information could save administrative waiting time and support clinical decision making.

Table 1. Expert assessment of QOSTMED based on the PIECES framework

PIECES dimension	Main expert findings	Recommendations
Performance	Faster documentation, coding, and validation processes	Add/improve user guidance module
Information	Real-time, complete, and standardized medical information; supports clinical pathways and claims processing	Maintain integration with e-claim
Economy	Potential to improve administrative cost efficiency and reduce rejected claims	—
Control	User-level authorization and audit trail support accountability and claims control	Strengthen encryption, backup, and firewall
Efficiency	Reduces redundancy, accelerates data entry, facilitates inter-unit collaboration, and may reduce workload	—
Service	Faster access to complete patient information and shorter administrative waiting time; supports decision-making	—

3.1.2 Quantitative Preliminary Evaluation

Following the qualitative expert validation, QOSTMED was evaluated in a limited-scale trial involving 30 healthcare professionals from two purposively selected hospitals. Participants evaluated both the standard electronic medical record (EMR) and QOSTMED using a questionnaire based on the six PIECES dimensions.

Descriptive analysis showed that QOSTMED received higher mean scores than the standard EMR across all six PIECES dimensions. The overall mean score increased from 63.5 ± 7.2 for the standard EMR to 74.2 ± 6.5 for QOSTMED. The largest mean score for QOSTMED was observed in the Information dimension (75.2 ± 6.5), followed by Control (74.6 ± 6.1) and Performance (74.5 ± 6.2).

Table 2. Descriptive statistics of user experience based on PIECES dimensions

PIECES dimension	Standard EMR, Mean ± SD	QOSTMED, Mean ± SD	n
Performance	62.8 ± 7.1	74.5 ± 6.2	30
Information	64.1 ± 6.8	75.2 ± 6.5	30
Economy	63.0 ± 7.5	73.8 ± 6.7	30
Control	64.2 ± 7.3	74.6 ± 6.1	30
Efficiency	63.8 ± 6.9	73.9 ± 6.8	30
Service	63.5 ± 7.0	74.4 ± 6.6	30
Total score	63.5 ± 7.2	74.2 ± 6.5	30

Source: Stage III quantitative evaluation.

3.1.3 Comparison between Standard EMR and QOSTMED

Paired-samples t-tests demonstrated statistically significant differences between the standard EMR and QOSTMED across all six PIECES dimensions. The total score also differed significantly between the two systems (mean difference = −10.7, $t = -6.33$, $df = 29$, $p < 0.001$). Because the mean difference was calculated as standard EMR minus QOSTMED, the negative values indicate higher scores for QOSTMED.

The Performance dimension showed a mean difference of −11.7 ($t = -6.10$, $p < 0.001$), while Information showed a mean difference of −11.1 ($t = -6.32$, $p < 0.001$). Significant differences were also observed for Economy (−10.8; $t = -6.01$; $p < 0.001$), Control (−10.4; $t = -6.22$; $p < 0.001$), Efficiency (−10.1; $t = -5.97$; $p < 0.001$), and Service (−10.9; $t = -6.15$; $p < 0.001$).

Table 3. Paired-samples t-test comparing standard EMR and QOSTMED

PIECES dimension	Mean difference*	t	df	p-value
Performance	−11.7	−6.10	29	<0.001
Information	−11.1	−6.32	29	<0.001
Economy	−10.8	−6.01	29	<0.001
Control	−10.4	−6.22	29	<0.001
Efficiency	−10.1	−5.97	29	<0.001
Service	−10.9	−6.15	29	<0.001
Total score	−10.7	−6.33	29	<0.001

*Mean difference = Standard EMR − QOSTMED. Negative values indicate higher scores for QOSTMED.

3.2 Discussion

In the current study, QOSTMED was rated positively by specialists on all 6 dimensions of PIECES and the user ratings of QOSTMED were much higher than the usual electronic medical record (EMR) on Performance, Information, Economy, Control, Efficiency and Service. The total score improved from 63.5 ± 7.2 with the standard EMR to 74.2 ± 6.5 with QOSTMED (paired difference statistically significant $p < 0.001$). These findings suggest that an EMR system that integrates clinical documentation, information management, workflow support and claims processing may offer a more complete user experience than an EMR that focuses solely on documentation. This view is consistent with previous results that EMR benefits are multidimensional and may encompass improvements in communication, workflow efficiency, information accessibility, treatment quality, and financial gains (Kavandi, Al Awar and Jaana, 2024).

The big improvement in the dimension of Performance shows that users felt that QOSTMED better supports the procedures of documentation, coding and validation. The

implication of this result is that the performance of an EMR should be interpreted in terms not only of its technical response time but also the degree to which the system facilitates health care providers' ability to execute their work. Studies have revealed that the effectiveness of EMR adoption depends on the relationship between system performance, usability, workflow compatibility and organizational context (Boonstra, Versluis and Vos, 2014; Nguyen, Bellucci and Nguyen, 2014). Similarly, emerging data suggests that usability and time spent interacting with EHRs are significant indicators of clinician experiences and can contribute to stress when systems are poorly designed (Alobayli *et al.*, 2023). Therefore, the higher Performance score for QOSTMED may represent a closer alignment to the process of clinical documentation and claims processing, rather than an enhancement in software capability.

The Information dimension of QOSTMED has the highest mean score (75.2 ± 6.5) It is particularly notable since the quality of electronic health information depends on its completeness, accuracy, consistency, timeliness and accessibility. Systematic research has recently been published showing that data quality in health information systems is multidimensional and that poor data quality may affect the usefulness of health information in clinical and administrative contexts (Ghalavand *et al.*, 2024). More recently, (Wu *et al.*, 2025) demonstrated that standardization, controlled vocabularies, ontologies and other semantic techniques can improve the quality of EHR data especially in terms of conformance, interoperability, usability and application. The QOSTMED approach addresses this challenge with structured clinical recordkeeping and integration of the data needed for downstream claims processing. Hence, the higher Information score may reflect the consumers' perception that QOSTMED provided more complete and valuable information about their process.

The relevance of information quality is also naturally related to the accuracy of clinical documentation and coding. Clinical documentation integrity is directly related to health data integrity, patient safety, quality outcomes, clinical coding and health information management (Davis and Shepheard, 2024). Similarly, (Seligson *et al.*, 2021) noted that better clinical documentation through standardized documenting techniques can impact quality metrics and reimbursement. The results provide a reasonable foundation for the positive estimation by experts and users on the information-oriented characteristics of QOSTMED. QOSTMED was created to save clinical information and to provide easy access to the information needed for the coding and claims process.

There is a substantial improvement in the Economy dimension. The study says nothing about actual savings, but it does reveal that consumers have a better view of economic efficiency. The expert study demonstrated the potential for reduction of administrative load and improvement of claims efficiency. The quantitative assessment showed that QOSTMED had a higher Economy score (73.8 ± 6.7) than the traditional EMR (63.0 ± 7.5). Reimbursement can be impacted by improved documentation and billing processes (Seligson *et al.*, 2021; Burks *et al.*, 2022; Kavandi, Al Awar and Jaana, 2024). They also argue that EMRs may provide indirect cost benefits through efficiency and data availability gains. This study did not analyze administrative spending, denied claims, claim turnaround time or income therefore you cannot infer that QOSTMED saves money or makes hospitals more money based on the observed Economy outcome.

The Control dimension also demonstrated a significant improvement with the mean score from 64.2 ± 7.3 for the conventional EMR to 74.6 ± 6.1 for QOSTMED . The qualitative review found user level authorization and audit-trail to be important strengths.

Experts said there was a need to further strengthen encryption, backup and firewall systems. These findings further corroborate the broader literature emphasizing that the evaluation of health information systems needs to encompass organizational and human elements as well as technical capability (Mukred *et al.*, 2019). The evaluation of information systems has been recognized for a long time as a difficult procedure. The success of the system is related to system quality, information quality, service quality, user satisfaction and organizational context (Delone and McLean, 2003; Mukred *et al.*, 2019).

The Efficiency findings are especially intriguing as healthcare personnel sometimes have a burden related to paperwork when technological solutions do not sufficiently support clinical operations. QOSTMED has an average score of Efficiency 73.9 ± 6.8 against 63.8 ± 6.9 for the traditional EMR. This conclusion aligns with systematic research suggesting that poor EHR design and excessive documentation time might contribute to clinical workload, which may result in stress and burnout (Alobayli *et al.*, 2023; Wu *et al.*, 2024). Some suggested ways to reduce the paperwork burden and increase user satisfaction are workflow optimization, EMR replacement, training and automation (Kang and Sarkar, 2024). Therefore, the QOSTMED results suggest that the existence of features during the documentation and claims procedures may cause the user to view the system as less redundant and more efficient.

The improvement in Service suggests that QOSTMED was seen as better providing access to patient information and healthcare service processes. This finding is in line with findings that EMR deployment can lead to improvements in communication, information accessibility, workflow, and patient-centred care when the system is well aligned with users' demands (Kavandi, Al Awar and Jaana, 2024). The conclusion is consistent with the research highlighting that usability should be examined in conjunction with happiness, performance, and safety rather than a simply technical attribute of a system (Park *et al.*, 2024). A systematic review of digital health usability evaluations also showed that user feedback via questionnaires remains one of the most frequently used methods. Furthermore, usability evaluations should be tailored based on the users' characteristics and the context of technology application (Maqbool and Herold, 2024).

Another possible explanation for the reported improvement is the interoperability and integration aspect of QOSTMED. The qualitative assessment led to EMR and e-claim process integration. Increasingly, interoperability is being recognized as a significant determinant of the quality of health information systems since fragmented systems can generate unnecessary effort, inconsistent information and inefficient information transmission. In a systematic review, (Li *et al.*, 2022) found that EHR interoperability was associated with improvements in drug safety and reductions in some patient safety events and costs, however the strength of the evidence was variable across outcomes. Thus, the good evaluation of the Information, Performance and Efficiency dimensions of QOSTMED may be attributed mostly to its integrated approach to information flow, rather than to the progress in individual modules.

The results also indicate a need for user-centered implementation. The current study analyzed QOSTMED after its creation, however the positive user assessments do not mean that technology design alone can lead to successful adoption. Recently, systematic assessments have highlighted the need of training, ease of use, compatibility with current processes, organizational backing and sufficient resources in realizing the benefits of EMR deployment (Kavandi, Al Awar and Jaana, 2024). (Pettersen, Eide and Berg, 2024) pointed out the role of healthcare workers as technology champions in facilitating implementation.

This is in line with the expert proposal in the present study to increase the user guide part of QOSTMED. Future deployment should therefore involve targeted training, user feedback and local implementation support instead of treating the system as a purely technical intervention.

A major contribution of this work is the use of PIECES as a multidimensional assessment framework. The framework made it possible to evaluate the system performance, information quality, economic consequences, control, efficiency and service at the same time instead of merely evaluating user happiness or technical usability. This comprehensive approach is in line with the literature on the evaluation of health information systems which emphasizes that the evaluation of HIS should cover technological, human and organizational factors (Mukred *et al.*, 2019). It is also complementary to the wider Information Systems Success perspective where system quality, information quality, service quality, utilization, user satisfaction and net benefits are interrelated components of information system success (Delone and McLean, 2003). The present results indicate that PIECES could be a feasible approach for the initial assessment of an EMR model to link clinical data with administrative and payment procedures.

However, these encouraging findings should be interpreted with caution due to a number of limitations. First, the quantitative evaluation was limited to only 30 healthcare professionals from two purposively selected hospitals. Second, the study employed a one-group pretest-posttest design without a concurrent control group, restricting the capacity to attribute all observed differences only to QOSTMED . Third, the results were views of users and not objective assessments of documentation time, accuracy of coding, rejected claims, claim turn-around time, administrative costs or hospital revenue. Fourth, the present study investigated short-term user experience and hence cannot confirm the sustainability of the reported gains over longer periods of time. These limitations are particularly relevant as systematic reviews of EHR interventions have pointed to the need for stronger study designs, longer follow-up, and objective outcome measures when assessing the effects of health information technologies (Kang and Sarkar, 2024; Maqbool and Herold, 2024).

The results should therefore be considered as evidence of model validity, supported by expert opinion and initial user approval, but not as definitive evidence of clinical or economic effectiveness. The statistically significant changes across all the PIECES categories provide an important basis for moving forward to a wider scale effectiveness review. Future studies should adopt controlled or quasi-experimental designs, larger and more diverse samples, longer follow-up periods, and objective indicators such as documentation completeness, coding accuracy, claim rejection or pending rates, claim processing time, administrative workload, and hospital reimbursement. Such an evaluation would allow to test the possible quality and cost-efficiency benefits of QOSTMED beyond perceived user experience.

Overall, the findings indicate that QOSTMED is a promising integrated solution to electronic medical record management by combining clinical documentation, information quality, workflow efficiency, system control, and claims-related procedures. The steady progress in the six PIECES criteria warrants further assessment of its clinical and economic effectiveness in routine health care.

CONCLUSION

QOSTMED is an integrated clinical recording, information management, workflow support and claims related procedures electronic medical record model promising in terms of quality and cost-efficiency. The model is positively perceived on all six PIECES aspects, according to expert validation and first user testing, which suggests its ability to boost quality and efficiency of electronic medical record procedures. However, these data indicate a first validation of the model and of the perceived benefits by users, and are not definitive evidence of clinical or economic effectiveness. Additional evaluation with bigger and more diverse samples, controlled study designs, longer follow-up, and objective measures of documentation quality, claims performance, workflow efficiency, and actual costs is needed.

AUTHOR'S CONTRIBUTION STATEMENT
Conceptualization: WM, YTU, MM.
Methodology: WM, YTU, MM.
Investigation: WM, YTU, MM.
Data curation: WM, YTU.
Formal analysis: WM, YTU.
Writing – original draft: WM.
Writing – review & editing: WM, YTU, MM.
Supervision: YTU, MM.
Project administration: WM.
All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST
The authors declare no conflicts of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS
The writers employed the AI-assisted tool, the open source model of the company Amazon, as an assistant during manuscript creation, mainly for language editing, grammatical correction, and improving the clarity and organization of the text. All AI-assisted outputs have been thoroughly evaluated and verified by the authors against the original data, analysis, references and study records. The authors independently examined the revised content for accuracy, integrity, consistency and appropriateness. The authors took all final decisions regarding the paper. The data, statistical results and research conclusions presented in the paper were not generated, modified or fabricated by any AI tool. The authors bear whole responsibility for the correctness and integrity of the final text.

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